Beyond the Green Box: The Economics of Agri-Environmental Policy and Free Trade

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Abstract

Joint production of agricultural and environmental 'outputs' means that agri-environmental policies aimed at internalising domestic externalities may affect trade flows and world prices and may impose burdens on a country's trading partners, setting the scene for conflict in the WTO. The trade burden may be exacerbated by inappropriately designed policies skewed towards protectionist goals at the cost of environmental effectiveness. The paper develops a conceptual framework for assessing the tradeoffs (and synergies) between agri-environmental and trade policies. The analysis leads to the conclusion that correcting for domestic externalities does not always result in net gains in global welfare, and that the gains (or losses) are not shared equally among trading partners. It is argued that agri-environmental policies classified as 'trade-correcting' should continue to enjoy Green Box status under the proviso that these policies pass a number of tests establishing their environmental efficiency, cost-effectiveness and trade compatibility.

Key words: Trade liberalization; CAP reform; Multifunctionality; WTO; Agri-environmental Policies

Jenseits der Green Box:
Zur Ökonomik von Agrar-Umweltpolitik und Handelsliberalisierung

Die Koppelproduktion von Agrar- und Umweltgütern hat zur Folge, dass umweltpolitische Maßnahmen, die auf eine Internalisierung von landwirtschaftlichen Externalitäten abzielen, Handelsströme und Weltmarktpreise beeinflussen und die Handelspartner eines Landes belasten können. Dies kann Anstoß für Konflikte innerhalb der WTO bieten. Handelsverzerrungen können durch Maßnahmen verstärkt werden, die protektionistische Ziele zu Lasten der Umwelteffektivität verfolgen. In diesem Papier wird ein konzeptioneller Rahmen für die Analyse der Wechselwirkungen zwischen Agrar- bzw. Umweltpolitik und Handelspolitik entwickelt. Die Analyse führt zum Ergebnis, dass die Korrektur von nationalen Externatilitäten nicht immer zu globalen Wohlfahrtserhöhungen führt, und dass Gewinne (und Verluste) nicht gleichmäßig unter den Handelspartnern verteilt werden. Agrar- bzw. umweltpolitische Maßnahmen, die als ‚trade-correcting' klassifiziert werden, sollten weiterhin Green Box Status genießen aber nur, wenn sie bestimmte Kriterien der Umwelt- und Kosteneffektivität sowie der Handelsverträglichkeit erfüllen.

Schlüsselwörter: Handelsliberalisierung; GAP-Reform; Multifunktionalität; WTO, Agar- Umweltpolitik

1 Introduction

The liberalization of agricultural trade and the increased recognition in policy of the environmental impacts of agriculture are two important trends affecting world agriculture at the turn of the century. Both trends are widely regarded by economists as necessary for social welfare improvements, yet they may give rise to new tensions in future trade rounds. On the one hand, policy makers in Europe and Japan fear that trade liberalization and reduction of agricultural support may adversely affect the multifunctional role of agriculture and the achievement of domestic environmental goals (LINDLAND, 1998; BREDAHL *et al.*, 1999; MAFF, 1999). On the other hand, free trade proponents are concerned that some countries could use the 'multifunctionality' argument to further a protectionist trade agenda or to manipulate the terms of trade in their favour (ERVIN, 1999; ABARE, 1998; VASAVADA and WARMERDAM, 1998). Both sides agree that information is currently lacking on the extent to which agri-environmental concerns and trade concerns conflict (RUNGE, 1999). Important questions for future trade talks remain to be answered (VASAVADA and WARMERDAM, 1998): How can the tradeoffs between environmental protection and trade distortion be assessed? To what extent may nations provide support to farmers for supplying environmental services or preventing environmental impairment? How will the WTO decide what policies are legitimate? Much of the uncertainty arises because agricultural and environmental 'outputs' are joint products of farming.

This paper aims to extend present knowledge of the tradeoffs and synergies between agri-environmental and trade policies by conceptualising 'multifunctionality'[1]) and incorporating it into traditional, partial equilibrium trade analysis. The paper is organized into four further sections. Section 2 is a conceptual elaboration of the 'multifunctionality' argument, drawing on the theory of joint production. Section 3 presents a partial equilibrium trade model which accounts for domestic joint products of agricultural production. The extended trade model is used to analyse the trade and welfare implications of agri-environmental policies in a large-country, open-economy context. Section 4 concludes by proposing a set of guidelines for distinguishing between genuine and protectionist agri-environmental measures in the WTO process.

2 Conceptualising 'multifunctionality'

Simple production economics can be used to conceptualize environmental 'multifunctionality'. Figure 1 depicts a production possibility frontier (PPF) which shows all technically efficient combinations of agricultural and environmental 'outputs' that can be produced from a country's resource base. The PPF is drawn to have three segments. Segment *0A* indicates that up to some level of agricultural output, an expansion of agriculture can be beneficial to the creation and preservation of environmental assets, for example, by enhancing landscape quality or by providing semi-natural habitats. This *complementary relationship* between the two outputs has been interpreted as a positive externality of production agriculture, the provision of a public good, or simply the result of multifunctional agriculture (LINDLAND, 1998; RUNGE, 1999). In this context, HODGE (2000) refers to the 'output model' of agriculture.

In contrast, segment *AB* in Figure 1 represents a *competi-*

1) For the purpose of this paper, 'multifunctionality' is taken to refer only to the environmental functions (and malfunctions) of agriculture. Other functions usually associated with the term 'multifunctionality', such as food security and sustaining rural communities, are not considered.

tive relationship between agricultural and environmental outputs. As agricultural production increases beyond point *A*, environmental quality starts to decline as a result of a decreasing share of natural (non-agricultural) land in the open landscape, increasing land use intensities, removal of landscape features, etc. The resulting negative joint products such as water and air pollution, soil erosion, habitat and biodiversity loss, have been interpreted as a negative externality from intensive agriculture, a public 'bad', or 'multi-dysfunctionality' (RUNGE, 1999) of agriculture. In this context, HODGE (2000) refers to the 'input model' of agriculture, regarding the environment as an un-priced input to agricultural production.

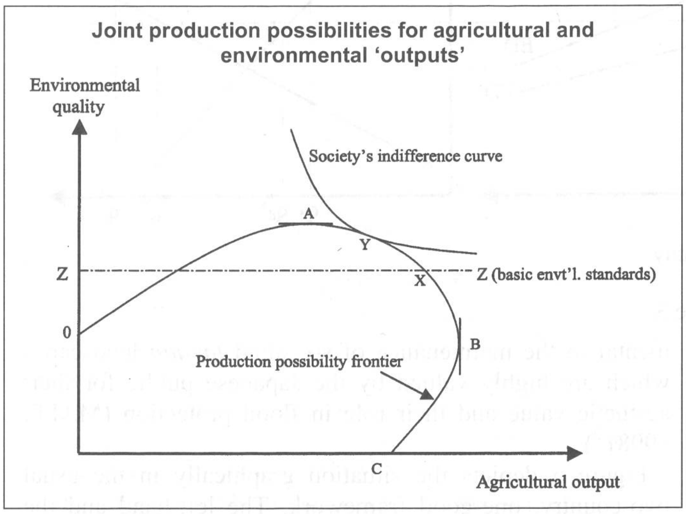

Figure 1

Segment *BC*, finally, depicts what might be termed 'inefficient technology choices' such as fertilizer application rates beyond levels that are internally efficient for producers. Such practices are assumed to result in reduced agricultural output and severe environmental disruption, hence the positive slope of the PPF in this segment.

Assuming well-behaved consumer (citizen) preferences, the social optimum (point *Y*) must lie on the segment *AB*. It is clear that, in the absence of agri-environmental policy, this social optimum is likely to be missed. It could be argued that, if the environment is un-priced, farmers would tend to overemphasize commodity production, leading to outcomes around point *B* in Figure 1, or point *X* which conforms to a minimum level of environmental quality (the constraint ZZ) as prescribed by environmental legislation.

However, this argument holds true only if farming is sufficiently attractive to be maintained everywhere. Some countries argue that trade liberalization and the removal of agricultural support would lead to marginalization of agriculture and rural areas, resulting in land abandonment and thus downward movements along segment *OA* on the PPF (LINDLAND, 1998; MAFF, 1998). This argument is illustrated in Figure 2.

The bottom panel shows a supply curve for agricultural output. High levels of support (price P_0) stimulate high land use intensities resulting in outcomes on segment *AB* of the PPF. Lowering protection (move from P_0 to P_W) may result in substantial reductions in agricultural output, partly due to land abandonment in marginal areas, leading to outcomes on segment *OA* of the PPF in (e.g. point *D*). Such outcomes cannot be economically efficient because the positive joint products of agricultural production are lost in the process. Some countries use this as an argument for continued support of agriculture as a means of internalising the non-market environmental benefits of agriculture in marginal areas (MAFF, 1998; LINDLAND, 1998; BREDAHL *et al.,* 1999).

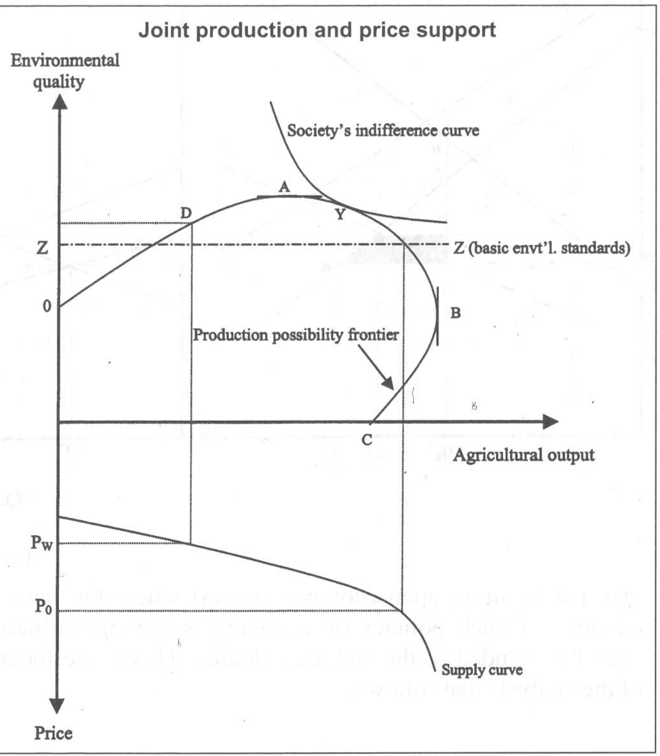

Figure 2

Similarly, there is a strong argument for internalising Pareto-relevant negative externalities from high-intensity agriculture on segment *YB* of the PPF. Reducing agricultural protection works in the right direction, but where this is not sufficient to realize point *Y*, additional agri-environmental measures may be required. SUTTON (1989) argues that unregulated negative externalities constitute an *implicit subsidy* to agricultural producers because the supply curve does not include a charge for the use of a socially valuable environmental resource, an argument in line with HODGE'S (2000) 'input model'. The resulting overproduction of agricultural goods provides ample justification for government intervention. Adequate agri-environmental measures to redress the problem may thus be classified as 'trade-correcting'.

It seems safe to conclude from Sutton's argument that the existence of an unregulated *positive* externality (in segment *OA*) constitutes an *implicit taxation* of agricultural producers. A given level of production results in both an agricultural output and an environmental 'good', but producers only perceive a willingness to pay for the former. The implications for trade are that too little of the externality-generating agricultural output is produced relative to efficient levels. Again, there is a case for 'trade-correcting' agri-environmental measures.

The conclusion that emerges is well-known: government intervention sufficient to internalize the externalities of agriculture, whether negative or positive, will increase social welfare even though it may, by virtue of joint production, affect quantities produced and traded. While this conclusion should be uncontroversial in a closed-economy context, it

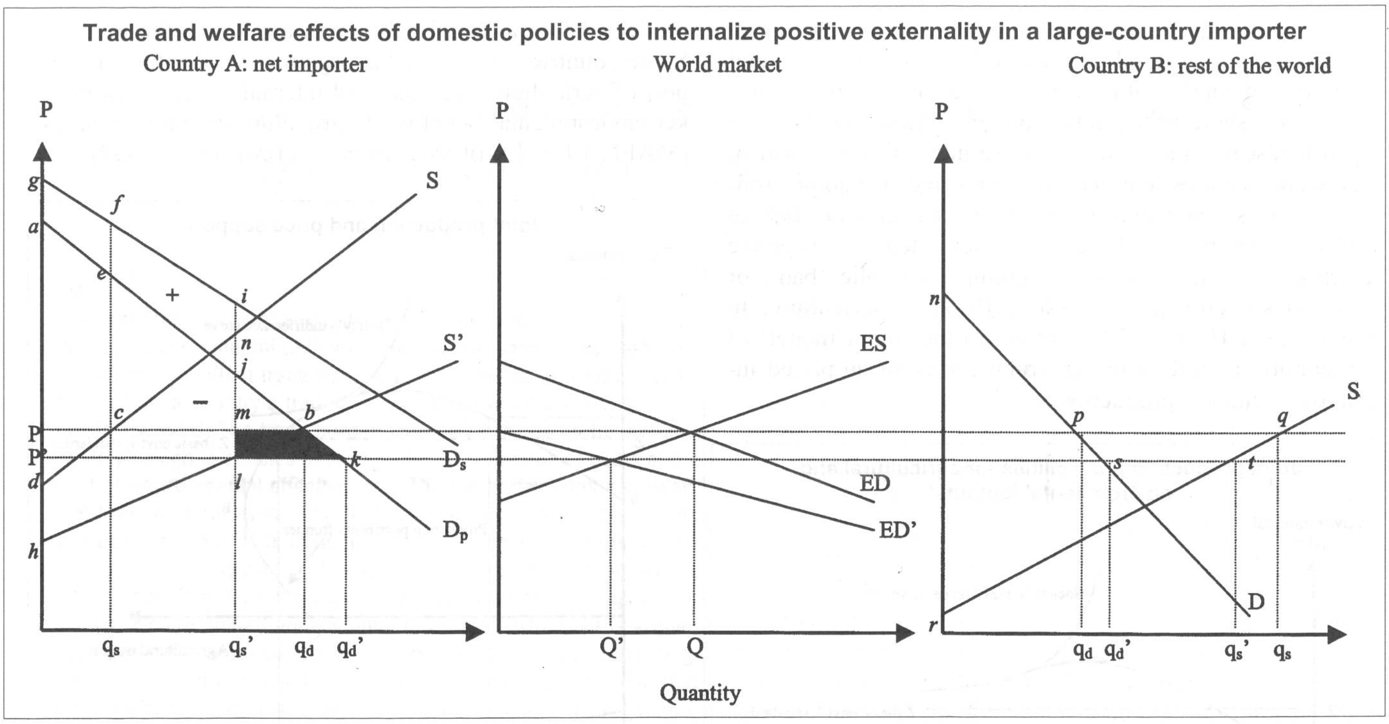

Figure 3

may not be in an open economy-context where the repercussions of such policies on a country's trading partners must be included in the welfare calculus. This is the focus of the analysis that follows.

3 'Multifunctionality' in partial equilibrium trade analysis

The analysis in this section builds upon a model by ANDERSON (1992) who showed that the welfare effects of trade liberalization would be ambiguous if (negative) environmental externalities were left uncontrolled, and can only be assured if such externalities are internalized by appropriate measures. The following analysis extends Anderson's model to demonstrate how the concept of multifunctionality can be incorporated into partial equilibrium trade models in a way which allows comparison of environmental and trade impacts in a common framework. Free trade in the absence of any government intervention serves as the benchmark against which to assess the effects of domestic agri-environmental measures. The usual assumptions of partial equilibrium trade analysis (such as perfect competition, homogeneity of the traded good, zero transaction costs, and no stock holding) apply. Assume further that all actors can value the joint non-market products concerned, and that the agri-environmental instrument used can be set at the optimum level.

3.1 Large-country importer with positive domestic externality

First consider the case of a large-country net importer of agricultural commodities under conditions of free trade. Assume that agricultural production in that country, under free trade, would involve positive joint products along segment *0A* of the PPF in Figure 2. This case may be exemplified with Japan as a major would-be importer of rice. Rice production in terraced paddy fields is considered instrumental to the maintenance of so-called *tanada* landscapes which are highly valued by the Japanese public for their aesthetic value and their role in flood protection (MAFF, 1998) [2]).

Figure 3 depicts the situation graphically in the usual two-country, one-good framework. The left-hand and the right-hand panels show demand and supply schedules for the importing country (Country A) and the rest of the world (Country B), respectively. Derived excess demand (*ED*) and excess supply curves (*ES*) are shown in the middle panel. The positive joint products in Country A are shown as a divergence between marginal private benefits (D_p) and marginal social benefits (D_s) for the agricultural commodity. D_s thus represents a demand curve for the agricultural commodity which incorporates the valuation of the unpriced joint product[3]). It is assumed that no externality is present in Country B.

Free trade with un-internalized externality, characterized by *Q/P*, serves as reference against which the effects of agri-environmental policies are assessed. In the reference scenario, net social welfare in Country A is represented by area *abcd*, which is the sum of consumer and producer surplus, plus the value of the positive joint product *agfe*. Note that the positive joint product, as a *domestic* externality, accrues only on agricultural output from *domestic* production (q_s), but not on imported quantities (q_d-q_s). Country B's welfare in the reference scenario is represented by area *npqr*, i.e. the sum of consumer and producer surplus.

2) A study reported in MAFF (1998) indicates that the monetary value of the non-market functions of *tanadas* such as flood protection, land conservation, and amenity amounts to more than 4.6 trillion Yen per year, which exceeds the total output value of rice (around 3 trillion Yen per year).

3) Positive externalities are usually illustrated as divergences between private and social marginal *costs*. In the context of this paper, it seems more appropriate to classify such externalities as divergences between private and social marginal *benefits* because most environmental goods and services from agriculture can be classified as public goods, a type of market failure that is usually associated with the *demand*-side.

Agri-environmental policy in Country A must take account of the fact that delivery of the positive joint product is tied to the level of domestic agricultural production. Internalization of the joint product would thus require an expansion of domestic production beyond the level forthcoming under free trade – a likely source of conflict in future trade rounds. It is clear that price support is inappropriate as it would simultaneously distort demand in Country A and boost land use intensities, encouraging negative externalities. A more appropriate agri-environmental programme, which pays farmers directly for the provision of environmental benefits, would still, by virtue of joint production, shift the supply curve. This effect is shown in Figure 3 as a shift from *S* to *S'*. As a consequence, the excess demand curve would shift from *ED* to *ED'*. Quantity traded on the world market would fall from *Q* to *Q'*, and the world price would drop from *P* to *P'*.

The implications for 'global' welfare are as follows. In Country A, more environmental benefits (area *efij*) are generated through increased domestic production. Consumers benefit from cheaper imports (area *PbkP'*), and producer surplus increases to *P'lh*. However, these benefits come at the cost of agri-environmental payments represented by area *dnlh*. In sum, there is a net benefit to consumers (shaded area *mbkl*), a net environmental benefit (area *efij*), but a loss of specialization gain (area *cnm*). It is important to note that Country B suffers a loss of welfare, represented by area *pqts*, as a consequence of agri-environmental measures undertaken in Country A.

The analysis leads to the conclusion that a policy classified as 'trade-correcting' in a national context does not represent a Pareto improvement in a global context. Indeed, it is not even clear whether it represents a potential Pareto improvement. The onus will be on countries proposing such policies to demonstrate, in future trade rounds, that the domestic net benefits of their policies outweigh the costs to their trading partners.

These findings represent a deviation from ANDERSON'S (1992) proposition that trade liberalization *must* be accompanied by appropriate environmental policies if welfare benefits are to be maximized. The case of internalising positive externalities appears to be less clear cut than the negative-externality case which formed the basis of Anderson's conclusion.

3.2 Summary of other cases

The analytical framework set out above can be used to assess a number of other cases involving positive or negative externalities in either importing or exporting countries or both. The Table summarizes these other cases. The overall change in a country's welfare comprises changes in consumer surplus, producer surplus, the size of the externality, and payments by or revenue for taxpayers. Where only one of these elements is negative, this is shown as '+(–)' in the Table. If only one element is positive, this is depicted as '–(+)'. The sign of the overall effect in such cases depends on the magnitude of the externality and the implied elasticities of demand and supply. Cumulative effects on world prices and quantities traded are shown as '++' or '– –'.

The above example of a net-importer internalising a positive externality is shown as Case 1 in the Table. Conflict of interest arises because actions undertaken by one country lead to a loss of welfare for that country's trading partners. No such conflict arises in Case 2, i.e. an importing country internalising a negative externality. An appropriately designed policy would lead to reduced domestic production and, thus, increased net imports and world prices which will be applauded by exporting countries. Case 2, however, is likely to represent a hypothetical scenario. The importing country will have little incentive to implement the policy in the first place because the net welfare change for that country is likely to be negative. This is because reductions in environmental damage will have to be 'bought' at the cost of reduced producer and consumer surplus. A similar, but reciprocal argument applies in Case 3.

Table: **The qualitative effects of domestic agri-environmental measures on trade flows, world prices and welfare**

Country with externality	Type of externality	Case	Change in . . . quantity traded	world price	welfare of . . . importer	exporter	global welfare	Conflict of interest
Importer	Positive	1	–	–	+ (–)	–	?	Yes
	Negative	2	+	+	– (+)	+	+?	No
Exporter	Positive	3	+	–	+	– (+)	+?	No
	Negative	4	–	+	–	+ (–)	+	Yes
Both	Positive	5	?	– –	+	–	?	Yes
	Negative	6	?	++	–	+	?	Yes
Exporter	Negative	7	– –	?	+	+ (–)	+?	No
Importer	Positive							
Exporter	Positive	8	++	?	+	– (+)	+?	?
Importer	Negative							

Case 4 (internalizing a negative externality in an exporting country) appears to be the only case where agri-environmental intervention results in an unambiguous gain in global welfare, although importing countries will lose due to increased world prices. It can be shown, however, that the net welfare gain in the exporting country always outweighs the net welfare loss suffered by its trading partners. In all other cases, the sign of the overall effect on global welfare is sensitive to the implied elasticities of demand and supply and the magnitude of the externality.

Cases 5 to 8 represent situations of *bilateral* introduction of agri-environmental policies, with externalities present in both importing and exporting countries. Cases 5 and 6 are hypothetical as, in either case, the implementation of policy would result in a loss of welfare for one country, precluding bilateral implementation. Cases 7 and 8 represent situations in which bilateral implementation should be uncontroversial and lead to improved overall welfare despite the possibility of substantial (cumulative) effects on trade flows.

In conclusion, it appears that it is mainly cases 1 and 4 that are likely to cause frictions in future trade negotiations. Case 1 because agri-environmental policy means continued support of agriculture. If such policies are pursued by a large enough number of countries, trade flows may be diverted and world prices may decline, engendering criticism from exporting nations with a strong say in the WTO. Countries proposing such policies will have to put forward convincing arguments that the environmental benefits generated are sufficiently large to justify the costs to their trade partners. Case 4 may be controversial because of the unequal distribution of the gains and losses from a policy classified as 'trade-correcting'. Indeed, low-income importing countries may feel that high-income country agri-environmental policies, which curb production in the interest of environmental protection, are a luxury which reduces trade flows and raises world prices.

4 Conclusions: agri-environmental policy and the WTO process

The conclusions derived thus far are all based on the assumption that nations implement agri-environmental policies in an attempt to increase domestic social welfare. It has been suggested that not all governments have such laudable intentions, but instead may try to use the green credentials of agri-environmental policies to further protectionist trade agendas (ABARE, 1998; VASAVADA and WARMERDAM, 1998). If 'subjective' environmental benefits are widely used to justify Green Box support or if the size of domestic externalities is misrepresented, there is indeed a danger of institutionalizing trade-distorting policies. This raises the question of how the WTO will decide which policies legitimately fall into the Green Box. Clearly, the onus will be on countries submitting domestic policies to the WTO to provide credible evidence that their policies are genuine and not green-label protectionism. ERVIN (1999), borrowing from the SPS[4]) agreement, proposes a 'Code of Good Process' for designing agri-environmental programmes that are consistent with WTO rules and guidelines. This paper proposes the following, more comprehensive, procedure for determining the legitimacy of agri-environmental measures.

1. Assessing evidence of genuine concern

Countries submitting agri-environmental policies to the WTO should provide evidence that the environmental problem concerned is in fact an issue of genuine concern. In cases involving negative joint products, it may be sufficient to demonstrate that environmental damage exists. Indicators such as rates of soil erosion or pesticide and nitrate concentrations in groundwater may serve as measuring rods, especially when compared with legislated standards, generally accepted threshold levels, or sustainability criteria.

This *evidence of damage test* will have to be supplemented with an *evidence of demand test* when a country submits policies to stimulate the provision of positive joint products. As demand for environmental public goods in the countryside is difficult to measure directly, demand indicators will have to be used. One such indicator may be the level of activity (membership, budget, etc) of environmental NGOs in the area concerned. For example, the Royal Society for the Protection of Birds (RSPB) in the UK is one of Britain's largest owners of environmentally sensitive land. This may be seen as evidence that conservation of birds and wildlife is a matter of genuine concern to the British. NGO data have the dual advantage of revealing information about the quantity demanded (e.g. membership, number and size of nature reserves, campaigns, etc) as well as giving an indication of the intensity of preferences (level of membership fees and other financial contributions to the NGO).

Where NGO data is not available, an indication of demand may be derived by assessing the intensity of media coverage, statements in political party manifestos, records of political decisions on the issue in the past, or the volume of research undertaken on the issue.

2. Assessing the 'technology' of policies

Evidence of genuine concern is a necessary but not a sufficient condition for the design of agri-environmental policies consistent with free trade requirements. Indeed, governments may try to use the evidence to implement policies which are heavily skewed towards protectionist goals, at the cost of environmental effectiveness. The sufficient condition thus is that the 'technology' of proposed policies must be clearly geared to achieving a given environmental gain at the least possible cost to the trading system. The Uruguay Round Agreement on Agriculture (URA) provisions relating to agri-environmental management contain two conditions in this respect, namely:

- that eligibility for agri-environmental payments shall be determined as part of a clearly defined government conservation programme and be dependent on the fulfilment of specific conditions relating, *inter alia*, to production methods and inputs; and
- that the amount of payment shall be limited to the extra costs involved in complying with the government programmes[5]).

The following criteria may be added:

- Agri-environmental programmes must have clearly specified environmental objectives (ERVIN, 1999). The objectives should, as far as possible, be quantifiable and formulated in a way that allows progress to be assessed quantitatively.
- Management prescriptions must be 'technically efficient' in achieving the objectives of the programme. This requires cause-effect relationships to be established as clearly as possible and the best conservation technology to be chosen for implementation.
- The type of incentive mechanism used (e.g. tax, charge, subsidy) should take account of existing property rights allocations and conform with internationally agreed principles such as the Polluter Pays Principle or the Beneficiary Pays Principle (ERVIN, 1999). Property rights in the rural environment are often defined through command-and-control regulations or through nationally agreed codes of good practice. These may be seen as 'reference levels' of environmental quality to be attained through the use of appropriate production techniques at the farmers' expense. Negative-incentive mechanisms are appropriate to enforce such baseline standards, while positive incentives (payments) are appropriate for agri-environmental programmes that aim at environmental enhancements clearly beyond the reference levels. Programmes that do little more than subsidize existing good agricultural practice should not be approved.
- Environmental programmes should account for the spatial dimension of agri-environmental problems. Some prob-

4) SPS = Sanitary and Phytosanitary agreement.

5) Uruguay Round Agreement on Agriculture, Annex 2.

lems are small-scale, local, or confined to environmentally sensitive areas, while others may be of regional, national or even global importance. The geographical delimitation of an agri-environmental programme should fit the spatial dimension of the problem in question.

- Agri-environmental contracts should be offered on a competitive basis. This could be done by inviting farmers to tender bids to the programme administrator stating the minimum amount of payment they would require for co-operation. Such a bidding mechanism would allow the programme administrator to target the most cost-effective producers, thus bringing agri-environmental contracting more in line with other forms of government procurement contracting. Model calculations show that bidding can significantly reduce the degree of overcompensation (LATACZ-LOHMANN and VAN DER HAMSVOORT, 1997, 1998).
- Countries submitting agri-environmental programmes to the WTO should demonstrate that they have in place an appropriate administrative framework for implementing the proposed policies, monitoring compliance and evaluating progress at pre-determined time intervals. Proper compliance ('process') and environmental ('outcome') monitoring can severely strain an agency's resources and may require that significant amounts of public money be set aside. (FALCONER and WHITBY, 1999). Evidence that the programme is achieving its objectives is not only important for programme management, but also to satisfy WTO partners that the programme is a legitimate exercise (ERVIN, 1999).
- Transparent design and implementation of agri-environmental programmes should be an imperative part of the validation process. Transparency is necessary to bridge the cultures of environmental and trade interests, to build trust, and to facilitate open trade-environmental negotiations and decisions (ERVIN, 1999).

3. *Probing for less trade-distorting alternatives*

Satisfaction of all the above conditions will reduce the likelihood of dispute in the WTO, but will not guarantee that agri-environmental policies are immune from challenge. Even an optimally designed and targeted policy may, by virtue of joint production, have adverse trade impacts. Trade negotiators will therefore want to be satisfied that there is no equally effective, yet less trade-distorting alternative to the proposed policy (ERVIN, 1999).

Given an optimally designed policy, the (remaining) impact on trade depends largely on the extent to which agricultural and environmental output are joint products. It is clear that the potential for trade conflicts will be substantially reduced if there is only a weak link between agricultural output and the level of environmental improvement sought. Examples of such relatively 'decoupled' policies include the planting and maintenance of hedgerows and other landscape features or the rebuilding of stonewalls as means of enhancing the aesthetic value of the cultural landscape. In contrast, measures like environmental set-aside of productive farmland or the subsidization of organic conversion involve a more direct link between environmental objectives and agricultural output. Organic conversion payments are excessively trade-distorting because they have direct impacts on the quantities supplied in a particular market, i.e. the organic food market, which is particularly sensitive to supply shocks. Alternative, more 'decoupled' measures should be preferred. RUNGE (1999) stresses that these alternatives must be feasible and not wholly hypothetical. Even if some of the alternatives may involve higher costs internally, they may be more efficient in a global context when their reduced impact on trade is considered.

In the language of production economics, the least trade-distortiveness test should ensure that only 'technically efficient' policies are approved, i.e. policies which lead to movements along the PPF in Figure 1, rather than to steps from the frontier to points within.

4. *Assessing the distribution of benefits and costs*

The ultimate test for any agri-environmental policy submitted to the WTO comes when it is assessed against the Pareto potential criterion. If a country can demonstrate that a proposed policy would result in a potential Pareto improvement, then the case appears clear cut, at least from a theoretical point of view. In practice however, there may still be potential for conflict in the WTO if benefits and burdens are distributed unequally among the countries involved and compensation remains hypothetical. There is indeed a precedent for the use of the Pareto potential criterion in the GATT's dispute settlement history. In a trade dispute between the US and Canada over restrictions imposed by the Canadian government on the landing in Canada of US salmon and herring, the GATT/FTA panel reasoned that the Canadian government would not have imposed the regulation if the full burden had fallen on Canadian citizens (RUNGE, 1999; RUNGE *et al.*, 1994).

It is obviously intrinsically difficult to apply the Pareto potential criterion in a quantitative manner, but a more qualitative assessment of the size and distribution of the benefits and costs of agri-environmental measures may help reduce the potential for conflict. For example, if an agri-environmental measure is found to impose a greater burden on foreign competitors than domestic producers, and an alternative exists which would allow the burden to be more equally shared, there is a good reason to adopt the alternative (RUNGE, 1999). Similarly, domestic policy measures are less likely to be subject to criticism in the WTO if they offer widespread benefits, and their costs are borne narrowly by affected parties. In such circumstances, it is easier to target the affected parties for compensation while retaining the widespread advantages of environmental protection (RUNGE, 1999).

References

ABARE (Australian Bureau of Agricultural and Resource Economics) (1998): Decoupling Farm Income Support. Paper presented at the OECD Workshop on Emerging Trade Issues in Agriculture, 26-27 October .– ANDERSON, K. (1992): The Standard Welfare Economics of Policies Affecting Trade and the Environment. In: Anderson, K; Blackhurst, R. (eds.): The Greening of World Trade Issues. London: Harvester Wheatsheaf, pp. 25-47. – BREDAHL, M.; NERSTEN, N.; PRESTEGARD, S. (1999): Multifunctionality: Concepts and Applications to the Cultural Landscape of Norway. Notad 1999:21. Norwegian Agricultural Economics Research Institute, Oslo. – ERVIN, D. (1999): Toward GATT-Proofing Environmental Programmes for Agriculture. *Journal of World Trade* 33(2), pp. 63-82. – FALCONER, K.; WHITBY, M. (1999): The Invisible Costs of Scheme Implementation and Administration. In: VAN HUYLENBROECK, G.; WHITBY, M. (eds): *Countryside Stewardship: Farmers, Policies and Markets*. Pergamon, pp. 67-88. – HODGE, I. (2000): Agri-environmental Relationships and the Choice of Policy Mechanisms. *The World Economy* 23(2, February), pp. 257-273. – LATACZ-LOHMANN, U.; VAN DER HAMSVOORT, C. (1997): Auctioning Conservation Contracts: A Theoretical Analysis and an Application. *American Journal of Agricultural Economics* 79 (2), pp. 407-418. – LATACZ-LOHMANN, U.; VAN DER HAMSVOORT, C. (1998): Auctions as a Means of Creating a Market for Public Goods from Agriculture. *Journal of Agricultural Economics* 49 (3), 334-345. – LINDLAND, J. (1998): Non-trade Concerns in a Multifunctional Agriculture. Implications for Agricultural Policy and the Multilateral Trading System. Paper presented at the OECD Workshop on Emerging Trade Issues in Agriculture, 26-27 October 1998, on behalf of the Norwegian Ministry of Agriculture. – MAFF (Ministry of Agriculture, Fisheries and Food of Japan) (1999): Multifunctionality in Japan (on the Internet under http:// www. maff. go.jp/ wto/ Ewto06-2.html). – RUNGE, C.F. (1999): Beyond the Green Box: A Conceptual Framework for Agricultural Policy and the Environment. Working Paper 99-1, Center for International Food and Agricultural Policy, University of Minnesota, St. Paul. – RUNGE, C.F.; ORTALO-MAGNÉ, F.; VANDE KAMP, P. (1994): *Freer Trade, Protected Environment: Balancing Trade Liberalization and Environmental Interests*. New York: Council on Foreign Relations Press. – SUTTON, J.D. (1986): Resource Policy Subsidies and the GATT Negotiations. Agricultural Economic Report 616, USDA-ERS, Washington, D.C. – VASAVADA, U.; WARMERDAM, S. (1998): Environmental Policy & the WTO: Unresolved Questions. Agricultural Outlook (November 1998), pp. 12-14. USDA-ERS, Washington, D.C.

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The Role of Biotechnology for Global Food Security

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Abstract

Biotechnology alone is no panacea for the world's problems of hunger and poverty. However, genetic engineering in particular has outstanding potential to increase the efficiency of crop improvement. Thus, biotechnology could enhance global food production and availability in a sustainable way. Two case studies from Kenya and Mexico demonstrate that transgenic crops are also very appropriate for agricultural producers and consumers in developing countries. As the entire technology can be packaged into the seed, it can easily be integrated into traditional smallholder farming systems. Except for a few innovative transfer projects, however, the application of biotechnology until now remains concentrated in the industrialized world. Combined with insufficient own scientific and regulatory capacities, the increasing privatisation of international agricultural research and the strengthening of intellectual property rights complicate the access of developing countries to biotechnology. Profound institutional adjustments are essential to ensure that biotechnology does not bypass the poor.

Key-words: biotechnology; food security; agriculture; developing countries; economic impact; technology transfer; intellectual property rights

Bedeutung von Biotechnologie für die Welternährung

Die Biotechnologie allein ist nicht das Allheilmittel für die Welternährungsproblematik. Insbesondere die Methoden der Gentechnik bieten jedoch große Potentiale, die pflanzliche Züchtung noch effizienter zu gestalten und damit die globale Nahrungsmittelproduktion in nachhaltiger Weise zu steigern. Zwei Fallstudien aus Kenia und Mexiko zeigen, dass gentechnisch veränderte Pflanzen auch sehr geeignet für landwirtschaftliche Produzenten und Konsumenten in Entwicklungsländern sind. Da die gesamte Technologie im Saatgut integriert werden kann, passt sie gut in die traditionellen Betriebssysteme ressourcenschwacher Kleinbauern. Abgesehen von einigen innovativen Technologietransferprojekten wird die Anwendung moderner Biotechnologie bisher allerdings von den Industrieländern dominiert. Mangelnde eigene Forschungs- und Regulierungskapazitäten, zusammen mit der zunehmenden Privatisierung der internationalen Agrarforschung und der Stärkung geistiger Eigentumsrechte, erschweren für Entwicklungsländer den Zugang zur Biotechnologie. Institutionelle Strukturen auf nationaler und internationaler Ebene müssen angepasst werden, um die großen Potentiale der Biotechnologie zugunsten armer Bevölkerungsgruppen zu verwirklichen.

Schlüsselwörter: Biotechnologie; Welternährung; Landwirtschaft; Entwicklungsländer; wirtschaftliche Auswirkungen; Technologietransfer; geistige Eigentumsrechte

1 Introduction

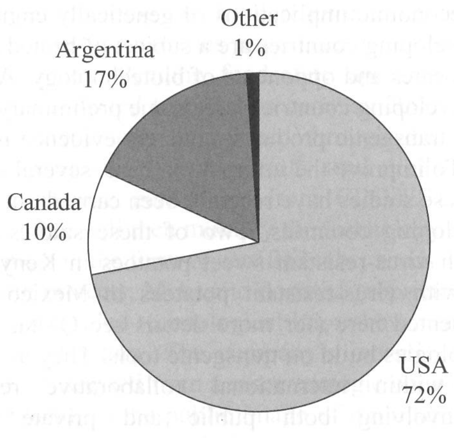
During the last decades, the number of hungry people at the global level declined both in relative and absolute terms. In part, this was made possible through remarkable technological progress in agriculture, involving the introduction of new high-yielding varieties of major food grains, combined with a more intense use of complementary inputs such as agrochemicals and irrigation, as well as improved farm management practices. Known as the green revolution, these technological advancements doubled grain yields in large parts of Asia and Latin America, entailing improved food availability at affordable prices for poor consumers.

However, this success story cannot hide the fact that hunger and poverty remain pervasive in the early twenty-first century. Today, around 800 million people still suffer from chronic food insecurity, most of them living in developing countries (FAO, 1999). It is estimated that population and income growth will lead to a further doubling of food demand over the next generation (MCCALLA, 1999, p. 99). At the same time, the natural resources available for agricultural production, particularly land and water, are becoming increasingly scarce. Hence, increases in food production will largely have to come from gains in resource productivity. Yet growth in crop yields has been decelerating since the 1980s, and in some regions of the world, grain yields have even tended to level off (PINSTRUP-ANDERSEN et al., 1999, p. 14). Evidently, the current state of agricultural technology will not suffice to meet the production challenges ahead. Innovative technologies have to be exploited in order to enable sufficient food availability in the future.

In this context biotechnology has promising potential. New tools of molecular genetics and genetic engineering in particular help to increase the efficiency of crop improvement programs. Thus, biotechnology could boost global crop output in the future while promoting environmentally friendly agricultural production patterns (e.g., SERAGELDIN, 1999; KENDALL et al., 1997). The adoption of genetically modified crops in agricultural practice has followed an exponential trend during the last few years. In 1996, 2,8 million ha were sown world-wide to transgenic crops; by 1999 this area had multiplied to 39,9 million ha (cf. JAMES, 1999). Most of the recombinant technologies developed so far involve soybeans, maize and cotton, which have been endowed with herbicide tolerance or insect resistance. But many other biotechnology products are already in the research pipeline.

Apart from its potential contribution to global equilibrium between food supply and demand, biotechnology could also contribute to enhanced food security by generating additional purchasing power. Agriculture is still a major source of income and employment in many developing countries, so a gain in sectoral profits through appropriate farm technologies also induces positive growth effects for the overall economy. Crop biotechnology is especially appealing because it is considered to be scale-neutral. Hence, large and small farms could benefit alike. Biotechnology applications, however, thus far remain concentrated in the industrialized world, notably in North America (see Figure 1). Private sector usually determines the direction of related research and development (R&D). By nature, private research efforts focus on areas with large market potentials. So there is the risk that biotechnology will bypass the poor, unless the specific needs of marginalized groups are addressed through public action. Private sector R&D dominance is also one reason why critics consider modern biotechnology to be inappropriate for the developing world (e.g., ALTIERI and ROSSET, 1999, p. 156).

The distribution of the global area planted to transgenic crops (1999)



Source: JAMES (1999).

Figure 1

This paper highlights the promises and limitations of crop biotechnology from a food security perspective. The next section briefly discusses the technology-inherent potentials and risks. Then two case studies from Kenya and Mexico are presented in section 3, evaluating the likely impacts of specified transgenic technology products. Both case studies demonstrate the benefit prospects of biotechnology for poor food producers and consumers. Appropriate policies, however, are required to realize these benefit prospects on a larger scale. Section 4 deals with the changing framework conditions of international agricultural R&D, especially the strengthening of intellectual property rights (IPRs) and related repercussions for developing countries' access to biotechnology. Major findings are discussed in the conclusion.

2 The potentials and risks of biotechnology

Biotechnology is broadly defined as "any technique that uses living organisms or substances from those organisms to make or modify a product, improve plants or animals, or develop micro-organisms for specific uses" (PERSLEY, 2000, p. 5). Here, however, we focus on the use of genetic engineering in crop improvement. This is a rather narrow view because many other biotechnology tools, such as tissue culture and molecular markers, are very promising, too. But genetic engineering is the most controversial of the biotechnology tools, and covering the whole range of techniques in greater detail would exceed the scope of this paper.

2.1 Potentials of Biotechnology in Crop Improvement

Biotechnology should not be understood as a substitute for traditional crop improvement tools. But integrating recombinant techniques into conventional breeding programs could substantially enhance the efficiency of agricultural R&D. On the one hand, breeding could be accelerated due to the more targeted transfer of desired genes. On the other hand, biotechnology could bring forth new traits that are not amenable to the conventional approach. Whereas traditional crossbreeding is confined to the exchange of genetic material within a certain crop species, recombinant techniques enable the transfer of valuable genes across species and even across kingdoms(i.e. between plants and animals). A case in point is *Bt* maize, where a gene of the soil bacterium *Bacillus thuringiensis* (*Bt*) has been incorporated into the plant genome to confer resistance to particular insects. The major transgenic breeding objectives are described in the following.

Agronomic traits. The category of agronomic traits embraces all genetic modifications that help to stabilize or increase crop yields in farmers' fields. Since the immediate benefits of such traits accrue at the level of agricultural production, they are often referred to as 'input traits'. Prominent input traits are mechanisms of pest and disease resistance, which are often encoded by only a single gene (monogenic traits). Different transgenic pest and disease resistances have already been commercialized. In assessing the potential value of such traits one must consider that global crop losses induced by biotic stress factors are estimated at 25-30 % (OERKE et al., 1994). Biotechnology could substantially reduce these losses without the need for increased pesticide applications. Other desirable agronomic crop traits include enhanced genetic yield potentials and tolerance to abiotic stresses, such as drought, low temperatures and nutrient deficiencies in soils. Since these latter traits are usually determined by multiple genes (polygenic traits), the research is often more complicated. Recent advances in molecular mapping and functional genomics, however, demonstrate that related biotechnology products are also quite realistic in the near to medium-term future (e.g., ABELSON and HINES, 1999). Thus, improved crop varieties could also be tailored to marginal agroecological regions, which have been largely neglected by the green revolution.

Quality traits. In contrast to agronomic traits, which help increase the quantity of agricultural production, quality traits are related to the appearance or the chemical composition of the crop product. Hence, they are often referred to as 'output traits'. Quality traits can include enhanced densi-