Trade and renewable resources in a second best world

Bulte, E.H.; Barbier, E.

Published in:
Environmental & Resource Economics

Publication date:
2005

Document Version
Peer reviewed version

Citation for published version (APA):
Bulte, E. H., & Barbier, E. (2005). Trade and renewable resources in a second best world: An overview. *Environmental & Resource Economics*, *30*(4), 423-464.

Draft: August 23, 2004

Paper based on Keynote address by Erwin Bulte, 12th annual conference of the European Association of Environmental and Resource Economists, Bilbao (Spain), June 28-30, 2003

Trade and Renewable Resources in a Second Best World: An Overview

Erwin H. Bulte[1] and Edward B. Barbier[2]

[1]: Department of Economics, Tilburg University,
P.O. Box 90153, 5000 LE Tilburg, Netherlands, E.H.Bulte@kub.nl

[2]: Department of Economics and Finance, University of Wyoming,
Laramie, WY 82071-3985, USA, ebarbier@uwyo.edu

Abstract: We provide an overview and introduction to the emerging field of trade and renewable resources, and discuss the potential impact of trade liberalization on welfare and resource conservation. A key factor determining the effect of trade reform is the institutional context or property rights regime, and our survey is organized such that it loosely follows the development of new insights with respect to institutions in this literature. This implies a transition from the benevolent planner's model to the polar opposite benchmark of open access in the 1990s. Currently the pendulum is swinging back towards management and regulation, but institutions are treated as endogenous. We discuss and compare various key models in some detail and search for common ground between protagonists and antagonists of free trade.

JEL code: F18, Q2, Q56

Acknowledgement: We would like to thank the Council of the European Association of Environmental and Resource Economists (EAERE) for the opportunity to deliver the speech on which this paper is based at the 12th Annual Conference in Bilbao, Spain. We also like to thank three anonymous referees for helpful suggestions and comments on an earlier draft.

1. Introduction

The past decade has witnessed a proliferation of texts on trade and pollution. Compared to this rapidly expanding literature, there are relatively few contributions on trade and renewable resource management.[1] This imbalance in the economics literature is not readily explained by lack of popular interest. The impact of trade liberalization on renewable resource management and conservation is a highly contentious issue – fiercely debated outside of academia by international bodies (e.g., the Convention on International Trade in Endangered Species, the International Tropical Timber Organization, the World Trade Organization and the World Bank), non-governmental organizations (e.g., TRAFFIC, the World Wildlife Fund (WWF), Greenpeace and Friends of the Earth), and the popular media (e.g., *The Wall Street Journal*, *The Economist*, *The Environment*, and *New Scientist*). Mass demonstrations against globalization and the freeing of world trade in recent years in Genoa, Copenhagen, Seattle and other cities hosting meetings of international policymakers dominated the news worldwide, and the alleged negative impact of free trade on environmental resources was a major theme during these demonstrations.

While the topic 'trade and renewable resources' might be capable of arousing strong emotions of the public, it is a fair question to ask whether it is sufficiently different from other fields in economics to warrant attention as a separate and emerging academic field (albeit obviously an applied one). We argue that this is indeed the case. Compared to the literature on trade and agriculture, environment or exhaustible resources, the economics literature on trade and renewable resources stands apart because of at least three reasons: i) the key role played by the institutional context as reflected in the resource management regime (i.e., optimal management *vs* open access); ii) the inherently dynamic nature of resource management, with stock size adjusting over time to the opposing forces of replenishment and harvesting; and finally, iii) the associated complex environmental issues beyond concern with just resource extraction (e.g., habitat conversion, non-use values, bio-invasions, biodiversity, *etc*.). Many resource stocks are not simply a production factor for the traded commodity at hand; they may also contribute to the stability and productivity of ecological systems that provide invaluable services to mankind, and affect the welfare of individuals directly.

[1] For instance, two recent surveys on renewable resource management in the *Journal of Economic Literature* and *Journal of Environmental Economics and Management* don't mention this topic (Brown 2000; Wilen 2000).

Imperfectly defined or enforced property rights and failure to internalize all external effects in extraction implies that natural resource management typically takes place in a "second-best world." Ever since pioneering work by Lipsey and Lancaster (1956), economists know that trade liberalization in the presence of pre-existing distortions might yield ambiguous welfare results. The second-best nature of resource management makes it a particularly interesting topic for economic research on the effect of trade liberalization.

We suggest that there are two distinct, albeit not necessarily conflicting, views on the relationship between trade and renewable resources. These two perspectives reflect the focal points of ecology and economics as scientific disciplines. Ecologists are typically interested in maintaining the integrity of ecosystems and ecological functions, whereas economists are often assumed to care predominantly about human welfare. In recent times, however, these two perspectives are increasingly converging. For example, for many environmental management problems, economists frequently consider ecological functions, or "services", to be important arguments in welfare functions. Equally, ecologists are realizing that protecting and enhancing ecosystems requires understanding and controlling the way in which humans exploit these systems to enhance their welfare. As will become apparent in our review of the economics literature on trade and renewable resources, recent advances in this field are increasingly adopting an integrated economic-ecological perspective to analyzing this topic. Unfortunately, when it comes to the impact of international trade on the environment, the popular perception is that the views of some economists and some ecologists are still at polar extremes.

Consider these typical positions taken by antagonists and protagonists of free trade. Environmentalists often espouse the "anti-free trade" view, which as summarized by Daly and Goodland (1994), centers around concerns about economic scale relative to ecological limits, distribution, the balance of power between multinational enterprises and national governments, and the implied effects of globalization on incentives for domestic governments to regulate resource use. The WWF (1999), for example, argues that the World Trade Organization (WTO) threatens the environment and believes it is no coincidence that "the Earth has lost 30 percent of its natural wealth" at the same time "the volume of world trade is 14 times greater than it was in 1950, and is growing at twice the pace of other economic activities." Trade boosts production, consumption and transport – all of which is at the detriment of resource systems. Trade liberalization undermines important environmental treaties, and might set the stage for a regulatory ‘race to the bottom’ in response to concerns about the private sector’s competitiveness on international markets. In addition, trade liberalization is claimed to potentially affect the social fabric of rural communities managing common property resources, undermining local institutions geared towards sustainable resource management. Causal observation of the devastating impact of the ivory trade on elephant populations, or the effect of the tropical timber trade on forest management in the Philippines or Ivory Coast, lends some credibility to the concerns of environmentalists.

The response of the caricature economist, in contrast, is that trade is unambiguously “good.” By exploiting scale economies or differences in technologies, factor endowments or preferences, trade essentially relaxes a binding constraint and enhances welfare. While the first-order effects of trade liberalization on resource management and stock conservation are likely to be ambiguous, all participating countries will experience Pareto-improving gains when conditions for a Walrasian economy are satisfied. Thus any “losers” from the resource impacts arising from trade liberalization could be potentially compensated by the “winners” in the rest of the economy. Of course, economists acknowledge that actual economies do not satisfy Walrasian conditions. But the general perception is that, if trade does trigger substantial damage to the environment, such outcomes are typically associated with the presence of domestic distortions. Various case studies on trade and renewable resources seem to support this view. For example, the ivory trade only resulted in excessive elephant slaughtering because property rights to elephants (and ivory) were not enforced, and range states had no incentive to protect and harvest this resource in a sustainable manner (Barbier et al 1990). Likewise, the timber trade only ravaged Philippine forests because corrupt policy makers had easy access to tempting rents (Ross 2001). Economists argue that the right response in such cases is to address the underlying problem through domestic regulation or environmental treaties, and not to restrict trade. Quite to the contrary, economists often argue that trade is good for conservation through the “environmental Kuznets curve” (EKC) argument – trade stimulates economic growth, and richer people demand more conservation of stocks which higher income countries can now afford to protect. Similarly, trade can provide the incentives for regulators to manage their resource base more carefully, because higher prices for the resource may imply a “pay off” for such a strategy (Swanson 1994). For example, although excessive timber-related deforestation is a major problem in many tropical forest countries, Barbier (2001, p. 147) argues that “producer countries that take a long-term perspective on the development of their forest industries and through sustainable management of their forests are likely to gain substantially from the expanding international trade in timber products."

In light of such opposing views it is no surprise that there are repeated calls for incorporating trade rules for improved resource management into the WTO. However, as pointed out by Copeland and Taylor (2003, p2), "there is a rather large gap between what we know about the relationship between international trade and renewable resource management, and what we would need to know in order to evaluate policy proposals, design new international treaties, or amend WTO obligations." Similarly, while multilaterial conventions like the Convention on International Trade in Endangered Species of wild fauna and flora (CITES) and the Convention on Biological Diversitas (CBD) have recently embraced the use of economic incentives to promote sustainable and efficient use of resources and wildlife, there is a lack of insight in how to make progress on this front.

The main objective of the paper is to provide a survey of the current literature, and discuss state of the art knowledge about the impact of trade liberalization on (i) the incentive to invest in stock conservation and (ii) welfare in resource-dependent economies. When stepping back from the theoretical Walrasian economy to allow for the existence of policy and market imperfections, we find that trade liberalization generally has ambiguous effects in terms of both impacts. Opening up for trade can increase welfare but when institutions are imperfect it might just as likely have the opposite effect. Similarly, environmentalists are sometimes right to fret about the consequences of trade for resource management, but there exist circumstances where trade promotes conservation and where banning trade could be detrimental and puts species at risk. Another objective of the current paper, therefore, is to demonstrate the conditions which produce outcomes that conform to either the typical economist's or environmentalist's view of trade and the environment, and to search for common ground between these two positions.

The importance of gaining a better understanding of the impact of trade on management of renewable resources is underscored by the simple observation that exports of key renewable resources continue to increase. Bourke and Leitch (2000) note that forestry has become a global activity (with ownership of forests and plans, concession rights increasingly held by foreign companies), and that exports of most forest products, as well as their value, have expanded considerably over the past 25 years.[2] Similarly, Vannuccini (2003) writes that some 40% of world fish production enters international trade, and that net exports of developing countries grew from US$4 billion in 1981 to US$ 17.7 billion in 2001. Within global trends there have been changes in the importance of different countries as exporters – for example, as the pattern of the timber trade shifts to value-added processed products such as wood pulp and paper, wood-based panels, and furniture, developing countries such as Indonesia, Malaysia, Brazil, Chile and the Asian newly industrializing countries are emerging as leading exporters (Barbier 2001). Partly this may be due to changing markets (both domestic and international) and other factors. However, this also represents changes in resource conditions because of exactly the processes discussed later in this chapter. For example, Brander and Taylor (1997a,b) argue it is no coincidence that countries like the Philippines and Cote d'Ivoire, with imperfect property rights to their valuable forest resources, have turned from net exporter to net importer of wood products.

We have organized the paper such that our presentation of the results loosely follows historical developments in the literature. In the 1970s and 1980s, following the rapid spread of optimal control methods throughout the resource economics field, most of the work assumed the perspective of a benevolent planner who either harvests the resource or controls the harvesting by private agents at zero cost.[3] The main results of this literature are discussed in section 2. The perspective drastically changed in the 1990s, and there was growing attention to the *polar opposite case* of open access resource extraction. This firmly places us in a second-best world, and salient features of these models are addressed in section 3. North South models are discussed in section 4. Currently the pendulum swings back again, moving from the case where are virtually no institutions (open access) to the socially optimal case. But rather than taking the existence of a planner for granted, this new literature treats the institutional context as endogenous, following from the incentives and constraints that agents have at the micro level. This literature, as well as some other work on intermediate cases between the polar extreme cases, is discussed in section 5. The conclusions and recommendations for future research ensue.

---

[2] Globally, exports of industrial roundwood have increased by 22% since 1970 to 120 million cubic meters (cum) in 1997; sawnwood and wood pulp have almost doubled to 113 million cum and 35 million metric tons, respectively. Wood based panels have increased five fold to 50 million cum, and paper and paperboard has quadrupled to 87 million metric tons.

[3] Of course there are a few very influential papers in the 1950s dealing with open access (Scott, Gordon). But these papers did not deal with trade explicitly, and their main insights were not used in trade models until the 1990s.

2. Benchmark 1: optimal management and perfect property rights

The simplest analysis of trade and renewable resources is not about trade at all. Rather, it is about the consequences of changing the relative price of resource commodities. In this section we take the simple case of optimal resource management in a partial equilibrium setting as a starting point, and then gradually complicate the analysis by adding general equilibrium considerations, and trade with exogenous and endogenous prices. Throughout the paper we assume that the country in question is 'resource abundant' which implies it faces a higher resource price after liberalization and becomes a net exporter (at least in the short run). Of course some countries are resource scarce so that the opposite holds, and many of the effects discussed below will be reversed.

Regardless of whether a country is resource abundant or scarce, the welfare effects of trade liberalization under optimal management with perfect property rights must be beneficial.[4] Trade relaxes a binding constraint, and makes society as a whole better off. As usual, there are distributional issues as well – the resource industry and consumers may gain or lose, depending on whether the country is resource abundant or scarce. The impact on producer surplus is readily assessed by comparing the rents or profits associated with harvesting at low and high prices. For an optimally managed resource it always holds that raising the price of the resource commodity is consistent with increasing the net present value (NPV) of harvesting. The effect on steady state rent is more complex because of the backward bending supply curve that is implied by hump-backed growth functions such as the logistic. While higher prices will unambiguously lower the optimal stock in the simple model, the associated equilibrium harvest level may go up or down.

In the following section we consider the impact of trade liberalization on stock conservation in a partial equilibrium context in more detail.

2.1 Single-market bioeconomic model

[4] Maintaining the renewable resource stock is also likely to generate wider social values, or "stock externalities", such as biodiversity values, watershed protection, carbon sequestration and nonuse values. These values can be incorporated in the model by including the resource stock, S, as a direct argument in the welfare function, typically increasing the optimal resource stock in equilibrium. Failing to account for externalities (such that *suboptimal management* is taking place) implies that welfare effects of a change in the terms of trade are generally ambiguous (Anderson and Blackhurst 1992). This is demonstrated formally in a model of renewable resource management and trade by Barbier and Schulz (1997).

Consider the most basic bioeconomic model where a planner maximizes the net present value of welfare from harvesting a resource stock, and where the resource commodity is initially only traded domestically. Assume that harvesting (H) is defined by the well-known Schaefer production function (time arguments are omitted for convenience):

(1) $H = qES,$

where q is a parameter (the so-called catchability coefficient), E is aggregate extraction effort (a control variable for the planner) and S is the extant resource stock, growing over time according to a logistic function . This defines the equation of motion for the stock:

(2) $dS/dt = G(S) - H = \gamma S(1\text{-}S/K) - qES,$

where γ and K are parameters (for now), representing the intrinsic growth rate and carrying capacity, respectively. Under autarky, the price received per unit of the resource varies according to the inverse demand function $p = D(H)$ with $D'<0$. The planner maximizes the discounted sum of consumer surplus and resource rent associated with this sector, and his current value Hamiltonian (H_c) reads as:

(3) $$\mathrm{H}_c = \int_0^H D(z)dz - \frac{cH}{qS} + \lambda[G(S) - H],$$

where λ is the shadow price of the resource stock, c represents the per unit cost of harvesting effort, and where we have used $E=H/qS$ (from (1)). The necessary conditions for an interior steady state (with constant resource stock and shadow price) are:

(4) $H^* = G(S^*)$, and

(5) $$r = G'(S^*) + \frac{cH^*}{S^*[qSD(H^*) - c]},$$

where r is the interest rate, and (*) denotes an optimal value. According to equation (4), any stock growth should always be harvested and equation (5) defines that, at the margin, the return to a unit of the resource *in situ* should equal the exogenous return on investments elsewhere in the economy. Condition (5) implies that the rate of return of the renewable resource may be broken up in two parts: the impact of a change in the stock on growth, and the impact of a change in stock on harvesting costs (see Clark 1990 for details).

What happens to extraction in the resource sector when this economy is opened up for trade? Assume that we are talking about a small economy that faces an infinitely elastic demand function, or an exogenous world price p for the traded resource commodity. With net benefits of extraction re-defined to account for the fixed price as $B = pH - cE$ (i.e. the government now only considers resource rents or profits for producers), the equilibrium condition that defines the optimal stock, denoted by (^), becomes:

$$(5') \qquad r = G'(\hat{S}) + \frac{c\hat{H}}{\hat{S}[q\hat{S}p - c]}.$$

The implications of opening for trade for domestic stock conservation in equilibrium are now straightforward. In this simple context they boil down to the question whether the new price p is greater or smaller than the one under autarky defined by $D(H^*)$. Since the growth function is strictly concave ($G''<0$), it follows that in equilibrium $dS/dp<0$. Therefore it holds that the domestic resource stock will (i) be unaffected if by accident $p=D(H^*)$ holds, (ii) be augmented whenever $p<D(H^*)$, and (iii) be smaller whenever $p>D(H^*)$ holds. For a resource-abundant country, therefore, the stock will fall after opening up for trade.

This unambiguous result has been used to interpret the effect of trade measures on resource conservation. For example, if restricting international trade in sea horses, ivory, exotic pets or tropical timber lowers the net price received by exporters (through a tariff), equation (5′) predicts that as a result the stock will increase. Trade sanctions appear to "work" in this case.

However, it is clear from this simple model that this outcome depends on some rather restrictive assumptions. For example, Barbier and Rauscher (1994) demonstrate that a more realistic model that allows for a positive resource stock externality (e.g. biodiversity benefits) as well as extraction for both export and domestic consumption will lead to an ambiguous trade policy outcome. That is, one can no longer be certain that any trade intervention such as a ban or a trade tariff that lowers the terms of trade of the resource-exporting economy will always increase the long-run equilibrium resource stock of the economy. As we show next, other important extensions to the single-market model, such as incorporating the opportunity cost of habitat conservation, also indicate that trade sanctions are unlikely to "work" unambiguously in terms of enhancing long-run resource stocks.

2.2 Adding opportunity costs of habitat

The basic model in 2.1 assumes that the only alternative to not harvesting a species is to leave it unexploited. This implies that the model is more suitable to analyze the case of managing marine systems (mainly fisheries) and trade, but less applicable to the case of terrestrial systems where alternative uses to land than just nature conservation exist. If the social planner in the economy does consider the opportunity cost of setting aside land as habitat in order to maintain the resource stock, foregoing potential returns from, say, agriculture or plantation forestry, then resource conservation in the long run will be affected.

To capture such effects, the basic model can be extended to include two sectors, e.g. agriculture and forestry, which are dependent on the same resource base, e.g. land or habitat area. In essence, such an extension now creates a **2 x 1** (two sectors and one factor) model of the small open economy, as land or habitat conversion by the non-traded sector (agriculture) affects production from the traded sector dependent on renewable resource exploitation (forestry). Such a model is especially important for analyzing a small open economy dependent on exploitation of terrestrial-based renewable resources for export (e.g. timber or wildlife products), which is threatened by widespread land conversion to another economic activity (e.g. agriculture). In developing economies, such a model is relevant to analyzing agricultural conversion of wildlife and biodiversity habitat (Barbier and Schulz 1997; Swanson 1994) and forestland (Barbier and Burgess 1997), or aquaculture conversion of mangroves (Barbier 2003).

If the economy takes into account this opportunity cost, then in the long run it will conserve less of the resource stock (i.e., S^* is lower). As demonstrated by Barbier and Schulz (1997), including the opportunity cost of conserving land to maintain the resource stock, implies that the comparative static effects of increasing the relative price of the resource commodity are now ambiguous. This leads to two opposite effects. On the one hand, the result will be increased exploitation of the resource stock as exports become more profitable; on the other, there is now less pressure to increase habitat conversion, as the value of wild lands (supporting replenishment of the valuable resource) increases. If the latter effect is strong, then banning or restricting trade is counter-productive as it triggers habitat conversion, undermining the system's ability to support the key resource in the long run.[5] Barbier et al (1990) use this as an important argument against banning the trade in ivory to protect elephants.[6] A similar argument suggests

[5] Adding to the ambiguity, when there are nonuse values associated with the stock, then income effects may play a role as well – extra revenues from resource sales may lower the marginal utility of consumption and increase demand of "nature."

[6] Bulte and van Kooten (1999) analyse the ivory trade ban in case in more detail, solving a Stackelberg game between regulator and poachers. There are damages associated with elephant conservation (akin to the opportunity cost of habitat). It is shown that the trade ban lowers elephant numbers when discount rates applied by African range states are sufficiently low (below 5%) and that the reverse holds when discount rates are "high." The impact of the trade ban on the regulator's incentive to enforce anti-poaching regulation is further discussed in section 5.

that trade sanctions on tropical timber products could actually further deforestation in exporting countries, as trade bans and punitive tariffs would increase the returns to agricultural conversion, which is the major cause of much tropical deforestation globally (Barbier 2001; Barbier et al. 1994).

2.3 The 2 x 2 small open economy

The small open economy model with renewable resources can be extended to a two-sector, two-factor (**2 x 2**) model. Such a model was developed by Kemp and Long (1984) to examine the conditions under which a small open economy may choose to specialize in production and exports of a relatively resource-intensive good or in a relatively labor-intensive good.[7] The resource harvesting process they consider is somewhat simpler than the one discussed above as the authors consider only the aggregate amount of resource extracted and thus harvesting costs are assumed independent of stock size. For the optimal stock in equilibrium, then, it must hold that $G'(S) = r$, or marginal growth of the wild stock must equal the discount rate.

For a small open economy the task is to choose the rate of harvest, H, so as to maximize:

$$(6) \qquad W = \int_0^\infty Y(p, H, L)e^{-rt}dt\,,$$

subject to $dS/dt = G(S) - H$. In (6), Y represents the aggregate output of the two-sector economy, which is a function of the terms of trade, harvest and the total endowment of the Ricardian labor factor, L. Both goods are produced with constant returns to scale technology. The terms of trade, p, represents the relative price of good 1 in terms of good 2, i.e. $p = P_1/P_2$, with the second good being the relative resource-intensive good. For given p constant, Kemp and Long consider how aggregate output, Y, changes with increases in the harvest rate. Over a defined interval $\left(\underline{H}, \overline{H}\right)$ the economy produces both the labor- and resource-intensive goods as the value marginal product of labor in production is the same. Over this interval, the aggregate output function is linear with respect to H (i.e., $\partial Y/\partial H$ is constant), and this interval defines the "threshold" for the economy to switch from specializing in one type of good to the other. Outside of this interval,

---

[7] Unlike the two-sector, two-factor (**2 x 2**) model of open access management (pioneered by Brander and Taylor 1997, and discussed below) it is assumed that both factors are combined to produce the two goods.

the economy specializes in one of the goods and Y has the normal concavity properties with respect to harvest.

Kemp and Long demonstrate that in the steady state, which is a saddle point, it may be optimal for the economy to produce and export only the labor-intensive good, only the resource-intensive good, or produce both goods. However, as the economy passes along one or other of the stable arms towards the saddle, production may switch from one pattern of specialization to another during the approach dynamics.

For example, Figure 1 illustrates the case where the economy specializes in the labor-intensive good (which does not imply that harvests are zero). The saddle path and equilibrium are depicted in (λ, S) space, where as before λ is the shadow price of the resource stock. As shown in Figure 1, the switching threshold occurs well below the steady state (λ^*, S^*). It follows that, if the economy begins with relatively low resource stocks, $S < S^*$, then it will follow the left-hand arm of the saddle path and always specialize in the labor-intensive good. In contrast, if the economy is relatively resource abundant initially, $S > S^*$, then the economy will specialize first in producing and exporting the resource-intensive good but will switch eventually to specializing in the labor-intensive good. Note that, along this right-hand arm of the saddle path, the economy continues to over-exploit the resource stock, which eventually declines to the steady state level S^*.

Kemp and Long also consider the effects of an increase in the terms of trade, p, i.e. an increase in the price of the relatively resource-intensive good. The result is an increase in the interval of time during which the relatively resource-intensive good is produced and exported, and a decrease in the time in which the economy specializes in the labor-intensive good. In Figure 1, this is represented by a shifting up of the line defined by $\left.\frac{\partial Y}{\partial H}\right|_{\underline{H<H<\overline{H}}}$, and if this effect is sufficiently large so that this line now exceeds the steady state (λ^*, S^*), then it is possible that a small open economy will specialize in the resource-intensive good or produce both goods.

The Kemp and Long model is clearly a highly simplified **2 x 2** model of a small open economy. No consideration is made of the opportunity cost of habitat, stock externalities or even the cost of resource harvesting. Nevertheless, the conditions under which a small open economy may choose to specialize in production and exports of a relatively resource-intensive good or in a relatively labor-intensive good prove an important contrast to other models of resource-trade relationships.

For example, Matsuyama (1992) showed how trade liberalization may lower welfare in model with external benefits in the non-resource (or non-agricultural) sector – a departure from the first best world discussed thus far. If there are increasing returns at the sector level due the spillover benefits of firms, then re-allocation of labor from manufacturing to resource extraction will lower the returns of firms that remain in manufacturing (an external cost that will be ignored by individuals). If opening up for trade induces such a re-allocation of labor, then total welfare may fall. This effect has been postulated as one potential explanation of the so-called resource curse effect – an empirical regularity suggesting that countries well endowed with resources tend to grow slower than their resource poor counterparts.[8]

3. The polar opposite benchmark: open access

One of the most important institutional frameworks to consider in a trade-renewable resource model is the situation of "unregulated common property" or "open access". There is a long tradition in bioeconomic models of the fishery in analyzing open access problems, beginning with the seminal works by Gordon (1954), Scott (1955) and Smith (1969). As Conrad (1995, p. 408) notes, "a fishery is open access when the fish stock is harvested by a large number of unregulated, competitive fishermen with no barrier to entry or exit … *de facto* open access can arise if management regulations are ineffective. These might occur, over time, if fishermen are adaptive and can reduce or eliminate the effect of regulations which previously restricted catch."

In recent years, there has been increased recognition that the "open access" resource management problem extends beyond fisheries to other renewable resources, notably forests, wildlife, mangroves and other terrestrial-based resources. Only recently, however, have the implications of open access for the impacts of trade on renewable resource management been explored.

However, not all trade-renewable resource models that incorporate open access resource exploitation necessarily arrive at the same conclusions. The results for resource conservation

[8] This effect is more likely to eventuate when countries are rich in point resources (like oil fields and mines) than in diffuse resources such as agricultural land (see Leite and Weidman 1999, Isham et al 2003). Other possible explanations for the resource curse include Dutch disease (Sachs and Warner 1997), and rent seeking (Torvik 2002), and also the potential adverse effect of resource wealth on institutional development, indirectly impacting on economic performance (Isham et al. 2003).

and welfare differ depending on whether models are constructed in a partial or general equilibrium setting, and depending on assumptions regarding market structure, technology and scale economies. To illustrate these models, we adopt a similar approach as in discussing trade-renewable resource models under optimal resource management. First we consider the simplest case of a single-market bioeconomic model. We then examine the case of the **2 x 2** model of a small open economy. The discussion of North-South models that incorporate various assumptions concerning open access resource exploitation will be discussed in Section 4.

3.1 Single-market bioeconomic model

As a counterpart to the basic single-market model optimal management model developed in Section 2.1, consider now the same model under open access exploitation. As demonstrated by Smith (1969) and Conrad (1995), the key feature of the latter model is that aggregate extraction effort, *E*, is determined by the profits generated by resource extraction. That is, an increase in profits will lead to greater extraction in the open access industry, whereas a decline in profits will reduce extraction. This suggests that the dynamics of effort in open access resource extraction, both for autarky and free trade, can be represented by the following equation of motion:

(7) $\dot{E} = \phi[D(H)qS - c]E$.

This differential condition implies that expectations are constantly adapting in response to observations in the field – some kind of "backward looking" behavior (for a model of rational expectations, see Berck and Perloff 1982).

We need to combine (7) with an equation that defines the dynamics of the resource stock. As before, we can assume both a logistic stock growth function for $G(S)$, and Schaefer harvest, $H = qSE$. This implies that stock dynamics are represented by equation (2) above.

Under autarky, the price received per unit of the resource varies according to the inverse demand function, $p = D(H)$ with $D' < 0$. Thus equation (7) indicates how exploitation effort adjusts, at some rate ϕ, to the profits from harvesting. In the long run, under open access, profits from exploitation are driven to zero and the renewable resource stock is constant. The long-run steady state is therefore

(8) $E^A = \dfrac{G(S^A)}{qS^A} = \dfrac{\gamma(1 - S^A/K)}{q}$, and

(9) $$S^A = \frac{c}{D(H^A)q},$$

where the superscript "*A*" is used to denote open access equilibrium values. The long-run steady state and the dynamic path corresponding to this state is depicted in Figure 2 for the case where the price elasticity of demand, $\varepsilon = D(H)/D'(H)H$, is elastic, i.e. $|\varepsilon| > 1$.

Once again, it is insightful to see what happens to extraction in the resource sector when the economy is opened for trade. If the economy is small, then it faces an exogenous world price, *p*, for the resource commodity it produces. Long-run condition (9) becomes simply:

(9') $$S^A = \frac{c}{pq},$$

which is a vertical line in Figure 2. The implications of opening for trade for resource conservation are straightforward and similar to the optimal management case, in that they once again depend on whether the new price *p* is greater or smaller than the price received under autarky defined by $D(H^A)$. That is, the domestic resource stock will be (i) unaffected if by accident $p=D(H^A)$ holds, (ii) augmented whenever $p<D(H^A)$, and (iii) smaller whenever $p>D(H^A)$ holds.

Assuming that prices rise as a consequence of opening up for trade, it follows that the resource stock will fall.[9] The latter effect is depicted in Figure 2, where the new open access equilibrium for the resource stock is indicated as $S^{A'}$. As also shown in Figure 2, however, equilibrium effort will rise, to $E^{A'}$.[10] Thus in the simple bioeconomic model, the stock and harvest effects of opening up of trade are the same in the open case as in optimal management. However, these two cases do differ in one important respect. Under open access, all rents from resource extraction are dissipated in the long run. Opening up the economy for trade does not affect this outcome; rent in the steady state is zero and remains so. In other words, there are no welfare effects (in terms of changes in producer surplus) in the resource sector.

The open access model has been extended to include the impacts of habitat conversion (e.g. Bulte and Horan 2003). For example, Barbier and Strand (1998) consider a model of an export-oriented shrimp fishery in Campeche, Mexico that produces shrimp for export.

[9] It is easy to see from (9') that $\frac{dS}{dp} = -\frac{S}{p} < 0$. This also implies a unitary price-stock elasticity response.

[10] From (8), $\frac{dE}{dS} = -\frac{\gamma}{qK}$ and therefore $\frac{dE}{dp} = \frac{\gamma S}{pqK} > 0$.

According to ecological evidence, the fishery is supported by coastal mangrove systems that serve as breeding and nursery habitat for the shrimp fry. Thus, by assuming that increasing mangrove area F effectively "extends" the carrying capacity of the fishery, Barbier and Strand modify the net growth equation (2) to

$$(10) \qquad \dot{S} = G(S) - H = \gamma S\left(1 - \frac{S}{K(F)}\right) - qSE, \qquad K'(F) > 0.$$

Starting with an open access equilibrium under trade conditions (i.e. point (S^{A}', E^{A}') in Figure 2), Barbier and Strand show that the effect of threats to mangrove habitat, through coastal developments in Campeche, is to reduce equilibrium effort in the fishery, but leave the resource stocks unchanged. This is shown in Figure 2 by the rotating down of the $\dot{S} = 0$ curve. The destruction of mangrove habitat creates a temporary disequilibrium in which stocks fall and so does harvest. Because export prices remain unchanged, a loss is made in the fishery causing some fishers to leave so that effort declines. This will mean less exploitation so stocks will recover, and in the long run zero profits prevail once again. Thus in the new equilibrium, stocks return to their steady state level, S^{A}', but effort has fallen (i.e. $E^{A} < E^{A}$'). The result must be lower levels of harvest and gross revenues in the fishery.[11]

In general, if a small open economy is exploiting and exporting a renewable resource under open access conditions, we would expect habitat conversion to have similar effects. This is readily apparent from (9') and (10). If a reduction in natural habitat (i.e. a decline in F) shifts down the growth function, either by reducing K or γ, then steady-state effort and thus harvest will fall but not steady-state resource stocks.

3.2 The 2 x 2 small open economy

Brander and Taylor (1997a) construct a **2 x 2 model** of a small open economy by combining an open access renewable resource model with a standard Ricardian model of international trade.[12] One of the two goods is a resource good produced using labor and the

[11] Barbier and Strand employ this model, under the assumption that the fishery is a price-taker in export markets, to estimate the long-run losses from mangrove deforestation on the open access shrimp fishery in Campeche. See Barbier (2003) for the example of applying the model with a finite elasticity of demand to a case study in Thailand of the impacts of the expansion of aquaculture shrimp, a leading export product, on mangrove conversion and off-shore fisheries. The analysis demonstrates why Thailand has chosen to expand coastal aquaculture to increase export earnings from shrimp production, despite the economic consequences of the accompanying mangrove deforestation for coastal fisheries.

[12] Qualitatively similar results are obtained for a **2 x 2 x 2 model** (see Brander and Taylor 1998).

resource stock. The other good is a generic "manufactures" good produced using labor. Brander and Taylor consider such a model to be applicable to understanding the effects of international trade on open access renewable resource exploitation, and believe that the insights of such a model are particularly relevant to small open developing economies. Over-exploitation of many renewable natural resources – particularly the conversion of forests to agricultural land – often occurs in developing countries because property rights over a resource stock are hard to define, difficult to enforce or costly to administer.

The country has a fixed labor force and produces and consumes two goods. The "manufactures" good, M, is treated as the numeraire whose price is normalized to one. In this constant returns to scale sector (but see below), one unit of labor is used to produce one unit of M and, hence, labor's value marginal product in manufacturing is also one. It follows that, given competitive labor markets, the wage rate in the economy is one if both goods are produced. The second good is harvest, H, from a renewable resource stock, which is subject to the standard net biological growth relationship. Harvest is produced with the Schaefer production function $H=qES$, and the labor constraint implies $L=E+M$. The effect of open access exploitation in the resource sector is to ensure that the price of the resource good must equal its unit cost of production in equilibrium. That is, as all rents from using the resource stock are dissipated, and only labor costs are incurred in harvesting, the equilibrium open access harvesting condition is always

$$(11) \qquad p = w\frac{E}{H} = \frac{w}{qS} = \frac{1}{qS},$$

where p is the (relative) price of the resource good. Equation (11) states that, under open access, the price of the resource good must equal its unit cost of production. Since the wage rate, w, in the economy is one (with diversified production), the unit labor requirements, and thus costs, of the resource sector are inversely related to the size of the stock.

To complete their model, Brander and Taylor assume a representative consumer endowed with one unit of labor, who has Cobb-Douglas preferences for both goods ($u=H^{\beta}M^{1-\beta}$). As this implies that both goods are essential, in autarky manufactures, M, must be also be produced. The authors show that the ratio of the resource's intrinsic growth rate (γ) to total labor in the economy, γ/L, determines autarky relative prices. This ratio defines Ricardian "comparative advantage". Thus for some sufficiently high ratio of γ/L a country would have an autarky price of the resource good less than the world price and can be considered relatively "resource abundant". For $\gamma/L > q$, the small economy may specialize in manufactures or the resource good (depending on relative prices) or be characterized by diversified production. For $\gamma/L < q$ it is impossible for the country to specialize in the resource sector.

Figure 3 illustrates the effects of opening of trade in a resource-abundant economy – a country where prices under autarky were below the world market level p^* (or a country where γ/L is sufficiently large). Figure 3a compares the initial post-trade impacts and the transition to the steady state, whereas Figure 3b contrasts steady state utility under autarky with various trade scenarios. Denoting p^A and S_A as the autarky equilibrium resource price and stock respectively, we have from (11) $p^A = 1/qS_A$ as the initial condition describing this equilibrium. In Figure 3a, the initial autarky production and consumption point is given by E, with β and $(1 - \beta)$ representing the share of labor employed in the resource and manufacturing sectors respectively. The production possibility frontier under autarky is the steep line with intercept LqS_A that goes through point E. If $p^* > p^A$ when trade opens (world market prices exceeding prior domestic prices under autarky), then the economy immediately specializes in the resource good. The condition $p^* qS_A > 1$ implies that the value marginal product of labor in harvesting exceeds the prevailing domestic wage in the resource sector. The temporary equilibrium production point moves to the vertical axis at LqS_A, and the economy's initial post-trade budget line has a slope $-1/p^*$ (represented by the dotted line in Figure 3), and it lies outside the autarky production possibility frontier. This implies that the economy exports initially the resource good, imports manufactures and experiences temporary gains from trade as the new consumption point is now C.

However, the initial trading equilibrium cannot be sustained. All labor has entered the resource sector, which will result in the temporary harvest rate rising above the steady-state autarky level. The harvest rate will exceed resource growth, and S will decline. As the resource stock falls, Schaefer production implies that harvests will also decline, and as shown in Figure 3a, the vertical intercept of the production possibility frontier shifts down as indicated by the arrows. Two possible steady-state outcomes may result.

First, if the resource stock stabilizes at a level that can sustain the entire labor force at a wage rate exceeding one, then the economy can specialize in production and export of the resource good in the long run. This is indicated by one line if Figure 3a, which is the small country's free-trade budget line that has a vertical intercept, and production level, of LqS_S and a intercept on the horizontal axis beyond L. As depicted in the figure, the specialized steady state would allow the country to gain from trade. However, this need not be the case. Steady-state consumption levels under complete trade specialization may not necessarily be higher than in autarky, and depending on the relationship between the terms of trade and steady-state utility, the economy may or may not have gained from trade.

Figure 3a also illustrates the case of steady-state diversification. In this case, the resource stock falls to a level, S_D, so that not all the labor is allocated to harvesting and its value marginal product equals one. The economy will consume at point D, and in comparison to autarky, international trade reduces the small country's steady-state utility unambiguously. While nominal income is unaffected by the opening up for trade, real income has fallen as the consumer price of the resource is now higher than before.

Figure 3b illustrates the consequences of trade for a resource-abundant economy, $\gamma/L > q$. The flat line labeled u^A represents the country's steady-state per capita utility under autarky, whereas u^T represents the country's steady state utility under trade, which is a function of different world prices, p^*, for the resource good. The standard gains from trade are a convex function of the difference between the world and autarky price, and are minimized if the world price equals the autarky price ($p^A = p^*$). In that case, trading and autarky utility are also equal. At all prices below p^A the economy would export manufactures and experience steady-state gains from trade. There is some possible world price p^{1*}, such that world prices below this level the economy would stop being diversified and specialize completely in manufactures. At world prices just above p^A the economy would be an exporter of the resource good but diversified in production. In this range, steady-state utility under trade would be less than it would be under autarky. However, if world prices rise to p^{2*}, the economy would specialize in the production of the resource good. This price level minimizes steady-state utility under trade. Above p^{2*} additional increases in the world price are beneficial to the economy, and there is some price, p^{3*}, beyond which steady-state gains from trade would occur relative to autarky.

The problem highlighted by Brander and Taylor is that too much harvesting takes place in autarky because there are no secure property rights to the resource. Opening up for trade makes matters worse for resource abundant countries. Conversely, resource scarce countries are better off as they now start importing the resource good. Brander and Taylor conclude that, as the problem lies with the open access nature of exploitation in the resource-abundant economy, then the first-best policy would be for the small open country to switch to more efficient resource management policy through simply establishing property rights.[13] However, as they acknowledge, there are many policy and institutional distortions that currently work against such solutions, particularly in developing countries and other resource-abundant small open economies. Consequently, Brander and Taylor (1997a, p. 550) argue in favor of "second best approaches." In a dynamic context where alternative assets are available, the exporting country could impose "a modified Hartwick's rule" (see Hartwick 1977) and re-invest temporary gains from selling a resource good on world markets.[14]

In an extension to the analysis by Brander and Taylor, Hannesson (2000) demonstrates that their results may depend critically on the assumption that the manufactures good sector is constant returns to scale. For example, in Brander and Taylor's model, the steady state national income in terms of manufactures does not change, as long as the country does not specialize fully in open access resource extraction. However, Hannesson argues that it is not at all unlikely for economies heavily dependent on extractive industries and with a locational disadvantage in manufacturing to have diminishing returns in the latter sector. As a consequence, the equilibrium national income of a small open economy in terms of manufactures is likely to rise from trade, even if harvested exports are exploited under open access, as the country is now able to import manufactures a constant world price rather than having to acquire these goods through reallocating resources with diminishing returns.[15] By shifting labor from manufacturing to harvesting the marginal and average return to labor in manufacturing increases (see also de Meza and Gould 1992). Note that an opposite result obtains when we assume increasing returns to scale in manufacturing instead (e.g. Matsuyama 1992). Increasing returns may be plausible, for

[13] But see Emami and Johnston (2000) who demonstrate that, in the context of imperfect property rights, resource management by only one country may benefit one or both trading partners, but may also reduce welfare for both, when compared to the case in which neither manages its resource sector.

[14] The Brander and Taylor model has been extended to include habitat (as emphasized in section 2) and a third sector that demands land (say agriculture) by Smulders et al (2004). While open access to resource stocks gives rise to within–industry externalities, it is shown that habitat destruction may create across–industry externalities.

[15] When the two goods are substitutes, and thus the indifference curves are linear, these gains from trade always dominate. However, with non-linear indifference curves, such as the case with a Cobb-Douglas utility function, the gains from trade are more ambiguous, and it is possible to obtain the same results as Brander and Taylor, even with diminishing returns in manufacturing. See Hannesson (2000).

example, because of spillover benefits in manufacturing – a key assumption in the endogenous growth literature.

Hannesson (2000) also demonstrates that, with diminishing returns to manufacturing, moving from an open access regime to optimal management may or may not lead to an improvement in welfare. Such an "immiserizing effect" of a transition from open access to optimal management will occur if the demand for the resource good is inelastic so that the value of harvested output is less than under open access, and more labor is withdrawn from the resource sector. The imperfection that drives this result is that insiders in the manufacturing sector cannot prevent outsiders (formerly harvesting the resource) from spilling into "their sector", adversely affecting the return to their labor.

4. Trade between North and South

After discussing the extreme cases of the perfect planner and open access, we now turn to a series of more complex intermediate cases. In this section we will present results from models with trade between different types of countries; North and South. North and South are assumed to be nearly identical (except perhaps in terms of initial resource stocks) but differ in terms of the institutional framework that shapes resource extraction. In the next section we present the static model by Chichilnisky (1994) where the North is assumed to have perfect property rights whereas the South has none – section 2 meets section 3.[16] In section 4.2 we present a model by Karp *et al*. (2001) where institutions are imperfect in both the North and South, but where the common pool externalities are worse in the South because there are more people using the pool. The Karp model is based on some different assumptions with respect to utility and production than most of the papers in this literature. This nicely complements the other work, and demonstrates that some of the conventional key assumptions are far from innocuous.

4.1 North-South: trade between polar opposite extremes

Extending the **2 x 2** optimal resource management model to a two-country, or North-South, **2 x 2 x 2** model does not in itself yield further insights beyond the basic Kemp and Long model

[16] Technically speaking, this is not quite true. Brander and Taylor consider the case of complete open access where individual harvesters completely ignore the external costs of their harvesting. Chichilnisky considers an unregulated common property model where individuals take a share of their external costs into account. The latter collapses to the former whenever the number of individuals approaches infinity.

discussed previously. As the authors demonstrate through rigorous proofs, their **2 x 2** optimal resource management model, whether applied to exhaustible or renewable resources, is fully consistent with standard Hecksher-Ohlin theorems, and is therefore applicable to any number of identical countries or regions with identical factor endowments, technologies, preferences and institutional arrangements, and which face competitive world factor and goods markets. However, a more complex and interesting case arises when we allow for the possibility that there are institutional differences between the trading partners. This is exactly what Chichilnisky (1994) does. She analyzes a North-South model of trade and resource management when the two countries are identical except that they differ in the pattern of ownership of an environmental resource used as an input to production. Specifically, resource owners in North have perfect property rights whereas management in South is characterized by unregulated common property.[17]

The harvested resource does not appear in the utility function directly as a consumption good. Instead, the resource flow serves as an input in the production of two goods A and B. Both goods are produced using Leontief or fixed proportions production technologies with the harvested resource and another factor (labor or capital) as inputs. It is assumed that good B is more resource-intensive than good A (which is more intensive in the other input). A key element in the model is the following question: how much of the resource is harvested as an intermediate input for the production of goods A and B? For a given resource stock and any given price, harvesting will be greater when property rights are weak. The common property resource supply curve lies below the optimal supply curve, implying that resources appear to be more abundant.[18] One major result is that while no trade is necessary for efficiency when the two countries are identical,[19] trade will nevertheless occur when property-rights regimes differ. Despite the fact that neither country has a real comparative advantage in producing the resource-intensive good, the lack of property rights for a property rights for a common-property resource in South leads it to produce and export resource-intensive goods in the steady state. In other words, the country

[17] Strictly speaking Chichilnisky does not consider a H-O model as she considers the case where the supply of inputs is not given but determined by (relative) prices.

[18] Chichilnisky considers a static model where the harvest function is strictly concave in effort. In a dynamic setting where the resource stock adjusts to harvesting pressures, it can be shown that equilibrium supply is backward bending (e.g., Clark 1990).

[19] Note there are no scale economies in production that could make specialization and trade beneficial (e.g., Markusen *et al*. 1997).

with weak property rights gains an apparent comparative advantage. Distortions, rather than true economic advantages, trigger and drive trade flows.

Karp *et al* (2001, 2003) define the apparent resource stock as δS, where δ is a parameter that measures the degree of the distortion (in an unregulated common property, this distortion is increasing in the number of people harvesting the resource, hence $\delta(n)$ with $\delta'(n)>0$). In Figure 4 the direction of trade is illustrated for North and South – two identical economies but possibly with different stocks (S^N and S^S, respectively) and South has imperfect property rights. The 45 degrees line (i.e. identical stocks in North and South) defines zero real comparative advantage. In contrast, the "no-trade line" defines the case where $S^N=\delta S^S$, or the condition with zero apparent advantage. If the ratio S^N/S^S is such that the system is above the 45 degrees line, South exports the resource-intensive good, and has a true advantage in doing this. For S^N/S^S below the "no-trade line", North exports the resource intensive good. For S^N/S^S between the 45 degrees line and the "no-trade line," the direction of trade will be inefficient as South has an apparent advantage and is an exporter of the resource-intensive good, while North has a true advantage.

If South exports the resource intensive good, the good will be traded at a price below social costs, even if factor prices are equal across the world, all markets are competitive. This implies that the country with well-defined resource property rights (the North) ends up over-consuming the resource-intensive good. Trade exacerbates a pre-existing distortion, which could make the South worse off than under autarky.

What would happen in a dynamic framework? Brander and Taylor (1997b) examine the case of a two-country model where a country governed by a planner meets a country characterized by open access management, and solve for steady states. While the country without property rights may export the resource good (and suffer a welfare loss as discussed in section 3) in case of 'mild overuse,' a trade reversal is obtained when relative prices give rise to 'severe overuse' in the open access country. The open access country will first exploit its apparent advantage and export the resource good, but following stock depletion will become a net importer. Efficient management in the short run therefore may result in a comparative advantage over time. If this is the case, both countries experience gains from trade.

4.2 Imperfect property rights in North and South

Building on Chichilnisky, the model by Karp, Sacheti and Zhao (2001) analyzes a more complex case of North–South trade. The main assumptions differ from those of Chichilnisky in the following respects:

i) Rather than contrasting private property in the North versus unregulated common property in the South, the Karp *et al* model assumes imperfect property rights in *both* countries. While there is no monitoring and enforcement in the North, the common property problem is assumed to be more serious in the South because there are more people utilizing the Southern pool, shifting the supply curve of harvested resources out as it inflates the apparent stock (given an actual certain resource stock *S*).

ii) There are two arguments in the utility function; consumption of a subsistence good *A* with unit price and the resource-intensive consumption good (and intermediate input in the harvesting process of the resource good) *B*. Subsistence good A is assumed to have an income elasticity of demand equal to unity for consumption levels below income threshold *A**, and an income elasticity equal to zero for income levels greater than *A**. That is; any (extra) income below the threshold will be spent on the subsistence good *A* and any income in excess of the constraint will be allocated to consumption of *B*.

iii) There are two production factors; the harvested resource flow and some other input (which may be labor or capital). Unlike Chichilnisky, who assumes this factor can be supplied at a certain cost, Karp *et al* assume its availability is exogenously given. Consistent with earlier discussions, let us assume this additional factor is labor.

The combination of zero substitution in production and consumption, combined with a given availability of labor, implies that the model may have multiple stable steady states. Three cases are depicted in Figure 5, graphing the harvesting rate *H/S* and three realizations of the resource growth rate $G(S)/S$. The kink in the piecewise linear harvest rate path occurs because of the assumption of fixed proportions in production between the inputs "harvested resource" and labor. For resource stocks below the kink ($S<S^c$), the resource flow is completely employed whereas labor is not (a feature not uncommon in some resource dependent communities). As the resource stock increases, so does the associated harvest level. Imperfect property rights imply that, for any given resource stock $S<S^c$, there will be excessive extraction – too much *B* will be allocated to harvesting and not enough will be consumed. At threshold level $S=S^c$ labor is fully employed and the distortion does not affect supply under autarky. Further increasing the stock

does not trigger more harvesting as there is no labor to match the resource in production—aggregate harvesting is constant for larger resource stocks, kinking the harvest schedule. The kinked path enables (but does not guarantee) three intersections between harvest and growth. For slow (fast) growing resources, the system settles in a unique 'low' ('high') steady state. For intermediate growth rates, low and high steady states occur simultaneously and initial conditions determine the long run outcome of the system. By shifting the harvest curve up or down, the stable steady states shift accordingly – quantitative changes to the system. However, more dramatic outcomes are also possible as equilibria might appear or disappear altogether.[20] Cases where the system "jumps" from one stable steady state to another (say: from 'low' to 'high,' or *vice versa*) are interpreted as qualitative changes.

What happens when the North and the South move from autarky to trade? When labor is fully employed in both countries, aggregate harvesting is unaffected by trade liberalization,[21] but the share of extraction is affected – some harvesting will shift from North to South where property rights are weaker. When some labor is unemployed in one of the two trading partners under autarky, it is possible that trade increases the aggregate level of extraction as well.[22] This happens because trade enables countries to re-allocate their production and specialize in those products in which they have a comparative advantage. In other words, the (apparently) resource-scarce country will specialize in the production of resource-extensive good *A*. This might enable them to reach a situation where eventually all labor is employed such that aggregate production increases.

The common theme throughout this survey has been to consider the effects of trade liberalization on welfare and stock conservation. In light of the argument above about multiple steady states in autarky, it is perhaps no surprise that there are also multiple stable candidates under trade for "intermediate" values of the resource growth as in Figure 5. Initial conditions then determine where the system 'settles down." For resources that grow sufficiently slow (fast),

---

[20] For example, the curves will shift in response to property rights reform. Karp *et al* (2003) explore the consequences of harmonization of environmental regulation when trade is driven by distortions rather than true underlying advantages. Among other things they show that, while upward harmonization (increasing property rights in the South towards the level in the North) is preferable in the long run as it increases the odds of ending up in a high steady state, even *downward* harmonization can be good for welfare.

[21] This is an artifact of the model, following from (i) the assumption that income elasticity of good *A* is zero, (ii) fixed proportions in production and (iii) a fixed total labor stock in both countries.

[22] When some labor is unemployed after trade in both countries, trade does not affect affect production or consumption and is irrelevant.

there exist a unique equilibrium where some (none) of the labor is unemployed. In equilibria where all labor is employed in both countries, the South with its weak property rights will export the resource intensive good, and as a consequence Southern stocks will be lower than under autarky. The reverse holds for Northern stocks.

In the short run, where the apparent resource stocks are fixed, trade may affect production and consumption, and, hence, welfare. Trade may trigger an inefficient direction of trade where the South exports the resource intensive good because its lax property rights regime provides it with a larger *apparent* stock, even though its actual stock is lower. If the direction of the trade flow is efficient, the volume might still be excessive. If these effects are sufficiently strong to outweigh the usual benefits of trade associated with comparative advantages, trading might lower welfare in the South. These effects have also been identified by Chichilnisky. But there are additional long run effects on the resource stocks to consider as well. The trade pattern identified above might result in a collapse of the local stock, and the South may possibly become an importer rather than an exporter of the resource-intensive good – a reversal in apparent comparative advantage.[23] This allows the Southern stock to recover, but could also set the stage for a phase of resource degradation in the North. Trade links the dynamics of resource stocks in North and South, and the topologies of the general equilibrium may change qualitatively as a result. That is; when resource stocks adjust in the long run, equilibria may appear or disappear.

Karp, Sacheti and Zhao show that the long run welfare effects of trade are complex and ambiguous – there are cases (parameter combinations) where the North pulls up the South so that freeing trade eventually makes both countries better off – the economist's dream scenario. Alternatively, there are circumstances where the South drags the North down, such that both countries are worse off – the environmentalist's nightmare. The latter result is not feasible in a model with a rational planner and perfect property rights in the North; one needs a model with imperfect property rights in the North. Of course mixed outcomes are also feasible. Karp *et al.* interpret these results as common ground between free traders and environmentalists; both perceptions on the welfare and conservation effects of trade liberalization may be correct and the fixed proportions model allows analysts the identify which perspective of the world is likely to prevail in specific conditions. The model suggests a key role for the intrinsic growth rate in this

[23] Brander and Taylor (1997b) also obtain this "reversal".

respect – for sufficiently low rates (or fragile stocks) the pessimistic outcome is more likely to occur.[24]

5. Endogenous institutions and property rights regimes

Thus far we have considered the effects of trade liberalization in polar opposite institutional settings; the benevolent dictator and the open access or unregulated common property case.[25] Or, put differently, the cases of perfect property rights and no property rights, respectively. These all-or-nothing cases are stylized extremes, and "real world harvesting" usually involves some intermediate property regime instead. While resource stocks may be formally owned by governments, it is typically the case that private agents do the harvesting. Firms have an incentive to harvest in excess of their quota or underreport their catches when these are taxed. The government must devote scarce resources to monitoring and enforcement to ensure that the resulting harvest schedule is efficient. Alternatively, the stock may be owned by a group of users who collectively decide on the management of the co-called common pool, but each individual has an incentive to cheat and free ride on the other's conservation efforts.

We would like to make the following three observations. First, the degree to which the *de jure* stock owner is willing to monitor and enforce its property rights is determined by relative prices and, hence, by the trading regime. Swanson (1993) and Schulz (1996) have argued that, by virtually eliminating the legal value of harvesting, trade bans might result in the cessation of all monitoring. In that case open access "poaching" for an illegal trade or domestic markets will ensue such that, from a environmentalist's perspective, the trade ban might be counterproductive. Second, the incentive of individuals and firms to cheat and harvest in excess of agreements (or poach when access is denied) is also endogenously determined. Finally, the effectiveness of regulation may be affected by trade as well. Trade liberalization may expand the set of "outside options" for individuals in a common pool, thereby making ostracism a less effective deterrent to enforce cooperative extraction from the common pool.

In other words, trade both impacts on the incentives to cooperate and the incentive to regulate – the net effect on the institutional context is unclear *a priori*. Because of the many

[24] When the rate is very low, however, trade does not harm the economy as the autarky outcomes would also be dismal.

[25] With 'unregulated common property management' the number of firms exploiting the resource is fixed. Market failure in such a setting is less severe (e.g. Baland and Platteau 1996).

possible linkages, there is no escape but to build on formal models to learn what mechanisms might exist. The economics discipline is increasingly attempting to cope with this issue, and in this section we will discuss three different approaches.

5.1 Enforcement, profits and welfare

Suppose a resource stock is formally 'owned' by a firm (say, a forest concessionaire or landowner extensively managing his land), but that no-encroachment enforcement is costly. The owner must decide whether to invest in securing its property rights, and if so; how much exactly? Alternatively, he may allow others to use it under open access conditions and dissipate any rents. De Meza and Gould (1992) provide an early and general analysis of the fact that the resource must be sufficiently valuable to expend funds on exclusion, monitoring and enforcement. Hotte *et al* (2000) related this insight to the case of renewable resources and trade. Households are again endowed with a unit of labor that is allocated to either manufacturing or extraction (legal or illegal). In contrast to the Brander and Taylor studies in section 3 (but consistent with Hannesson 2000) it is assumed that there are decreasing returns with respect to labor in manufacturing.

Two types of labor may be extracting the same stock—legal and illegal (poaching) labor (L_H and E, respectively). The parameter ϕ measures the strength of enforcement, and with more enforcement the return from poaching labor is smaller. This occurs because poachers have to avoid detection by the owner. It is assumed that only a share $(1-\phi_i)$, where $0 \leq \phi \leq 1$, of the poaching labor E_i is effectively geared towards extraction on plot *i* (owned by firm *i*). The firm (resource owner) can manipulate parameter ϕ, by choosing enforcement intensity as this affects the precautionary efforts that poachers must incur. The costs associated with achieving enforcement level ϕ are $c(\phi)$ where $c'>0$ and $c''>0$.[26]

Households compare the return to their labor in both activities, and either work in manufacturing or legal extraction (with the wage rate determined by the marginal product of labor), or in poaching (where labor earns its average product, driven by the sum of legal and effective illegal effort). The firm chooses legal harvesting and enforcement effort. Both variables have in common that they drive out illegal harvesting effort; legal harvests depress the average return to labor, and enforcement increases the costs of avoiding detection. The firm first

[26] For additional work along these lines, see Clarke *et al*. (1993), Bulte and van Kooten (1999).

optimally sets its level of enforcement, ϕ. Depending on parameters, $\phi^*=0$ (true open access) or $\phi^*>0$.[27] Next, the firm decides about the hiring of legal labor. For the case where $\phi^*=0$, firms do not bother to employ anybody as there are no rents to be gained from (legal) harvesting. In contrast, when $\phi^*>0$ legal labor is employed up to the level where it exactly crowds out poaching – the entry-deterrence employment level involving rent dissipation for poachers but positive profits for the firm (whose laborers are more productive as they don't worry about detection). While the latter outcome generates positive profits for the firm, it is shown that enforcing property rights may involve a welfare loss at the level of society as a whole. Enforcement of private property rights implies that labor switches to manufacturing (depressing its marginal return which implies a fall in labor income) and also involves enforcement costs.[28] Since the effect of enforcement on labor income in manufacturing is external to the firm it does not affect its optimal enforcement stringency. The firm only compares gross profits and private enforcement costs.

Under autarky, firms may set $\phi^*=0$ or $\phi^*>0$, depending on key parameters. Assume that firm do not bother to enforce their property rights such that *de facto* extraction takes place under conditions of open access. How does opening up for trade affect the firm's enforcement decision? The authors find that the firm's optimal level of enforcement is increasing in the resource price and decreasing in the prevailing wage rate. Hence, when resource prices increase as a result of trade liberalization, the firm may suddenly find enforcement privately profitable and respond by switching from $\phi^*=0$ to $\phi^*>0$. The firm will hire some poachers and others will be forced into manufacturing. Profits of the firm increase but, as outlined above, welfare in society as a whole may fall – another example of immiserizing trade. Hotte and co-authors also analyse a more involved dynamic model where the resource stock contracts or grows in response to natural growth and harvesting. They show that the increase in enforcement brought about by higher price raises equilibrium stock levels. Endogenizing property rights thus opens the possibility that trade might be good for conservation and bad for welfare – reversing some of the insights of section 2.

[27] The owner will set $\phi^*=0$ if enforcement combined with the hiring of legal labor to deter entry by poachers earns negative profits. In contrast, if enforcement plus entry deterrence employment earns positive profits, the owner will set $\phi^*>0$.

[28] For more information on comparing income under open access and private property, see Weitzman (1974) and De Meza and Gould (1987, 1992).

5.2 Trade and common pool management

The analysis in 5.1 was based on the assumption that an owner can raise the costs of illegal extraction by raising the effort that poachers *must* incur in order to avoid detection. Nobody ever gets caught and punished because either there is no enforcement and all harvesting is "illegal" (ϕ*=0, L_H=0), or all illegal harvesting is crowded out (ϕ*>0, E=0). Copeland and Taylor choose another perspective. They assume imperfect enforcement by the resource owner, and recognize that individuals may have an incentive to harvest illegally (or harvest in excess of an agreed-upon quota), but must balance the gains from "cheating" against the expected penalties if caught.

Consider the familiar case where there is a single production factor (labor) that is allocated between CRS manufacturing or resource extraction from a common pool. Unlike in the earlier work of Brander and Taylor (1997), Copeland and Taylor assume the presence of a benevolent resource manager or village elder that sets rules on resource use to maximize steady state utility of the group. The manager decides how much labor households can spend in the common resource (say l*), and attempts to enforce its rule by monitoring the behavior of the group members (which translates into a certain probability of detection; ρ). Next, individuals have to decide whether to behave in accordance with the rule (l=l*) or allocate extra labor (l>l*) to harvesting. If too much time is spent in the commons, households run the risk of being detected (probability ρ, independent of the extent of cheating). If this happens, the household is ostracised and is denied access to the common again. Cheating households that are caught should support themselves by working in manufacturing henceforth.[29] Assume the resource stock is large enough to make extraction more profitable than manufacturing.

The trade off that households make is relatively straightforward. Adhere to the rules and earn some income in extraction and some in manufacturing. Alternatively, it is possible to take a risk and cheat by spending all the time in the common (recall the detection probability is assumed independent of the degree of violation, hence a maximum violation is optimal when cheating). The optimal choice depends on comparing the expected present value of income from

[29] Note the difference with the model of Hotte et al. (2002) where the resource owner tried to drive out illegal effort by reducing the return to poaching (by increasing legal harvesting or enforcement). Copeland and Taylor, instead, focus on the disciplining effect of punishment, which depends on the foregone profits of working in the commons relative to the wage in manufacturing.

these options. Formally, the discounted benefits of not cheating in the current period are defined as:

(12) $V^N(t) = [ph^* + (1–l^*)w]dt + (1–rdt)\ V^R(t+dt)$,

where $h^*=ql^*S$ is the harvest associated with the allowed time in the common, w is the wage rate in manufacturing and V^R is the (unrestricted) continuation value. The latter might differ from the benefits of cooperation since playing by the rules in the current period leaves all options open for the future (including cheating). Future benefits are discounted. The benefits of cheating in the current period:

(13) $V^C(t) = (pqS)dt + (1–rdt)\ [\rho dtV^M(t+dt) + (1-\rho dt)V^R(t+dt)]$,

where V^M is the present value of working in manufacturing henceforth. Note from (12) that cheaters who are not caught have the same set of options for the future as those who abided by the rules. From the above, these options are defined as $V^R(t) = \max[V^N(t),V^C(t)]$. Comparing the benefits and losses from cheating (or the costs associated with ostracism) defines a forward-looking incentive constraint. The manager must choose l^* such that this incentive constraint is satisfied, otherwise people will rationally choose to ignore the rules. After some manipulation, Copeland and Taylor demonstrate that in steady state the incentive constraint boils down to:

(14) $$l^*(pqS - w) \geq \frac{r}{r+\rho}(pqS - w).$$

When resource rents are positive (pqS-w>0), this condition simply implies $l^*>r/(r+\rho)$ or the allowable harvest should be sufficiently large to deter cheating. The threshold level is composed of parameters reflecting impatience and the probability of detection. However, there is no guarantee that the rents associated with such a policy will be positive (i.e. $pqS>w$). When the returns of harvesting according to the threshold fall below those in manufacturing, people will switch their occupation. If we define the open access allocation of labor to the common as L^O, the incentive constraint is written as:

(15) $$L^* = \min\left[L^O, \frac{r}{r+\rho}N\right],$$

where N is the number of households in the village. The planner takes the incentive constraint into account when formulating a policy that will not be violated. There are three possibilities. First, the incentive constraint is not binding and no individual is tempted to increase his harvest effort when aggregate harvesting is at the optimal level. The outcome is conventional first best management as outlined in section 2. Second, the incentive constraint binds even as the system approaches open access harvesting. This may happen when the resource good's price is very low so that L^0 is small and lower than the other term in brackets in (15). The planner is not able to re-direct the allocation of labor from harvesting to manufacturing and the outcome is as modelled in section 3. Depending on key parameters, notably the growth rate, catchability coefficient, detection and death rates, and the size of the human population, such an outcome may be temporary (that is; depending on relative prices) or permanent. Finally, and most interestingly, it may be the case that the incentive constraint binds in steady state while there are positive profits associated with current harvesting. This yields an intermediate allocation of labor and intermediate level of stock depletion (between first best and open access), and defines a 'constrained optimum.' The institutional context thus defined therefore measures whether it is feasible and necessary for an imperfectly informed planner to constrain agents' harvesting.

How does trade fit into this analysis? Copeland and Taylor distinguish between three different categories of countries; (i) countries who are never able to move beyond open access harvesting, (ii) countries who might secure some form of a "constrained optimal regime" if the conditions are favorable, and (iii) countries that achieve the fully efficient outcome given the right set of parameters. If moving from autarky to trade increases the price of the resource good, countries of category (ii) and (iii) can move from open access to limited property rights. If prices rise further, category (iii) countries can even make the final step to the full cooperative outcome (and categories from the other categories will not become worse off). The reason for this transition to happen is that rising prices trigger a flow of labor entering the resource sector and a fall of the stock. Eventually, for category (ii) and (iii) countries, both arguments in (4) are of equal size and the incentive constraint begins to bind. Depending on whether the first best allocation of labor to the common pool L^* is greater or smaller than $N[r/(\rho+r)]$ for any arbitrarily high value of p, the country can reach the first best (or not). For $L^* > N[r/(\rho+r)]$, first best harvesting can be sustained while meeting the incentive constraint.

Consistent with Hotte et al (2002), Copeland and Taylor also find that a country can have open access harvesting or (limited) control over harvesting, depending on the price of the resource good. Raising the value of the stock provides the incentive to generate rents from harvesting. Transition towards controlled harvesting is facilitated by rapid replenishment of the stock, good detection possibilities ρ and a small size of the group N. The key insight of these models is that observing conditions of *de facto* open access under autarky need not imply equally wasteful management under trade. Trade may be pre-condition for management reform, and arguing the other way around might be counterproductive. Yet, they also warn that some countries (category 1 countries) will not benefit from trade-induced higher prices. These countries will "lose" as spelled out in section 3.

5.3 Trade and corruption

In the previous two sub-sections we explored the possibility that higher prices for resource commodities might result in more efficient management. Implicitly it was assumed that harvesters do not change their behavior, other than intensifying their extraction effort in response to higher prices. But typically harvesters have additional instruments at their disposal, other than harvest effort. For example, harvesters might organize themselves and lobby for more lenient regulation. Alternatively, they may bribe planners for special favors in their pursuit of resource rents. Corruption is increasingly recognized as a major issue in "real world" management of resources like oil fields (Karl 1997) and forests (Ross 2001), and analyzing the consequences of trade liberalization on the incentive to bribe therefore is important.

For economists, the static common agency model by Grossman and Helpman (1994) provides a logical starting point to consider this issue. In this model, a self-interested planner maximizes a linear objective function that includes social welfare (W) and bribes from interest groups (T) as arguments, and a linear welfare weight to quantify tradeoffs between them:

(16) $$\text{Max } \Pi = [\alpha W + (1-\theta)T],$$

where Π represents the objective for the planner, and θ is the weight of welfare in the planner's objective function. In the sections with a planner thus far we implicitly assumed that α=1 and that the planner only has eye for the social good. This is clearly unrealistic, certainly for many resource rich countries, as is readily gleaned from the various corruption indices that are available (e.g. World Bank governance indicators or Transparency International data).

There are multiple interest groups in society – say: resource firms versus environmentalists – "bidding" on a menu of possible policies announced by the planner. In the first stage of the game the lobby groups offer the government a so-called bribe schedule that links bribes to the policies implemented. In the second stage, the government chooses the 'optimal' policy, taking objective function (16) and bribe schedules as given, and collects the bribes. In the third stage production and consumption take place, taking environmental policies as given. The model should be solved through backward induction.

In other words, there exists a political market where policies are exchanged for bribes, and where the sum of bribes is balanced against welfare. The welfare weight θ is typically assumed constant, and may be interpreted as a measure of corruption in the economy – the lower θ, the more corrupt is the planner. Interestingly, empirical work by Leite and Weidmann (1999) suggests that the extent of corruption is increasing in natural resource abundance. Given positive values of θ, more extensive lobbying translates into more distorted policies, steering the economy further away from the first best allocation of factors. In the context of resource economics, firms may have incentives to bribe the planner to pay lower taxes or receive more generous harvest quota.

Assume resource firms lobby for extending the harvest quota beyond the socially optimal quota. Privately optimal quota might diverge from socially optimal ones because firms and planner apply a different discount rate, or because there are external effects in harvesting or conservation. As demonstrated by Bernheim and Whinston (1986), the Nash equilibrium outcome is characterized by two conditions: (1) maximization of the government objective function, and (2) maximization of the joint utilities of lobby groups and planner. This implies that outcomes on the political market are *locally truthful*, or that the firm's willingness to pay (bribe) is increasing in the policy's benefits. Outcomes are on the bargaining frontier and are Pareto efficient in the sense that no actor (lobby group or otherwise) can be made better off without making someone else worse off.

Since the firm's benefits of securing a larger quota are increasing in the resource price, the equilibrium transfer from firm to planner is determined by this price too. When trade liberalization changes relative prices it affects political pressures and, hence, the balance on the political market. Following this reasoning, a resource abundant country that opens up for trade will experience an increase in lobbying and, as a result, larger quotas (in the short run) at the detriment of welfare and stock conservation – another example of endogenous institutions.[30]

[30] Leite and Weidmann (1999) also consider the effect of opening up for trade on corruption, and find a reverse effect – more 'open' economies are typically characterized by less extensive corruption. Trade regulations (as occurring at intermediate levels of 'trade openness') are a source of rents and thereby trigger further bribing (see also Baland and Francois 2000). Removing such regulations lowers the potential for rent seeking and corruption, and provides a force that works in an opposite direction from the 'price effect' of trade liberalization discussed in the main text.

While this effect has yet to be analyzed fully in the context of resource management, such an approach could yield similar insights as studies of the relation between pollution, trade and corruption.[31]

However, the interaction effects between corruption, trade and resource conversion can also be complex. For example, a recent cross-country analysis of the economic factors underlying tropical deforestation and agricultural land expansion indicates that the influence of corruption on land conversion may depend on what happens to a country's terms of trade as well as its degree of resource dependency (Barbier 2004). The presence of significant interaction effects between the terms of trade and corruption and primary product export dependency suggest caution in assuming that an important policy mechanism by which the rest of the world can reduce land conversion in developing economies is through sanctions, taxation and other trade interventions that reduce the terms of trade of these economies.

Such a finding is consistent with the theoretical models reviewed here. Throughout this paper we have noted that the impact of higher prices on the institutional setting is ambiguous: while the 'optimal enforcement models' in sections 5.1 and 5.2 implied that higher prices may result in more efficient resource management, corruption is a force that may pull in an opposite direction. By enhancing the incentive to bribe, greater corruption may cause deviations from optimal management. In such a sub-optimal world, it is difficult to predict how trade interventions and other policies will affect renewable resource management in the exporting country.

6. Conclusions

This paper has provided only a brief overview of the literature on trade and renewable resource management. The key motivation for the paper is the lack of consensus between economists and environmentalists about the desirability of international trade, and that these opposing views

[31] While we cannot do justice to the rapidly growing field of corruption and environmental regulation, we can highlight a few examples. Evidently, corruption enables firms to evade stringent regulation by paying a bribes rather than abating emissions (Pargal et al 1996). Lopez and Mitra (2000) consider the effect effect of corruption on the relation between income and pollution levels and find that both the level and 'turning point' of the EKC are affected by the degree of corruptability; Frederiksson and Svensson (2003) analyze the relation between corruption, political instability and environmental policy; Damania et al (2003) find a negative direct effect of corruption on the standard for lead content in gasoline (as well as an interaction effect between trade openness and corruption); and Frederiksson et al (2004) analyze the effects of corruption and industry size on energy policy outcomes (finding that policy stringency is inversely related to corruptability and positively related to lobbying costs, and that capitalists and workers lobbying efforts are negatively related).

offer different recommendations for reform of WTO policies. While many economists argue that trade is not the issue, and that domestic and international institutions for environmental management should be strengthened if resource conservation is a goal, environmentalists often take the opposite stand and argue the case for severely restricting and regulating trade to protect biodiversity and critical renewable resource stocks.

We organized the paper such that it loosely followed the main developments in the literature. The guiding principle in structuring the literature is the changing perspective on the role of institutions in resource management. In the 1970s and 1980s, following standard models in resource economics, most of the work assumed the perspective of a benevolent planner or sole owner with full property rights. In the 1990s, with the increasing recognition of the implications for resource management of open access resource extraction, more attention was given to the second-best setting where property rights are either *de facto* or *de jure* absent. More recent contributions treat the institutional context as endogenous, and model the incentives and constraints that agents have at the micro level to influence resource management outcomes.

Our summary of the literature suggests a very mixed overall picture, both in terms of welfare and effects on stock conservation. While generally it is possible to obtain relatively clean results for the polar extreme cases of perfect management and open access, it is evident that more realistic assessments generally imply ambiguous outcomes. The interplay of economic, ecological and institutional variables therefore determines whether trade is overall "good" or "bad", which provides quite a bit of common ground between economists and environmentalists. This has important implications for international policymaking concerned with trade and renewable resource management issues. Neither the "conventional" view of economists that trade impacts on resource management can safely be ignored, nor the equally "simplistic" view of environmentalists that trade is the source of resource losses and must therefore be curbed, is a good starting point for recommending specific trade policies and reforms for most of the pressing biodiversity and renewable resource management problems facing the world today. While trade restrictions and impediments lower welfare in a first best world, it is evident that export and import measures may promote welfare in exporting countries when, say, enforcement of property rights is imperfect. The presence of international nonuse values associated with resource conservation, of spillover regulatory benefits, may perhaps also justify trade interventions on certain occasions (albeit clearly not a first-best approach to maximize global welfare).

Space limitations do not permit a thorough treatment of trade policy (but see Anderson and Blackhurst 1992; Barbier and Rauscher 1994; Barbier et al. 1990 and 1994; Schulz 1996, Brander and Taylor 1998, and others). While tariffs for most resource commodities have declined, there is evidence that non-tariff measures continue to play a large role in shaping trade patterns (Barbier 2001; Bourke and Leitch 2000). Tariff escalation – higher rates on higher levels of procession – is also still exerting an influence on the structure of resource sector in developing countries.[32] However, whether the net welfare effects of such distortions are positive or negative is hard to determine in general. It appears as if each specific management problem, whether it be control of ivory poaching, tropical forest conservation, fisheries management, protection of endangered species or preservation of biodiversity "hot spots", must be analyzed on a case by case basis in order to determine the linkages between the key economic, ecological and institutional factors that are driving the problem. Only through such careful analysis can the impacts of trade and resource management and economic welfare be identified, and only then can possible policy recommendations be identified.

In conducting this summary of the economics literature on trade and renewable resources, we are aware that new developments are already occurring in this rapidly evolving literature. Several additional research topics have a direct bearing on the focus of the current paper, but cannot be addressed here for reasons of space. One example is the risk and welfare impacts posed by biological invasions, or "bioinvasions". Trade typically involves transport, which implies the risk of introducing non-native species. Managing this complex and unpredictable issue has recently received ample attention (e.g. Barbier and Shogren 2004; Horan et al, 2002, McAusland and Costello 2004), and will likely continue to be a topic of interest for some time. Another example is the effect of trade on habitat and biodiversity. If trade triggers specialization and if this in turn impacts on land use (e.g. forestry versus agricultural land use options) then

[32] For example, consider the case of forest commodities. Rates for most forest products are 5% or lower, but rates for processed goods like plywood are typically 10-15%. Tariff escalation discourages local processing, negatively affecting the scope for investment and industrialization in exporting countries, and the ability of exporters to capture a larger share of the value added associated with processing resource commodities. Depending on linkages and scale economies (as well as alternative employment and investment opportunities in the economy, and the institutional context within which harvesting takes place), this may or may not seriously affect the scope for modernization. There are cases where tariff escalation has been countered by export bans of unprocessed commodities. Often such efforts to promote industrialization have spurred inefficient and uncompetitive industries.

trade liberalization can be linked to biodiversity loss through the so-called species-area curve (Polasky et al. 2004). Recent research also suggests that ecolabeling is relevant in the context of trade and resource management (e.g., Swallow and Sedjo 2002, Nunes and Riyanto 2001). In the context of an information problem, ecolabeling allows consumers to identify the environmentally friendly (e.g. "sustainably managed") alternatives and express their preference for such commodities. It also enables complying producers to earn a green premium, although evidence of such premiums for sustainably produced timber and biodiversity-friendly shade-grown coffee is modest (Barbier 2001; Nunes and Riyanto 2001). Another issue that has recently been explored is the interaction between wild species, stockpiled commodities from the wilds, and the impact of legalized trade from *ex situ* stocks on the incentive to poach (Kremer and Morcom 2000) and coordinate on extinction scenarios (Bulte et al 2003).

Finally, we will briefly mention a few issues that have received little attention in the literature thus far, and that could possibly be of interest to consider in the future. First, since trade liberalization affects factor flows it is relevant to know how such flows affect factor income in the non-resource sector (e.g. de Meza and Gould 1992). The literature is silent on increasing returns to scale at firm or sector level, but exploring this possibility would link the literature with that on trade and pollution (Neary 1999) and the so-called "resource curse" (Matsuyama 1992, Sachs and Warner 1997). As discussed above in the context of Matusyama's model, when labor flows out of manufacturing, as will be the case for a resource-abundant country that opens for trade, scale economies will lower income in manufacturing. If external linkages are strong enough, this effect can dominate any gains from trade. Conversely, when trade triggers an inflow of factors, for example because of enhanced enforcement in the resource sector, this brings a positive welfare effect.

Other overlooked issues thus far include the simple observation that most models do not consider more than one production factor (labor) in addition to the resource stock or flow, and that key results can change when we distinguish between multiple factors. The distinction between mobile and immobile factors (capital versus labor) also seems apt – a questionable simplification in light of evidence that, for example, international logging firms are 'footloose' (Marchak 1995). In a similar vein, the effect of trade on investment, technology diffusion and capital accumulation is relevant. Trade may also impact on preferences for nature conservation through the impact on income, as demand for conversation has always been considered income elastic. Imperfect competition and strategic interaction between jurisdictions sharing access to common stocks or output markets has yet to be analyzed (see Ruseski (1998) for such a model that does not involve trade). Finally, empirical work seems to lag far behind theory. It appears as if the literature on trade and resource management has only just begun.

List of References

Anderson, K. and R. Blackhurst (eds), 1992. *The greening of world trade issues*. Hertfordshire: Harvester Wheatsheaf

Baland J. and Francois, P., 2000. Rent Seeking and Resource Booms. *Journal of Development Economics* 61: 527-42.

Baland, J. and J. Platteau, 1996. *Halting Degradation of Natural Resources*. Oxford: Clarendon Press.

Barbier, E.B. 2001. “International Trade and Sustainable Forestry.” In Günther G. Schulze and Heinrich W. Ursprung, eds. *International Environmental Economics: A Survey of the Issues*. Oxford University Press, Oxford, pp. 114-147.

Barbier, E.B. 2003. “Habitat Fishery Linkages and Mangrove Loss in Thailand.” *Contemporary Economic Policy* 21(1):59-77.

Barbier, E.B. 2004. “Explaining Agricultural Land Expansion and Deforestation in Developing Countries.” *American Journal of Agricultural Economics*, December, forthcoming.

Barbier, E.B. and J.C. Burgess. 1997. “The Economics of Tropical Forest Land Use Options.” *Land Economics* 73(2):174-195.

Barbier E.B. and M. Rauscher, 1994. Trade, Tropical Deforestation and Policy Interventions, *Environmental and Resource Economics* 4: 75-90

Barbier, E.B. and C.E. Schulz. 1997. “Wildlife, Biodiversity and Trade.” *Environment and Development Economics* 2(2):145-172.

Barbier, E.G. and J.F. Shogren. 2004. “Growth with Endogenous Risk of Bioinvasion.” *Economic Inquiry*, in press.

Barbier, E.B. and I. Strand, 1998. Valuing Mangrove–Fishery Linkages–A Case Study of Campeche, Mexico, *Environmental and Resource Economics* 12: 151-166.

Barbier, E., J.C. Burgess, T.M. Swanson and D.W. Pearce. 1990. *Elephants, Economics and Ivory*. London: Earthscan.

Barbier, E., J.C. Burgess, J.T. Bishop and B.A. Aylward, 1994. *The Economics of the Tropical Timber Trade*. London: Earthscan.

Berck, P. and J.M. Perloff, 1984. An Open Access Fishery with Rational Expectations, *Econometrica* 52: 489-506.

Bernheim, B D. and M. Whinston, 1986. Menu Actions, Resource Allocation and Economic Influence, *Quarterly Journal of Economics* 101: 1-31

Bourke, I.J. and J. Leitch, 2000. Trade Restrictions and Their Impact on International Trade in Forest Products. Rome: Food and Agricultural Organization of the United Nations.

Brander J. and M.S. Taylor, 1997. International Trade and Open Access Renewable Resources: The Small Open Economy Case, *Canadian Journal of Economics* 30: 526-525

Brander, J. and M.S. Taylor, 1997b. International Trade between Consumer and Conservationist' Countries, *Resource and Energy Economics* 19: 267-279

Brander J. and M.S. Taylor, 1998. Open Access Renewable Resources: Trade and Trade Policy in a two Country Model, *Journal of International Economics* 44: 181-209

Brown, G., 2000. Renewable Natural Resource Management and Use Without Markets, *Journal of Economic Literature* 38: 875-914

Bulte E.H. and G.C. van Kooten, 1999. The Ivory Trade ban and Elephant Numbers: Theory and Application to Zambia, *American Journal of Agricultural Economics* 81: 453-466

Bulte E.H. and D. van Soest, 2001. Environmental Degradation in Developing Countries: Households and the (Reverse) Environmental Kuznets Curve, *Journal of Development Economics* 65: 225-235

Bulte, E.H and R.D. Horan, 2003. Habitat Conservation, Wildlife Extraction and Agricultural Expansion, *Journal of Environmental Economics and Management* 45: 109-127

Bulte, E.H., R.D. Horan and J.F. Shogren, 2003. Elephants: Comment, *American Economic Review* 93: 1437-1445

Chichilnisky, G., 1994. North–South Trade and the Global Environment, *American Economic Review* 84: 851-874

Clark, C.W., 1990. *Mathematical Bioeconomics*. New York: Wiley Interscience

Copeland, B.R. and M.S. Taylor, 2003. Trade, Tragedy and the Commons. Department of Economics, University of British Columbia, Working Paper

Damania, R., P.G. Frederiksson and J.A. List, 2003. Trade Liberalization, Corruption, and Environmental Policy Formation: Theory and Evidence, *Journal of Environmental Economics and Management* 46: 490-512

De Meza, D. and J.R. Gould, 1987. Free Access versus Private property in a Resource: Income Distributions Compared, *Journal of Political Economy* 95: 1317-1325

De Meza, D and J.R. Gould, 1992. The Social Efficiency of Private Decisions to Enforce Property Rights, *Journal of Political Economy* 95: 561-580

Economist, 2002. Out of the Blue: Trade in Endangered Species. *The Economist*, November 2: 85-86.

Emami, A. and R. Johnston, 2000. Unilateral Resource Management in a Two-Country General Equilibrium Model of Trade in a Renewable Fishery Resource, *American Journal of Agricultural Economics* 82: 161-172

Frederiksson, P.G., H. Vollebergh and E. Dijkgraaf, 2004. Corruption and Energy Efficiency in OECD Countries: Theory and Evidence, *Journal of Environmental Economics and Management* 47: 207-231

Frederiksson, P.G. and J. Svensson, 2003. Political Instability, Corruption and Policy Formation: The Case of Environmental Policy, *Journal of Public Economics* 87: 1383-1405

Grossman, G. and E. Helpman, 1994. Protection for Sale, *American Economic Review* 84: 833-850

Hannesson, R., 2000. Renewable Resources and the Gain from Trade, *Canadian Journal of Economics* 33: 122-132

Horan, R.D., F. Lupi, C. Perrings and E.H. Bulte, 2002. Management of Invasive Species under Ignorance, *American Journal of Agricultural Economics* (Principal Paper Session): 84: 1303-1310

Hotte, L., N. van Long and H. Tian, 2000. International Trade with Endogenous Enforcement of Property Rights, *Journal of Development Economics* 62: 25-54

Isham, J., Woodcock, M., Pritchett, L. and Busby, G. (2003). The varieties of resource experience: How natural resource export structures affect the political economy of economic growth. Vermont: Middlebury College, Middlebury College Economics Discussion Paper 03-08.

Karl, T. L. 1997. *The Paradox of Plenty: Oil Booms and Petro-States*. University of California Press, Berkeley.

Karp, L., S. Sacheti and J, Zhao, 2001. Common Ground Between Free Traders and Environmentalists, *International Economic Review* 42: 617-647

Karp, L., J. Zhao and S. Sacheti, 2003. The Long Run Effects of Environmental Reform in Open Economies, *Journal of Environmental Economics and Management* 45: 246-264

Kemp, M.C. and N.V. Long, 1984. The Role of Natural Resources in Trade Models, in: *Handbook of International Economics* vol.I, Jones, R. and P. Kenen (eds.), Amsterdam: North Holland

Kremer, M. and C. Morcom, 2000. Elephants, *American Economic Review* 90: 212-34.

Leite, C. and J. Weidmann, 1999. Does Mother Nature Corrupt? Natural Resources, Corruption and Economic Growth, IMF Working Paper WP/99/85

Lipsey, R and K. Lancaster, 1956. The General Law of Second Best, *Review of Economic Studies* 24: 11-32

Loomis, J.B. and D.S. White, 1996. Economic benefits of Rare and Endangered Species: Summary and Meta–analysis, *Ecological Economics* 18: 197–206.

Lopez, R. and S. Mitra, 2000. Corruption, Pollution and the Environmental Kuznets Curve, *Journal of Environmental Economics and Management* 40: 137-150

Marchak, M.P. 1995. *Logging the Globe*, McGill-Queen's University Press

Markusen**,** J., J. Melvin, W. Kaempfer and K. Maskus, 1995. *International Trade: Theory and Evidence*, Boston: McGraw Hill

McAusland, C. and C. Costello, 2004. Avoiding invasives: trade-related policies for controlling unintentional exotic species introductions, *Journal of Environmental Economics and Management*, In Press

Matsuyama, K., 1992. Agricultural Productivity, Comparative Advantage and Economic Growth, *Journal of Economic Theory* 58: 317-34.

Neary, J., 1999. *International trade and the environment: Theoretical and policy linkages*, Invited lecture; Annual Conference of the European Association of Environmental and Resource Economists (Oslo, 25-27 June).

Nunes, P. and Y. Riyanto, 2001. Policy Instruments for Creating Markets for Biodiversity: Certification and Ecolabeling, FEEM Working Paper 72, Rome, Italy

Polasky,S. C. Costello and C. McAusland, 2004. On trade, land-use, and biodiversity**,** *Journal of Environmental Economics and Management,* In Press.

Rauscher, M., 1994. On Ecological Dumping, *Oxford Economic Papers* 46: 822-840

Ross, M. L., 2001. *Timber booms and institutional breakdown in Southeast Asia*. Cambridge: Cambridge University Press.

Ruseski, G., 1998. International Fish Wars: The Strategic Role for Fleet Licensing and Effort Subsidies, *Journal of Environmental Economics and Management* 36: 70-88

Sachs, J.D and A.M. Warner, 1997. *Natural Resource Abundance and Economic Growth*, NBER Working Paper Series, WP 5398, Cambridge: National Bureau of Economic Research.

Schulz, C., 1996. Trade Policy and Ecology, *Environmental and Resource Economics* 8: 15–38.

Smulders, J.A., D.P. van Soest and C. Withagen, 2004. International Trade, Species Diversity and Habitat Conservation, *Journal of Environmental Economics and Management*, forthcoming.

Swallow, S. and R. Sedjo, 2002. Voluntary Eco-Labeling and the Price Premium, *Land Economics* 87: 272-284

Swanson T., 1994. The Economics of Extinction Revisited and Revised: A Generalised Framework for the Analysis of the Problems of Endangered Species and Biodiversity Losses, *Oxford Economic Papers* 46: 800–821.

Tanzi, V., 1998. Corruption around the World: Consequences, Scope and Cures, *IMF Staff Papers* 45: 559-594

Torvik, R., 2002. Natural resources, rent seeking and welfare. *Journal of Development Economics* 67: 455-70.

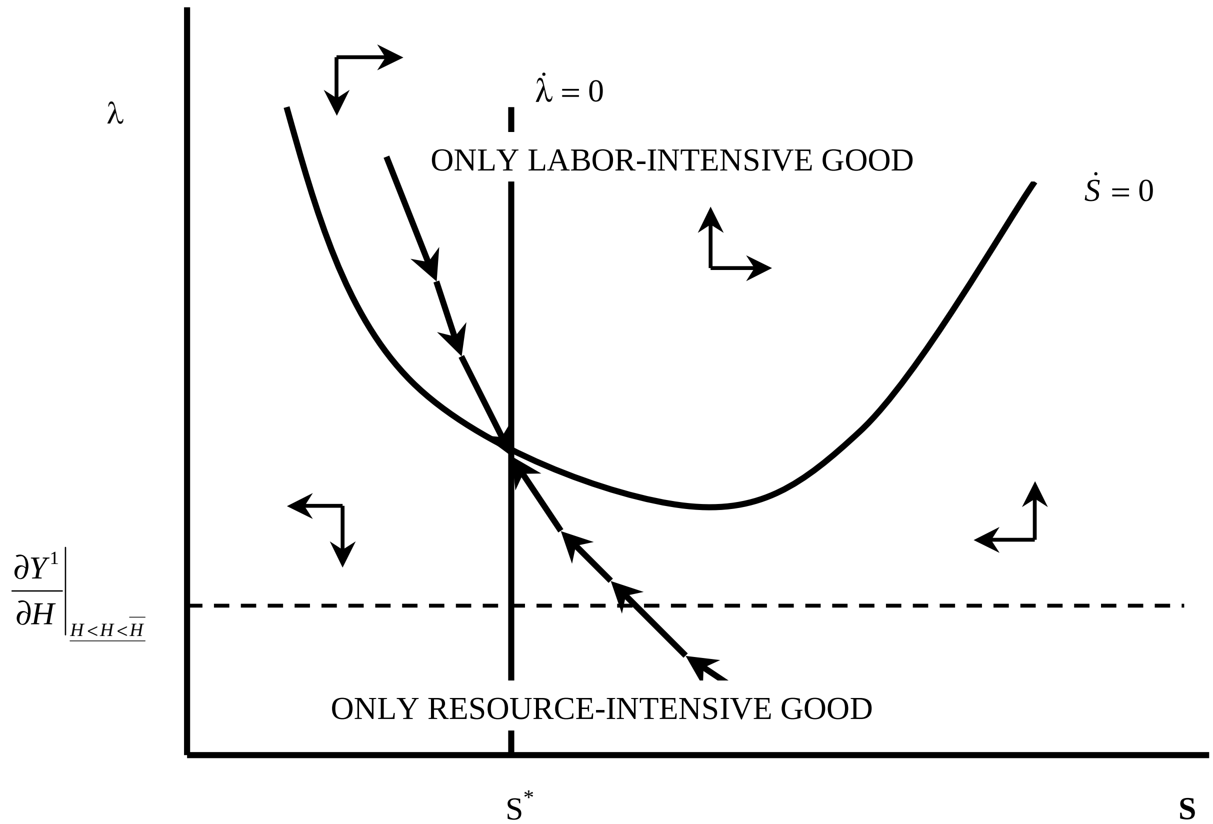
Ulph, A., 1998. International Trade and the Environment: A survey of recent economic analysis, in: H. Folmer and T. Tietenberg (eds.), *The International Yearbook of Environmental and Resource Economics* 1997/1998, Edward Elgar: Aldershot

Vannuccini, S., 2003. Overview of Fish Production, Utilization, Consumption and Trade, Rome: Fishery Information, Data and Statistics Unit, Food and Agricultural Organization of the Unites Nations.

Weitzman, M., 1974. Free Acces vs Private Ownership as Alternative Systems for Managing Common Property, *Journal of Economic Theory* 8: 225-234

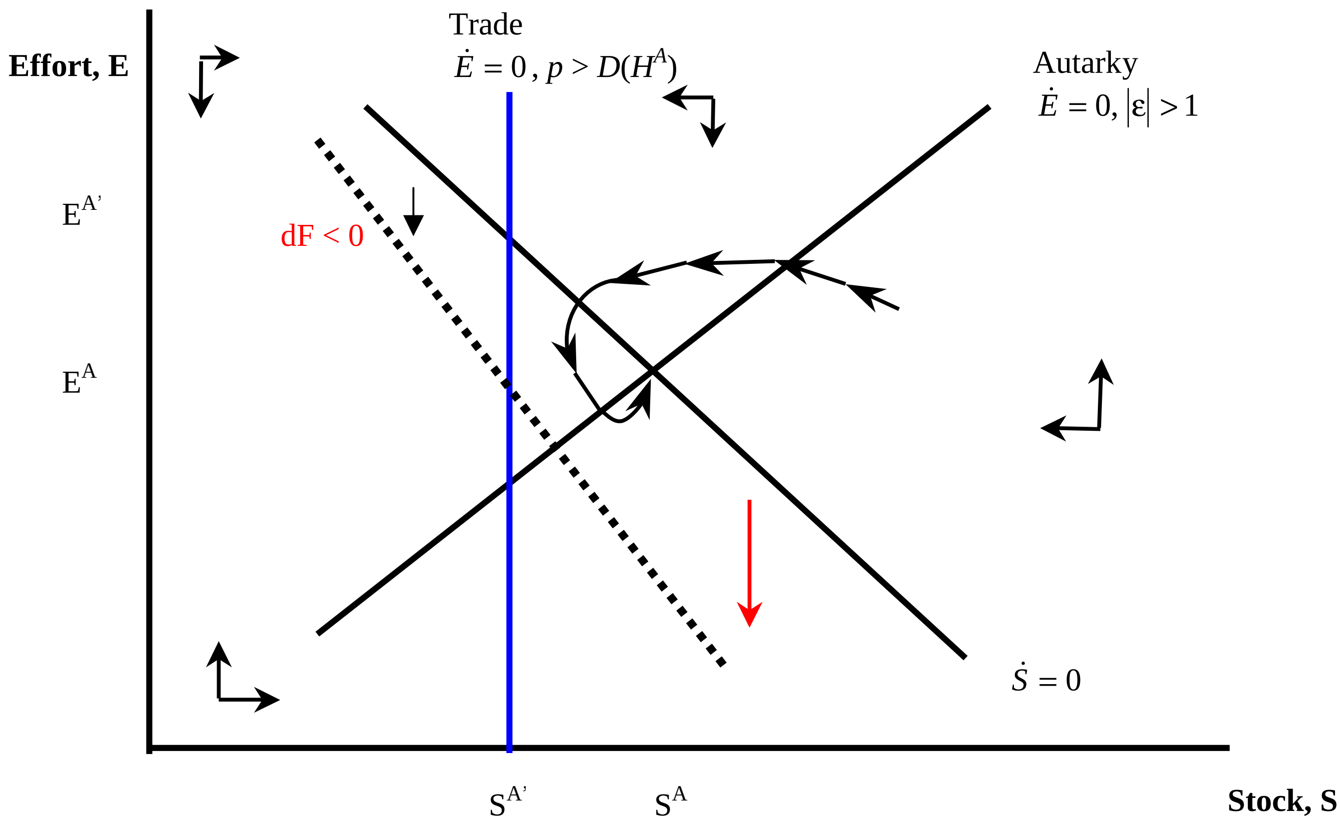
Wilen, J., 2000. Renewable Resource Economists and Policy: What Differences Have we Made? *Journal of Environmental Economics and Management* 39: 306-327

Figure 1. An Equilibrium for the 2x2 Small Open Economy



Source: Kemp and Long (1984).

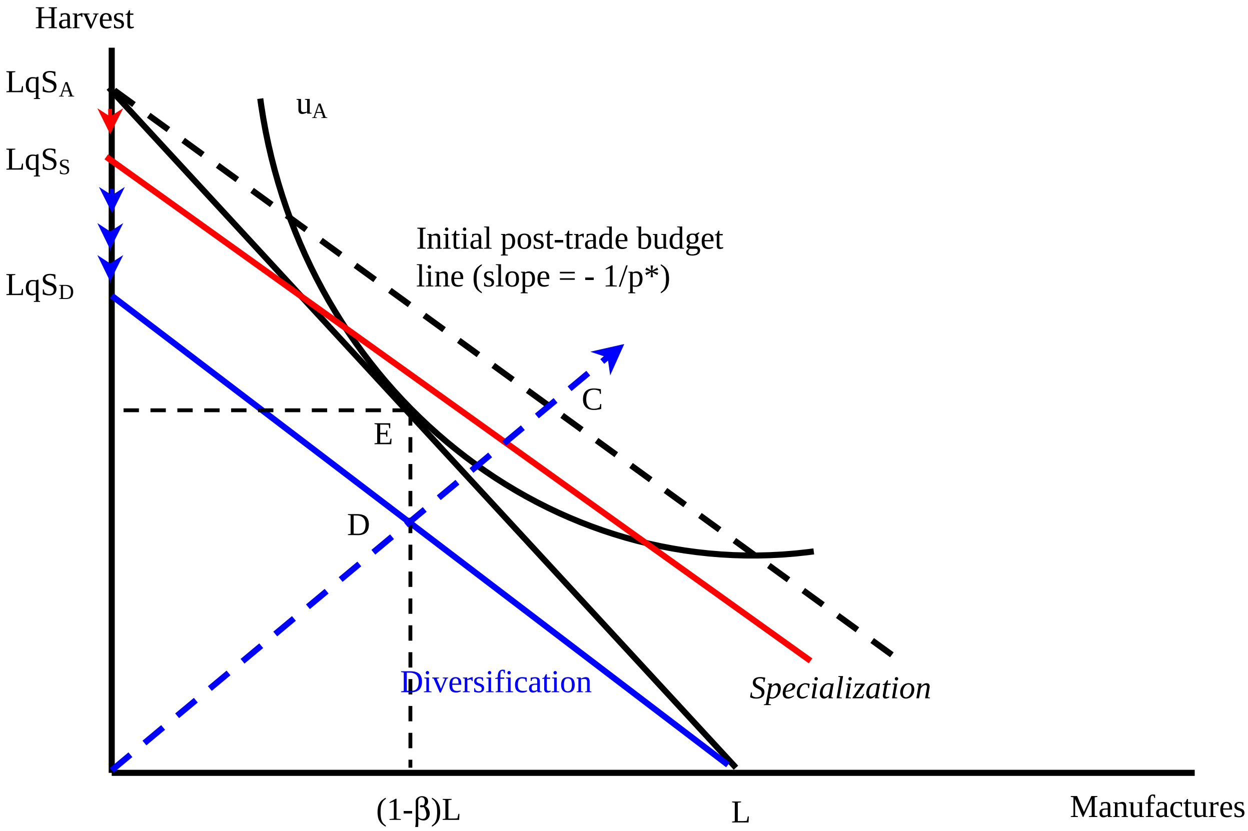
Figure 2. Open Access Equilibrium in the Single-Market Bioeconomic Model



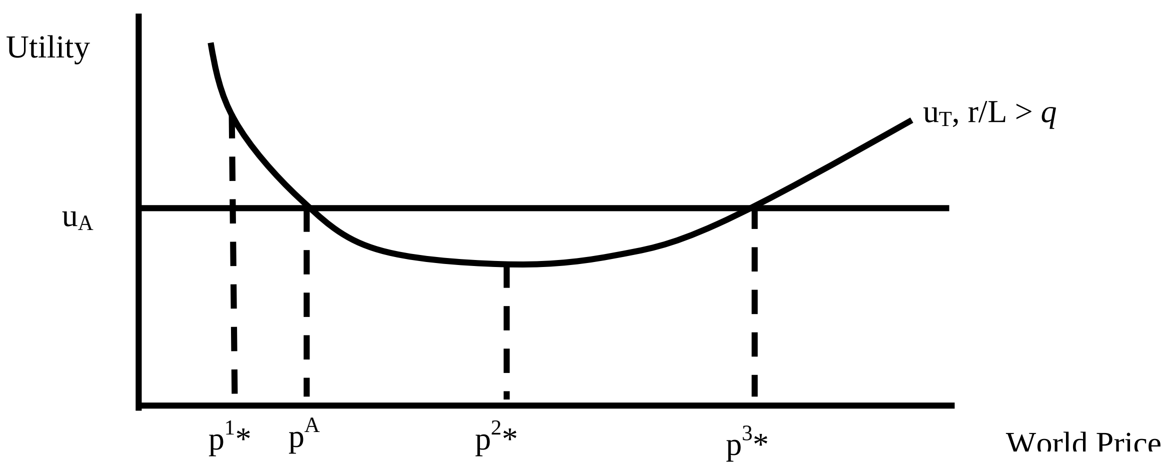
Source: Adapted from Barbier (2003).

Figure 3. Open Access Resource Exploitation and Trade in a Resource-Abundant Economy

3.a. Temporary Equilibrium and Transition to a Steady State



3.b. Steady State Utility and the Terms of Trade



Source: Brander and Taylor (1997).

Figure 4: Trade Patterns between North and South
(Source Karp et al 2001)

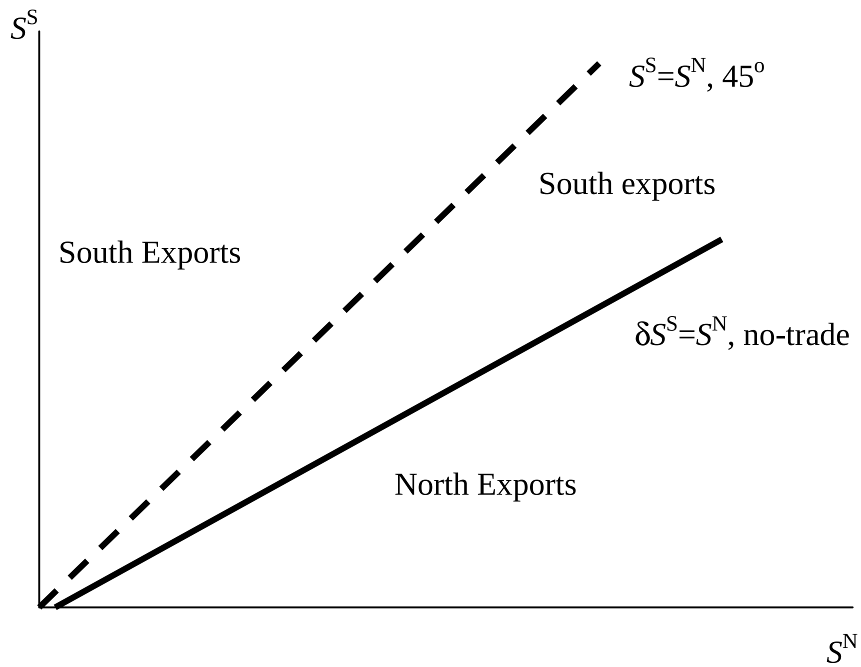


Figure 5: Harvesting and growth in the absence of substitution possibilities
(Source Karp et al. 2001)