TRADE LIBERALISATION AND THE ENVIRONMENT: THE CASE OF AGRICULTURE IN SOUTH AFRICA

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An input-output framework with environmental accounting module was used to investigate the implications of liberalising agricultural trade on the environment in South Africa. The results showed that trade liberalisation in the case of agricultural commodities will lead to environmental improvement. The empirical multi-sector model results were consistent with theoretical results obtained from comparative-statics partial-equilibrium trade models for the case of goods the production of which is associated with environmental externality and their domestic prices above world prices. The study suggested a general equilibrium approach, allowing for more flexible structure of substitution in demand and supply, output composition response, income effects and improved measures of environmental impact parameters for proper assessment of welfare changes associated with environmental externalities.

HANDELSLIBERALISERING EN DIE OMGEWING TEN OPSIGTE VAN DIE SUID-AFRIKAANSE LANDBOU

'n Inset-uitset raamwerk met 'n omgewingsrekenkundige module is gebruik om die implikasies van die liberalisering van landbouhandel op die omgewing in Suid-Afrika te ondersoek. Die bevinding was dat die liberalisering van handel in landboukommoditeite 'n voordelige uitwerking op omgewingstoestande sou hê. Die resultate van die empiriese multi-sektormodel was in pas met die teoretiese bevindinge, wat deur vergelykend-statiese parsiële-ewewighandelsmodelle verkry is, en waartydens die produksie van goedere geassosieer is met omgewingseksternaliteite en plaaslike pryse hoër as wêreldpryse gekies is. Die studie het die gebruik van 'n algehele ewewigsbenadering aangedui, wat ruimte sou laat vir 'n buigbare struktuur van vraag- en aanbodsubstitusie, uitsetsamestellingsrespons, inkome-effekte en verbeterde maatreëls vir die meting van omgewingsimpakparameters, sodat die doeltreffende opname van welfaartsveranderings, geassosieer met omgewingseksternaliteite, verseker sou word.

INTRODUCTION

The international economic community has been intensely occupied over the past two decades with the world-wide campaign for economic reforms based on the structural adjustment and economic stabilisation programmes under the advocacy and conditionality of the World Bank and the International Monetary Fund. However, during the late eighties and early nineties the structural adjustment and stabilisation debate has shifted the emphasis to focus primarily on global economic integration through trade liberalisation and fair competition

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in international markets. Concurrently, the world-wide concern over the sustainability and environmental consequences of present patterns of economic expansion and growth elevated to become a major source of pressure on development planning and policy design. As the debate on these two issues evolved, many regional and international initiatives and agreements came to being in the direction of economic co-operation, removal of barriers to trade and conservation of the environment and the natural resource base. The GATT, NAFTA, Framework Convention on Climate Change, CITIES, GEF, International Treaties on Biodiversity Conservation are examples.

Even structural adjustment and economic stabilisation policies could not escape the critical review of their environmental consequences. In the rapidly expanding body of contemporary research and analysis on these issues in the post-adjustment era, free trade and environmental health often stood as rival social goals. While the debate between advocates of trade liberalisation and environmental conservationists has reached advanced stages, the question of whether the world will be better or worse off in terms of net welfare change with free trade remains unresolved.

Nevertheless, most countries are moving ahead with liberalisation and environmental protection, signing trade agreements, ratifying environmental treaties and introducing national environmental codes. South Africa (SA) is largely involved in and subscribed to a number of regional and international agreements and conventions of this kind. However, the implications of the new regional and global economic and environmental order on the country's economy and natural resources are not yet very well researched and understood. Certain structural weaknesses in SA's economy and its past and present environmental management practices make her very vulnerable to such unfolding changes and emerging challenges. The high dependence on extraction and export of mineral resources in generation of foreign exchange is one source of vulnerability to the mounting pressure on environmental conservation and regulation. Also, most of SA's manufactured exports are highly energy intensive relying mainly on subsidised coal-fired electric power, making SA among the largest contributors to green house gases. This is of particular importance as the international pressure against atmospheric emissions causing climate change is rapidly building up, especially now SA has ratified the FWCCC (For more details see Bethlehem (1997) and van Horen (1997)). Moreover, exports from primary production sectors, which enjoy high protection constitutes the majority of SA's share in international trade.

This indicates the significance for SA of adequately understanding the implications of dismantling protective trade measures with trade liberalisation and of internalising the social costs of environmental externalities under the growing global demand for environmental protection. It is therefore very crucial for SA to begin to evaluate the consequences of this new order on its economy in order to design appropriate adjustment mechanisms. This paper makes an attempt to contribute towards the objective of better understanding of the implications and the nature of the impacts and interactions between such changes in both the trade and environment spheres. A special emphasis is placed on the agricultural sector in SA as an example of a resource-based economic activity that have enjoyed high protection and subsidisation in the past and which is expected to face stiffer competition as comparative advantage in agriculture is revealed with liberalisation of trade in the southern Africa region. Also, the agricultural sector in SA currently faces a number of challenges as new policy measures are being introduced to correct for resource misuse and inequality, especially in water and land use rights and allocation.

THE DEBATED ISSUES AND LINKAGES BETWEEN FREE TRADE AND THE ENVIRONMENT

Conventional trade theory asserts that everybody is better off with trade than no trade. Given production efficiency differences between countries (due to differences in factor endowments and technology), trade provides an opportunity for countries to meet domestic demand and sell excess supplies of some commodities through exchange with others (import and export). Instead of each country producing all needed goods, trade enables countries to specialise in the production of goods in which they have comparative advantage (lower cost). As a result, goods are produced with higher efficiency as production costs are reduced through specialisation and total output, income and consumption are maximised. The outcome is therefore a net welfare gain from trade. This leads proponents of free trade to accordingly conclude that the world is better off if all interventions and policy measures that reduce trade opportunities are removed to realise the greater social benefits from increased trade (Ricardo 1817; Samuelson 1969; Bhagwati 1969).

However, the argument that freer trade results in net welfare gain has been challenged by many economists. The major criticism to the assertions of the traditional free trade school centres around the validity of some of the basic assumptions from which these results were derived. Many believe that several failures and imperfections exist in the real world that clearly violate the assumption of perfect competition. Examples on evidence of imperfections provided in the literature include cases of economies of scale, market power and externalities (Kaldor 1980; Corden 1974; Lucas 1988; Solow 1991). Krugman (1990) and Solow (1991) addressed the consequences of unequal initial endowments (natural and human capital), technological sophistication and economies of scale at entry into the world of free trade and their likely undesirable outcomes in terms of the distribution of gains from free trade and the "specialisation trap and stagnation" for disadvantaged economies (Røpke, 1994; Ekins *et al.,* 1994). Moreover, some of the basic assumptions behind the principles of comparative advantage such as absence of transport costs and international immobility of factors between countries are weakening in our current world of high factor mobility and significant transport costs associated with the massive movement of goods across the world (Findlay, 1987).

The environmental consequences of free trade. In addition to the critical questions raised above about the ambiguity of the net economic benefits from free trade (at least to some countries), several objections were advanced against free trade by environmentalists. The major argument against free trade is based on the fact that markets and prices fail to account for the value of many environmental resources and services consumed in the production and consumption of economic goods and services. Accordingly, the social costs of environmental externalities are not reflected in production costs. Hence, countries using environmentally damaging processes have a cost advantage over others using relatively cleaner technologies to produce the same good. In this case free trade will increase the production of that good in the country with the dirty technology at the expense of reduced production of the same good in countries using cleaner methods. Free trade will therefore lead to inefficient allocation of resources and increased misuse and degradation of the environment. Those who argue for environmental protection assert that, in general, the demand for resource use and waste discharge expands as total output increases due to freer trade, leading to excessive extraction and pollution. Opponents to free trade also argue that increased volume of trade entails increased use of transportation to move goods between trading countries and hence the associated energy-related environmental damage caused by emissions from burning transport fuels increases (Meddow *et al.,* 1992; Bailey, 1988; Anderson, 1992; Repetto, 1986 & 1988).

On the other hand, proponents of free trade propose benign impacts on the environment based on the following arguments (GATT 1992):

1. Free trade leads to economic growth and increases wealth and income. High income from free trade leads to increased demand for environmental quality and as a result, more resources will be available for investment in environmental protection.

2. Free trade enhances competition leading to improved production efficiency and consequently reduces the use of resource inputs and waste generation.

3. International competition through trade will also contribute to the development and spread of less environmentally damaging technologies.

4. Free trade leads to the removal of protectionists policies and the distortions they cause and hence contributes to more efficient allocation of resources including environmental resources.
5. Increased income from trade contributes to reduced poverty-induced pressures on the environment.

Whereas no conclusion is reached between the two camps, there is a general consensus that in the presence of pervasive externalities and failure to account for the value of environmental quality, free trade is more likely to be accompanied with higher environmental risks (Røpke 1994; Young 1994; and Dean 1992). At the same time, many analysts showed that protectionism is a major source of environmental externalities and inefficiencies (Repetto, 1986; 1988; Anderson, 1992; Kosmo, 1987). There is also a general agreement that movement towards trade liberalisation must be coupled with adequate and more effective environmental policy measures, nationally and internationally to internalise the social costs of environmental damage and safeguard against environmental degradation (Røpke, 1994; Daly & Goodland, 1994; Pearce, 1992).

Welfare changes due to liberalisation in the presence of environmental externalities. This section utilises standard comparative-static partial-equilibrium trade models to analyse the impact of trade liberalisation on the environment and social welfare. Figures 1 and 2 depict the case of a small country (no influence on world prices) that produces and consumes a commodity the production of which causes environmental damage. The value of the environmental externality to the society is measured as the difference between the marginal social cost curve SS (which reflects the externality cost) and the marginal private cost curve SP (supply curves). All other assumptions of perfect functioning of the market of the commodity in question are maintained.

Figure 1: **Welfare Effects of Trade Liberalisation in the Presence of Environmental Externality : World Price lower than domestic price**

Figure 2: **Welfare Effects of Trade Liberalisation in the Presence of Environmental Externality : World Price Higher than Domestic Price**

In absence of trade (autarchy case) equilibrium output (Q_a) and price levels (P_a) of the commodity in this closed economy are set at the intersection of the marginal private cost curve (SP) and the domestic demand curve (DD). At that level of domestic production and consumption, net social welfare is measured as the sum of consumer and producer surplus (area abc) minus the social cost of the environmental externality (area bcd -- divergence between marginal social and private cost curves). This is ambiguous and can be negative (loss) or positive (gain) depending on the relative size of the two areas (slopes of the DD and SP curves and the magnitude of society's valuation of the environmental loss, i.e. the distortion in private prices).

When this country opens up to trade, two scenarios are possible: the world price may be higher or lower than the autarchy price. The scenarios of moving from no trade to trade can easily be modified to correspond to the case where countries impose tariff and non-tariff barriers to reduce (not eliminate completely) imports or promote exports. The same analysis can be applied to examine the impacts of removing such protectionists distortions that maintain domestic prices below or above world prices.

a. *The case of a world price (P_w) below autarchy price (P_a)-Figure 1*. This is the case where trade (or freer trade) makes it cheaper for the small country to import this good and hence causes local production to decline and domestic consumption to expand. The resulting net welfare change is measured as follows:

   i. The increase in consumer surplus (CS) due to the lower price (area $P_w ecP_a$), minus

   ii. The decrease in producer surplus (PS) as a result of the lower price (area $P_w ecP_a$), plus

   iii. The increase in welfare due to lower externality costs as environmental damage is reduced with lower production (area dcfg).

   Trade (or liberalised trade) will lead, in this case to an unambiguous welfare gain equivalent to the area dcefg (Figure 1). This means freer trade increases welfare even in the absence of environmental policy measures to internalise the negative externality.

b. *The case of a world price above the autarchy price (Figure 2)*. Opening up to trade in this case, will lead to expansion in the domestic production of the environmentally damaging good for export. Local consumption drops to C_w, domestic production increases to Q_w and the surplus (Q_w - C_w) is exported. As a result, CS declines due to the higher price by area $P_w ecP_a$ and PS increase by area $P_w fcP_a$, leading to a net welfare gain (before accounting for the externality) of the magnitude fec. However, the expansion in domestic production of the damaging good for export causes social costs of the environmental externality to rise (over production) by area dcfg (Figure 2). The net welfare effect (the sum of the change in CS and PS minus externality costs, i.e. dcfg-fec) is accordingly ambiguous. In this case trade can lead to welfare loss or gain depending on the size of the two areas. Again, the outcome will depend on how large is the distortion in prices (e.g. the magnitude of the divergence between the social valuation of the environmental damage and private costs) as well as on the steepness of the slopes of domestic demand and supply curves. It can be shown however, that even in the exporting country case, the outcome can be a net welfare gain if environmental policy measures are introduced to correct for the externality (Anderson 1992).

Similar results (with some exceptions) were obtained with the assumptions of the partial equilibrium case of the small country model relaxed. Extensions of this analytical framework covered cases of non-linear demand and supply curves (large country), distortions in prices of other goods the production and consumption of which may be more environmentally damaging, liberalisation and environmental policy adjustments in the rest of the world and transboundary externalities (Anderson 1992).

The movement towards freer trade begins with dismantling trade barriers in the form of export and import controls, taxes and subsidies. Removal of such protectionists policies eliminates the distortions between domestic and world prices. This in turn leads to changes in the relative prices of exports and imports and consequently induces changes in the level and composition of total output. As different production processes have different environmental impacts, such liberalisation induced changes may lead to higher or lower environmental damage depending on the nature of change in the composition of output and accompanied changes in factor proportions and intensity of resources use and waste generation. As a result of changes in relative prices and increased income with liberalisation the composition of consumption also changes. The net effect of changing consumption and production patterns on the environment is therefore depends on every individual case in question and can only be determined through quantitative analysis.
Accordingly, the following section turns to address the question of the likely environmental impacts of agricultural trade liberalisation in SA using quantitative analysis techniques.

THE AGRICULTURAL SECTOR IN SA: STRUCTURE, EXTENT OF POLICY DISTORTIONS AND ENVIRONMENTAL CONCERNS

As shown in Appendix 1, agricultural production activities have several degrading impacts on the environment. It is accordingly, a fair assertion to say that the production of agricultural commodities, whether for domestic consumption or for export, is associated with negative environmental externalities. The various environmental impacts of agriculture, as described in Appendix 1, depend on many factors. Different production systems (irrigation, dry land, etc.), degree of intensification and intensification (level of input use, e.g. land, water, purchased inputs, etc.) And the type of commodity produced (livestock, horticultural or field crops, etc.) lead to different environmental impacts.

This section describes the main structural features of the present systems of agricultural production in SA and their historical origins. The present structure of SA agriculture was shaped by a long history of racially biased laws and distorted economic policies during the Apartheid era. An agricultural sector that is characterised by striking dualism of severe inequality in resource endowments, levels of technology, productivity, income consumption and human capital development has emerged as a result. This pattern of agricultural transformation had profound implications on the environment and the natural resource base in rural SA, to which the discussion will attend later. The nature of the evolution of this dualistic agrarian structure and the shaping forces and policies responsible for its emergence are discussed in detail elsewhere (Ellis Jones, 1987; Vink, 1990; Christodoulou & Vink, 1990; Brand *et al.*, 1992; van Rooyen *et al.*, 1993; Kirsten & Van Zyl, 1996). The main features of these policies and their consequences are summarised below.

The main structural force causing the present dualism in SA agriculture was the land ownership laws which led to the geographical segregation of black and white farmers and the creation of homelands for the black population. As a consequence, non-white SA's comprising more than 70% of the population, concentrated on only 13% of the land with the lowest potential and none or extremely limited public investment in development infrastructure and services. The minority of white SA's, on the other hand (less than 30%) controlled the remaining 87% of the country with the best arable land supported with substantial public investment in infrastructure and services. This dualism was further accentuated, under the objective of food self-sufficiency through high subsidisation and heavy protection to the white large-scale commercial farmers. Protectionist policies and subsidisation programs to this group included high tariff and non-tariff barriers to imports, subsidies on inputs such as chemical, mechanical and biological technology and water, low interest rates and tax shelters on capital, guaranteed producer prices through subsidised output marketing boards and substantial public investments in research and agricultural services.

These policies provided strong incentives for the large commercial sector to expand into marginal lands, over-invest in farm capital beyond optimal levels, overuse irrigation water and rapidly intensify the use of chemical inputs. As a result, high productivity gains were realised in this sector which currently contributes about 90% of total agricultural value added, making SA selfsufficient and surplus producer in the majority of agricultural commodities (Kirsten & Van Zyl, 1996). However, this triggered excessive degradation of land and water resources leading to severe soil erosion, loss of soil nutrients, siltation of water courses, salinisation and pollution (McKenzie *et al*., 1994; World Bank, 1994). On the other hand, the majority of the black population were crowded on low potential land at an average of 1.3 ha/person (compared to 16.2 ha/person among whites) depended on low input agriculture with virtually no support services. The consequence of such a mode of agricultural production and population pressure on the limited resource base was massive poverty driven environmental degradation (Van Zyl *et al*., 1997).

As a result of a number of national political and economic changes and a growing international pressure and demand for decontrol, liberalisation and democratic rule, SA could not maintain such racially biased and protective agricultural policies which began to collapse by the early 1980s. Since then, the government began to gradually phase out direct and indirect farmers' support programs, dismantle non-tariff (quantitative) trade barriers, decontrol prices and dissolve marketing boards, reduce subsidies on inputs and tax incentives on capital (Vink, 1993; Kirsten & Van Zyl, 1996). With the exception of a few commodities (see Table 1), SA today is believed to be approaching complete liberalisation and decontrol of agricultural trade. The major goals of the new agricultural policy in SA shifted away from self-sufficiency and protection against agricultural imports through non-tariff barriers towards export promotion, tariff policies that comply with the GATT ceiling binding levels and sustainable development and allocation of resources according to comparative advantage and economic efficiency principles and environmental conservation (White Paper on Agriculture, 1995). Moreover, the agricultural sector in SA is currently facing major structural reforms in the allocation and access to and security of land ownership and water rights as new bills on land reform and water rights are being introduced.

The following sections attempt to develop and use quantitative analysis tools to address the question of how will such policy changes impact on the environment. Issues and questions related to the extent of changes in relative prices due to trade liberalisation and the nature of the consequent response of agricultural supply in terms of changes in the level and composition of total output and their impact on the environment will be analysed. An empirical model is developed in the next section and used to conduct the intended analysis.

THE ANALYTICAL FRAMEWORK AND EMPIRICAL MODEL

An environmental accounting module is developed and integrated into an input-output framework to capture the environmental impacts of economic adjustments induced by trade liberalisation and environmental policy changes. A social accounting matrix (SAM) based on 1995 data (DBSA 1997) was modified and employed to account for the economy wide impacts of such policy changes. As agricultural production uses inputs produced by other sectors and its output is absorbed in other economic activities, it is appropriate to model multi sectoral linkages to capture direct and direct environmental impacts induced by changes in the level and composition of agricultural output. Several aggregations were used to modify the SAM in order to reflect the emphasis on agriculture. The final sectoral aggregation (24 production sectors and a final demand sector) is given in appendix 2. As this study is not concerned with impacts on income distribution, employment or government budget, functional distribution of income and transfers (taxes) are not derived and the demand side of the SAM structure was grouped into only one sector of final demand. Agricultural production and processing activities modelled are shown in Table 1.

The I-O model employed and its environmental module are specified below. In the standard I-O formulation (Leontief, 1953), a material balance equation governs the generation and use of total output:

$$X = AX + D \qquad (1)$$

Where X is the matrix of total sectoral output, A is the Leontief I-O coefficient matrix of intermediate use and D is the vector of final demand. With algebraic manipulation, the terms of equation 1 can be rearranged to get:

$$X - AX = D$$

$$X (I - A) = D$$

$$X = (I - A)^{-1} D \qquad (2)$$

From equation 2, one can solve for total sectoral output X given an exogenously set D and the production structure of the economy as described by the I-O coefficients matrix A.

Quantitative linkages between the environment and economic sectors can be established in terms measures of environmental impacts and natural resource use coefficients. Units of resources used and waste discharged or damage rates to the environment can be derived per unit of economic output generated by each producing or consuming sector. The following matrix R of units of resource use, waste discharge or environmental damage is specified to establish the link between economic activities and environmental impacts:

$$S = R X \qquad (3)$$

Where

$$S_s = S_j r_{sj} X_j$$

r_{sj} are the elements of matrix R that measure units of environmental impacts s caused by sector j and S is the matrix of total environmental or resource use impacts of all economic sectors contained in X. Substituting the solution value for X from equation 2 into 3, we obtain:

$$S = R X = R (I - A)^{-1} D \qquad (4)$$

Equation 4 can then be used to derive total resource use and environmental impacts on the set of resource in S.

Data on selected environmental impact coefficients were adapted from the SANEEP Model of DBSA (1997) and Hassan *et al.,* (1997). Information on water and land resource use, solid waste, liquid effluent and atmospheric emissions were compiled from the said sources. Quantitative data on soil erosion by land type by the commodity groupings in the model could not be obtained.
Accordingly, no assessment was made for soil degradation impacts based on land use changes.

Adjustment in trade and environmental policies are transmitted to the above real sectors model through output and input price response functions. This study made no attempt to estimate output supply and final and factor demand systems to derive the multitude of economy wide structure of elasticities. The linearity of the I-O technology coefficients and the lumping of demand sectors are limitations on such models to accommodate substitution effects in supply and demand. Instead, available estimates on agricultural supply elasticities (Liebenberg & Groenewald, 1997) were employed to translate price shocks caused by tariff reductions into real output movements through the model presented above.

According to Table 1, there is currently very low or no protection to agricultural commodities except for few (mainly livestock and sugar). It is also clear that processing sectors enjoy relatively higher protection than primary production sectors. This is consistent with the common practice world-wide in protecting value addition activities (Anderson 1992a). Moreover, the data in Table 1 is also consistent with amble empirical evidence in the literature on the short-term inelasticity of agricultural supply. This may explain the yet very limited adjustment in agricultural supply in SA, especially in land reallocation in response to the major recent liberalisation moves. However, the long-term elasticity estimates given in Table 1 indicate that agricultural production in SA is very responsive to price changes given enough time lapse.

While the elasticity estimates contained in Table 1 will allow analysis of output supply levels adjustments to price shocks, the study could not obtain cross price elasticity estimates to quantitatively examine substitution effects on the supply side. Alternatively, some heroic qualitative assumptions were made to define likely shifts in the composition of agricultural output in response to price movements. Information and predictions contained in the results of relevant research recently conducted to analyse the impacts of liberalisation and changing comparative advantage on agriculture in SA (Van Zyl *et al*., 1997, Jooste & van Zyl, 1997; Jooste, 1996) were used to direct those assumptions. Moreover, the current tariff levels shown in Table 1 also provided some basis for predicting the nature of likely sectoral shares and impacts of such price adjustments.

Table 1: Disaggregation of agricultural activities in the I-O model and estimates of current tariffs and elasticities.

Economic sectors	Tariffs		Own price elasticity (output)		Price elasticities of demand for inputs	
	Current (%)	Years for phasing out	Short-term	Long-term	Land (output price)	Water (water price)
Primary Production			.39	1.34	NA	-.629
Grains (maize and wheat)	0%[1]	4[1]	.45[4]	NA	.63[6]	
Livestock (meat/poultry)	40%	5	NA	.975[5]	NA	
Dairy	NA	NA	.55	NA	NA	
Fibres	0%	0	NA	NA	NA	
Fruits and vegetables	15%[2]	6	.07[7]	NA	NA	
Sugar	20%	1	NA	9.4	NA	
Other agricultural products	0%-10%	1-5	NA	NA	NA	
Forestry and fishing	-	-	-	-	-	
Agricultural Processing						
Grains (milling and baking)	5%-	2-4				
Meat	50%[3]	3				
Dairy products	40%	NA				
Fibre products	NA	7				
Fruits and vegetables (canning)	15%	4				
Other agricultural products	20%	1				
Animal feed	10%	1				
Tanning and leather	0%-6%	1				
Wood products	0%-10%	-				

1. With a trigger mechanism for a minimum price.
2. Highest on guavas and mangoes (35%). For citrus and others range between 5%-15%.
3. on maize flour and 50% on wheat flour.
4. Average of Cape and Free State provinces for wheat.
5. Estimate for live cattle in Namibia.
6. Average of short run estimates for wheat and maize.
7. Estimate of export supply elasticity.

Sources: Tariffs data from Department of Agriculture (1997).
Elasticities from Liebenberg & Groenewald (1997).

SCENARIOS OF THE POLICY SIMULATION AND ANALYSIS.

The impacts of two types of policy changes were analysed:

a. *Trade liberalisation policy scenarios*. To evaluate the environmental impacts of lifting remaining tariffs. In this policy regime, the model was solved to analyse the environmental consequences of adjustments in the level and composition of agricultural supply in response to an output price shock caused by a tariff reduction scheme. A further 15% reduction in current tariff levels was transmitted to real economic activity through the multi-sector model using the long-term aggregate output price elasticity of 1.34 given in Table 1. This translates into 20% reduction in aggregate agricultural output, which amounted to R 20 billion in 1995. This adjustment was allocated among sectors of agricultural production using existing tariff structure and background information from available literature. The following scenarios were analysed:

1. <u>No reallocation of land.</u> This meant that land (and other agricultural resources) released as a result of reduced production in affected sectors are not used by other agricultural activities and all given back to nature. Given current tariff levels (Table 1), the biggest share of this adjustment is expected to go to the livestock sector (most protected) and hence was allocated 75% of the reduction, followed by sugar (10%), grains (10%) and other agricultural products (5%).

2. <u>Complete substitution.</u> All land released was recovered within the agricultural sector by other activities as follows:

   i. 25% of the reduction in production is reallocated within the livestock sector to other enterprises, such as expansion in sheep production (for wool). This meant that livestock production will only drop by 50% in this scenario instead of the previous 75%.

   ii. The remaining 75% of the reduction is recovered in the fruits and vegetables (25%), grains (25%) and other agricultural products (25%) sectors. This meant that sugar production continue to decline by the same earlier 10%, whereas grains production will increase by 15% instead of the previous 10% decline. These allocations are consistent with results obtained elsewhere (Van Zyl *et al*., 1997).

3. <u>Partial substitution.</u> In this scenario, 60% of the released land is assumed to be relocated to other agricultural activities following the same pattern of scenario 2 above.

b. *Water pricing policy.* Used as an environmental policy instrument to correct for (internalise) the environmental externality on water use and allocation. Based on estimates of the extent of water underpricing for irrigation agriculture (Hassan *et al*., 1996; DWAF, 1996) the impact of a 40% increase in water rates was analysed. This translates to 25% reduction in aggregate agricultural output (R 10 billion) given the input price elasticity of demand for water of -0.629 in Table 1. The effects of this policy regime was simulated under the no reallocation and partial substitution (80% in this case) scenarios of the liberalisation regime. Target sectors however, were different in the water case. Major sectors affected by the water price policy shock were the fruits and vegetables (25%), grains (50%), sugar (15%) and other agricultural products (10%).

c. Both the trade liberalisation and water policy regimes were applied in this scenario with 50% partial substitution.

RESULTS OF THE EMPIRICAL ANALYSIS

Table 2 summarises the main results of the policy simulations described above. Under the liberalisation scenario 1, where no substitution was allowed, total economic output fell by 2% (R 16.5 billion) as a result of a 20% decrease in total agricultural output (R 8 billion) caused by a tariff reduction. This established the significance of the economic linkages and multiplier effects of agricultural production as 46.6% of the change in total economic output came from sectors other than the primary agricultural production sectors directly affected (Table 2). When all land released from affected sectors was reallocated to other agricultural activities, trade liberalisation had increased total economic output by a small margin. However, the improvement in economic output came from non-target primary sectors. With a partial recovery of only 60% of the released land, total economic output declined by less than 1%. This may indicate some efficiency gains in reallocation of resources away from protected sectors as a result of liberalisation. Similar results were obtained from the water price policy with slightly higher impacts, mainly due to the higher price shock (25% reduction in agricultural output).

Table 2: Results of the policy simulation analysis

Policy scenarios	% change in total output (R billion)	Contribution to total change (%)		Change in land resource use (%)	Change in water use (%)	Change in effluent discharge		Change in solid waste		Change in emissions	
		Direct effects	Indirect effects			Direct (%)	Indirect (%)	Direct (%)	Indirect (%)	Direct (%)	Indirect (%)
Liberalisation policy											
1.1 No substitution	-2.03% (16.53)	53.4	46.6	-44.2	-12.4	-22.5	-.62	-28.9	-1.26	-22.54	-1.0
1.2 Complete substitution	0.06% (0.47)	-140.2	240.2	-26.5	-33.6	-1.83	-.01	-9.04	0.53	-1.83	0.17
1.3 Partial substitution	-0.67% (5.48)	63.5	36.5	-33	-16.24	-8.99	-.132	-16.14	-0.14	-8.99	-.242
Water policy											
1.1 No substitution	-2.57% (21)	51.2	48.8	-13.3	-72.5	-27.5	-.89	-20.97	-2.3	-27.51	-1.35
1.3 Partial substitution	-0.9% (7.32)	43.7	56.3	0.43	-37.4	-8.4	-.36	-4.51	-1.0	-8.4	-0.54
Water and liberalisation											
1.1 Partial substitution	-2.51% (20.47)	47.8	52.2	-26.4	-50.5	-25.6	-.91	-24.9	-2.02	-25.56	-1.36

The environmental impact results are consistent with the earlier result of the partial-equilibrium framework which stipulates that liberalisation of trade in a commodity the production of which generates an environmental externality and its domestic price is higher than the world price (such as many agricultural commodities in SA), is environmentally benign. However, one can only assess the net change in social welfare when the welfare impacts of this environmental improvement is weighed against welfare impacts of reduced economic output. Nevertheless, it is clear that when reduced production is recovered (even only partially) in other segments of the agricultural sector (which is the most likely long-run scenario), the probability of a welfare gain from trade liberalisation is very strong. It is clear that substantial savings in water can be achieved from improved water tariff regimes. The coupling of liberalisation with an externality endogenizing environmental policy instrument (water pricing) led to even higher land and water savings. About 50% of the water and 26% of the land are saved under the combined scenario 3. Greater reductions in effluent discharge and solid waste generation as well as significant reductions in emissions were also achieved under this scenario.

CONCLUSIONS AND LIMITATIONS OF THE STUDY

The preceding analysis indicated that trade liberalisation in the case of agricultural commodities in SA will lead to environmental improvement as their production is associated with environmental externality and their domestic prices are above world prices. Theoretical results derived from the conventional comparative-statics partial-equilibrium trade models are confirmed even under this multi-market analytical framework. The results also showed that trade liberalisation will redirect resources to other agricultural production activities that may be more efficient and less environmentally damaging than the protected sectors. With only partial recovery of the land and water resources, the likelihood of a net welfare gain from liberalisation is very strong.

The study however, points to a number of issues of crucial importance to a good understanding of the implications of trade liberalisation for the environment as revealed by the many deficiencies of the used model. First, there is a clearly dearth of comprehensive information on the structure of substitution in supply and output composition response in agriculture in SA. This is one task of quantitative research that of crucial importance to proper understanding of the behaviour of agricultural supply in response to any exogenous shock, whether as a result of movement in sectoral variables or macro-economics aggregates (trade, foreign exchange or monetary policies). Given the huge spatial extent of SA and associated transportation costs that place a substantial wedge between domestic and border prices for many inland markets, regional disaggregation of agricultural activity is very critical for capturing important regional differences in comparative advantage. In other words, the commodity groupings we usually adopt may hide important details and policy information . This means that considering commodities such as wheat, maize or livestock as homogenous economic goods across the country, may reduce the power of our analysis and its usefulness to policy making.

Another important deficiency of this analysis is the absence of input demand responses to changes in output prices and the consequent change in factor use intensities and proportions. This is of special importance to evaluating environmental impacts as it matters for the environment what production method is used. Data in this regard is also lacking. The third weakness of the present framework is the exclusion of income effects and substitution in demand. The positive income effect on environmental conservation is a major argument in the advocacy for free trade, that is very important to validate or disproof. Again this extension will require more quantitative data on demand parameters and the impact of changing the composition of consumption on supply and the environment. As the above implies, a general equilibrium framework with a flexible supply and demand structures that allow for substitution and income effects appear to be the way to go for conducting more adequate analysis of these issues. The fourth major limitation of the analysis is the deficiency in environmental impact variables data and parameters. To be able to make any meaningful judgements on the social desirability of any change, the marginal social costs or value of environmental impacts or externalities to the society must be properly measured. Although we have a long way to go towards that end, without defining marginal social cost functions for environmental damage, proper welfare assessment of the desirability of any economic change will not be feasible.

REFERENCE

ANDERSON, K. (1992a). Effects on the environment and welfare of liberalising world trade : The cases of coal and food. In: K. Anderson and R. Blackhurst (Eds.), *The greening of world trade issues.* London : Harvester Wheatsheaf, pp.145-172.

ANDERSON, K. (1992). The standard welfare economics of policies affecting trade and the environment. In: K. Anderson and R. Blackhurst (Editors). *The* *greening of world trade issues*. London : Harvester Wheatsheaf, pp.145-172.

BAILEY, C. (1988). The social consequences of tropical shrimp mariculture development. *Ocean Shoreline Manage*, 11:31-44.

BAHAGWATI, J. (1969). *Trade, tariffs and growth*. London : Weidenfeld & Nicholson.

BETHLEHEM, L. (1997). Catalysing change : International environmental pressures on South African exports. In L. Bethlehem and M. Goldblatt (Eds.). *The bottom line : Industry and the environment in South Africa.* International Development Research Centre, University of Cape Town Press.

BRAND, S., CHRISTODOULOU N., VAN ROOYEN, C.J. & VINK, N. (1992). Agriculture and redistribution. In: R. Stirrer (Des), *Wealth or poverty? Critical choices for South Africa*. Cape Town : Oxford University Press.

CHRISTODOULOU, N.T. & VINK, N. (1990). The potential for black smallholder farmers' participation in the South African agriculture economy. *Paper presented at a conference on 'Land reform and agricultural development'*. United Kingdom : Newick Park Initiative.

CORDEN, W.M. (1974). *Trade policy and economic welfare*. Oxford : Clarendon Press.

DALY, H.E. & GOODLAND, R. (1994). An ecological-economic assessment of deregulation of international commerce under GATT. *Ecological Economics,* 9:73-92.

DBSA (Development Bank of Southern Africa). (1997). *South African National Economic and Environmental Policy Model- SANEEP*. DBSA Discussion Paper (in press).

DEAN, J. (1992). Trade and the environment: A survey of the literature. In: P. Low (ed.). *International trade and the environment*. World Bank Discussion Paper 159, Washington DC : World Bank.

DWAF (Department of Water Affairs and Forestry). (1996). *Water tariff policy committee*. Unpublished memo, DWAF, Pretoria.

EKINS, P., FOLKE, C. & COSTANZA, R. (1994). Trade, environment and development: The issues in perspective. *Ecological Economics,* 9:1-12.

ELLIS-JONES, J. (1987). Guidelines for the role of the public sector in promoting agricultural development, with particular reference to Transkei. *Development Southern Africa,* 4(3):538-542.

FINDLAY, R. (1987). Comparative advantage. In: J. Eatwell, M. Milgate and P. Newman (Editors), *The new Palgrave : A dictionary of economics*, Vol. 1. London : Macmillan.

GATT (GENERAL AGREEMENT ON TARIFFS AND TRADE). (1992). Trade and the environment. In: *International trade 1990-91.* GATT, Geneva, pp. 19-48.

HASSAN, R., BEUKMAN, R., LE MAITRE, D., WILSON, J., MAGAGULA, L. & MANDER, M.. (1997). *Environmental accounting for sustainable management of forest resources in South Africa: An I-O framework; Part 2: Estimation of model parameters*. Environmental Report ENV/P/I/97087; Pretoria : CSIR.

HASSAN, R., OLBRICHT, B. & VAN DER MERWE, R. (1997). *Comparative analysis of the economic efficiency of water use in plantation forestry and irrigation agriculture in the Crocodile river catchment*. *WRC Report (forthcoming).*

HASSAN, R.M. BERNS, J. & CHAPMAN, S. (1996). Economic policies and the environment in South Africa: The case of water resources in Mpumalanga. *LAPC Policy Paper No 24, LAPC, Johannesburg.*

JOOSTE, A. (1996). The impact of different macro-economics variables on the optimal distribution of beef in the Southern African Customs Union. *Agrekon*, 35(4):276-282.

JOOSTE, A. & VAN ZYL, J. (1997). *Analysis of comparative economic advantage of agricultural production and trade in South Africa*. SD Technical Paper series, AFR/SD and REDSO/ESA, USAID Washington DC (forthcoming).

KALDOR, N. (1980). The foundations of free trade theory and their implications for the current world recession. In E. Malinvaud and J. Fitoussi (Eds.). *Unemployment in Western Countries*. Proceedings of a conference held by the International Economic Association at Bischenberg, France. London : MacMillan Press.

KOSMO, M. (1987). *Money to burn? The high cost of energy subsidies.* Washington, DC : World Resources Institute.

KRUGMAN, P.R. (1990). Trade, accumulation and uneven development. In: P.R. Krugman, *Rethinking international trade.* Cambridge, MA : MIT Press, pp.93-105.

LIEBENBERG, F.G. & GROENEWALD, J.A. (1997). Demand and supply elasticities of agricultural products: A compilation of South African estimates. Pretoria : Agricultural Research Council Report.

LUCAS, R.E., (Jr.). (1988). On the mechanics of economic development. *Journal of Monetary Economics*, 22:3-42.

McKENZIE, C.G., VAN ZYL, J. & KIRSTEN, J.F. (1994). Agricultural issues relating to natural resources and the environment in South Africa. *Agrekon*, 33(4):222-224.

PEARCE, D. (1992). *Should the GATT be reformed for environmental reasons?* CSERGE Working Paper GEC 92-06, CSERGE, University of East Anglia/University College London.

REPETTO, R. (1986). *Skimming the water : Rent-seeking and the performance of public irrigation systems.* Washington DC : World Resources Institute.

REPETTO, R. (1988). *The forest for the trees?* Government policies and the misuse of forest resources. Washington DC : World Resources Institute.

RICARDO, D. (1817). On the principles of political economy and taxation. London : J. Murray.

RØPKE, I. (1994). Trade, development and sustainability : A critical assessment of the 'free trade dogma'. *Ecological Economics,* 9:13-22.

ROSENZWEIG, C. & IGLESIAS, A. (eds.). (1994). *Implications of climate change for international agriculture : Crop modelling study*. Washington DC : US Environmental Protection Agency.

SAMUELSON, P.A. (1969). The gains from international trade once again. In: J. Bhagwati (Editor), *International trade*. Harmondsworth : Penguin.

SOLOW, R.M. (1991). Growth theory. In: D. Greenaway, M. Bleaney, and I.M.T. Stewart (Eds.), *Companion to contemporary economic thought.* London : Routledge.

VAN HOREN, C. (1996). Counting the social costs : Electricity and externalities in South Africa. Industrial Strategy Project, Cape Town : Ellan Press and UCT Press.
VAN ROOYEN, J., VINK, N. & MALATSI, M. (1993). Viewpoint : Agricultural change, the farm sector and the land issue in South Africa. *Development Southern Africa*, 10(1):127-130.

VAN ZYL, J., VINK, N., TOWNSEND, R. & KIRSTEN, J. (1997). *Agricultural market liberalisation: A case study of the Western Cape Province in South Africa.* Presented to the ESRC Development Economics Study Group Conference, Whiteknights Hall, University of Reading: 11-12 July, 1997.

VINK, N. (1993). Entrepreneurs and the political economy of reform in South African agriculture. *Agrekon*, 32(4):153-166.

YOUNG, M.D. (1994). Ecological-accelerated trade liberalisation : A set of disciplines for environment and trade agreements. *Ecological Economics*, 9:43-51.

WORLD BANK, (1994). *South African agriculture, structure, performance and options for the future*. Washington, DC : World Bank Southern Africa Department.

Appendix 1:

The Linkages Between Agricultural Production and The Environment

In terms of plant and animal growth, agriculture is basically a biological process that extracts and converts natural elements such as water, soil nutrients and solar energy into food and fibre. Mankind however, intervenes through the application of economic effort (the combination of labour, purchased inputs and science) to control and influence this natural process of plant and animal growth and development. Although productivity gains are realised as a result of the application of these modern practices and management methods, expanding the agricultural production potential comes at a cost to the environment. The major linkages and impacts of agriculture on the environment are outlined in this section.

As mentioned earlier, agriculture is a resource-based economic activity exploiting and impacting on land, water, biological diversity and the atmosphere. Apart from higher rates of extraction from the intensive use of the natural resource base, species are altered through genetic manipulation, the sink functions of soil, water and atmospheric resources are depreciated due to increased waste generation and several other ecological functions are disrupted as a consequence of this agricultural transformation process.

Impacts on land resources. As a result of the *horizontal* expansion of agriculture, more land is converted from its natural pristine state and brought under regular cultivation of crops and pastures. This causes various types of soil degradation.

a. Soil erosion. Removal of the vegetative cover through conversion of natural forests and wood or grass lands, leads to increased exposure of the soil surface to water and wind erosion. Erosion causes the displacement of top soil leading to important on-site and off-site effects. With erosion essential nutrients and organic matter that support plant growth are lost on-site. Those nutrients may be deposited on other farm sites as a positive externality, or end up causing siltation of dams and water courses as a negative externality on power generation and irrigation activities and impacting on the aquatic life.

b. Mining of soil nutrients through harvesting of agricultural produce which is transported to the market for consumption or further processing elsewhere (e.g. exported to other countries).

c. Deterioration of the physical properties of the soil as top soil is lost. This is mainly due to the fact that subsoils have inferior physical properties such as lower moisture holding capacity. The result is increased runoff and water erosion and less moisture to support plant growth.

Vertical expansion (intensification) in agriculture on the other hand, leads to similar soil degradation impacts.

d. Erosion and soil compaction are caused by the use of machinery for tillage operations, especially regular ploughing.

e. Excessive mining of soil nutrients due to intensive farming, reduced fallow periods and low use of commercial fertilisers is a major source of soil degradation.

f. Poor management of irrigation lands (poor drainage systems) results in salinisation (increased salt concentration) and water logging which cause significant reductions in soil quality and productivity.

Impacts on water resources. Expansion of irrigation agriculture increases the demand for water depleting under ground water and increasing surface water losses through evapotranspiration. Moreover, the intensive use of chemical inputs such as fertilisers and pesticides pollutes surface and ground water. This is a major source of health hazards to animals and humans (toxicity and water borne diseases) as well as damage to aquatic life.

Impacts on biological diversity. Conversion of natural forests and wood/grass lands for agricultural production erodes biological diversity and disrupts the ecological functions and services provided by such natural habitats. Also, the use of improved plant varieties and animal breeds can increase the risks of biodiversity loss by narrowing the genetic base and parental lineage of plants and animals produced on extensive land areas.

Impacts on the atmosphere. Increased use of agricultural chemicals (e.g. spraying of pesticides) causes air pollution leading to higher health risks to humans (air-borne diseases) as well as to plants and animals, especially non-target beneficial insects such as bees and the loss of their valuable role as natural pollination agents and suppliers of food (honey). Acid rain caused by increased emission of methane mainly from livestock production systems is another negative externality of farming on the atmosphere that causes various economic damages. Moreover, reduction of the continuous green cover of forests and natural vegetation through conversion of land reduces the ecosystem's carbon sink capacity. The reduced ability to absorb carbon contributes to relatively higher concentrations of CO_2 in the atmosphere. CO_2 is the major contributor to climate change and global warming, the environmental impacts of which on agriculture as well as on other sectors are well known (see Rosenzweig & Iglesias, 1994). Also regular and deep ploughing expose lower levels of the soil surface leading to the release of carbon captured within inner depths of subsoils.

Indirect environmental impacts of agriculture. Agriculture also contributes indirectly to atmospheric pollution through emissions generated by burning fuel in the mechanisation and transport operations. In addition, food storage, refrigeration and processing are important sources of green house gases.

It is important to note however, the most important environmental impacts of agriculture are largely national, e.g. soil degradation. On the other hand excessive extraction of and effluent discharge into water (pollution) have important regional implications, clearing of forested land and atmospheric emissions have more global impacts.

Appendix 2

Sectors of the I-O model

Economic sectors				
Primary agriculture				
Grains (maize and wheat)				
Livestock (meat/poultry)				
Dairy				
Fibres				
Fruits and vegetables				
Sugar				
Other agricultural products				
Forestry and fishing				
Agricultural Processing				
Grains (milling and baking)				
Meat				
Dairy products				
Fibre products				
Fruits and vegetables (canning)				
Other agric. Products				
Animal feed				
Tanning and leather				
Wood products				
Non-agricultural sectors				
Coal Mining				
Other mining				
Chemicals and petroleum				
Rubber, glass and metal				
Machinery and equipment				
Electricity, utilities and transport				
Services and business				