CASE STUDY 2: Zimbabwe: Economy-Wide Policies And Deforestation: Applied General Equilibrium Modelling[17]

a) Introduction

The 1990s in Zimbabwe can be described as the era of economic reforms. Since 1991 the Government has pursued a market-oriented strategy aimed at economic growth and poverty reduction. The first phase of this strategy (1991-1996) was implemented under the Economic Structural Adjustment Programme (ESAP). The second phase (1996-2000) is currently being implemented following the policy framework enunciated in the Zimbabwe Programme for Economic and Social Transformation (ZIMPREST). The benefits of structural reforms, in particular, have been many, but combined with initially adverse external shocks (bad weather and sluggish world growth) and poor policy sequencing, these policy shifts had significant effects on output growth, poverty and income distribution, with environmental and political repercussions that are still working themselves out.

Adjustment is usually seen as merely a macroeconomic problem because of its strong link to stabilisation, which deals with the full restoration of internal as well as external equilibrium of the economy. But the aim of economic reforms is larger: it is meant to place the economy on a new efficient path. Unprecedented concern over the effects of the economic crisis has somewhat obscured its truly disturbing consequences: the increased exploitation of fragile natural resources hence leading to environmental degradation in Zimbabwe. It is estimated that the country is losing 0.6 per cent of its forest area of about 23 million hectares annually. Land clearance for agricultural purposes accounts for more deforestation than all other agents put together. According to Campbell and Whitlow (1989) some 52 000 ha of woodland were converted to cropped land annually between 1963 and 1977. During this time both large scale commercial farmers and small scale farmers were responsible for clearing. However, since independence in 1980, small scale/rural farmers have mainly been responsible for land clearing for agriculture. The estimated amount of deforestation has since then been estimated to be 70 000 ha of land per year. Evidence of this is found in the sharp increases in areas under various crops over the years. For instance, the area for maize has increased from 649 000 ha in 1970-72 to 966 000 ha in 1987-89. Currently some communal areas no longer have any natural forests and have become a market for wood sales from resettlement and

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commercial farming areas. It is estimated that about 1.5 million hectares out of the total of 1.8 million hectares of eroded land is in the communal areas and about half is crop-land and half non-cropland.

Economic reforms affect deforestation in several ways[18]. First, reforms make shifts towards tradeables and exports particularly attractive. In agriculture, a shift towards export crops and processed forest products can lead to a degradation of such natural resources as forests. Industrialisation and production of manufactured goods for export can have a similar effect not only on agricultural resources but also on urban environment, thus polluting air and water. Secondly, if export crops cause more soil erosion and land degradation than food crops, the effect of reforms on deforestation can be adverse. Thirdly, indirectly by contributing to greater poverty at least in the short run (through an increase in food prices for example) economic reforms can accelerate environmental degradation. Reforms can exacerbate social polarisation as the costs and benefits of reforms accumulate differentially to social groups. This takes place through relative price and income distributional shifts. Environmental pressures intensify due to a combination of factors resulting from the skewed income redistribution. By favouring the rich, this may enhance their capacity to degrade, leading to unregulated resource exploitation by elites. The poor, on the other hand, intensify pressure on the environment as a survival tactic. Fourthly, to reduce political pressure, the government has decided to subsidise the poor with natural assets in the form of a sweeping land reform, which if done without complementary measures (such as access to agro-economy technology and credit systems) can have further aggravated environmental stress, especially in the so-called resettled areas.

To capture these different interactions and their influence on the consequent impact of policy reforms on the economy and deforestation, a computable general equilibrium (CGE) approach was used. Although not directly aimed at the forestry sector, economy-wide policies have an impact upon deforestation and forest degradation. In fact, a study by the World Bank concludes that policy spillovers are among the major causes of global deforestation. Following this argument, the main response to deforestation lies with measures that operate outside the forest. CGE models are an appropriate tool to comprehensively analyse such

[18] It is, however, important to understand that environmental degradation occurs even without economic reforms, due partly to population pressures and worsening human-land ratio.

policy spillovers (Devarajan 1990). They simulate for the entire economy the interactions between production and consumption simultaneously.

b) The Model, Theory and Solution Technique

In brief, the model consists of a deforestation sub-module embedded in a standard CGE model that represents the Zimbabwe economy. A full description of the CGE model can be found in Chitiga and Mabugu (1999). Here we briefly sketch the main characteristics of the model. A standard CGE model is summarised by a set of equations, which are based on assumptions about the structure, and interactions of the economy. Most of these are standard for such models. Consumers are assumed to maximise their satisfaction or utility while producers maximise profits, subject to the constraints facing each in the model. Prices, wages and quantities produced and consumed of each good are then determined within the model.

The model simulated the interaction from the economy sector to the deforestation sector (or sub-module) and vice versa. For the deforestation sector, the production equations for output and cleared land, link with the economic sector through income and price effects. Typical to most CGE models, the model operates on two different levels. At the macro level, the model is strongly influenced by the pattern of savings and investment. A variety of income distributional are present to ensure equality of savings and investment. These are mediated by changes in real factor payments (to land, labour, capital) and relative product prices. The general equilibrium model also features issues of a microeconomic nature about workers relocating across sectors in response to wage differences. These are represented in sectoral production functions on the supply side and consumer responses to price and income changes in demand. Hence, relative prices and their effect on incentives play a major role in the model, and indeed in the economy.

The demand and supply side are brought together via the material balance equation. Output itself is distributed among intermediate deliveries ($a_{ij}\ X_j$), consumption (C_i), investment (J_i), change in stocks (DS_i) and government uses (G_i), exports (E_i) and imports (M_i)

$$X_i = a_{ij} X_j + C_i + J_i + DS_i + G_i + Ei M_i$$

A consistency check for the model is the requirement that savings equal investment. Foreign savings, public savings and private savings adjust to balance investment. Public savings are the excess of revenue over expenditure. Private savings are influenced by sectoral output adjustments through flexible prices and differences in saving rates of the different income groups.

The key dataset underlying the analysis is a Social Accounting Matrix (SAM) for Zimbabwe. The base year for the analysis is 1994. It incorporates seven sectors and six income groups. To come up with the present data set, various sources of data from the Central Statistics Office were used. The National Income and Expenditure Report, 1995, National statistics of Zimbabwe, 1997, the Quarterly Digest of Statistics, 1996, Crop Production on Large Scale Commercial Farms, 1995 and Agriculture, 1995 were also used.

The proposed model includes numerous parameters that must be quantified before the model can be applied. Given that there is inadequate time series data for econometric estimation of these parameters, most of them had to be calibrated. The details can be found in Chitiga and Mabugu (1998).

c) Policy Simulations

To find the effect of various policies directed toward economic development since 1991 on deforestation, various numerical simulations were run and compared to the benchmark (no change or base case) scenario. The three experiments were: 1) currency devaluation, 2) removing input subsidies on fertiliser, and 3) land reform. The results are displayed in Table 1.

Experiment 1, Currency Devaluation

The threat of loss in cost competitiveness on external markets has already induced the Zimbabwean government to devalue the currency. Devaluation is supposed to improve the trade balance and stimulate the level of internal activity by raising the price of traded goods relative to home goods. This relative price shift works by generating excess demand for home goods while also making exporting or import substitution more profitable. What is rarely discussed is the environmental consequences of this policy. Using the CGE model for Zimbabwe, we study the effects of devaluation on the economy and the rate of deforestation.

Conceptually, we accommodate the devaluation by varying the exchange rate, which enters exogenously in the model. In this experiment, we simulate a 30 percent devaluation.

Table 1: Impact of economic reform policies (percent changes from base values)

Variable and percentage change from base case values	*Experiment 1 Currency Devaluation*	*Experiment 2 Removal of Fertiliser Subsidy*	*Experiment 3 Land Reform Programme*
GDP	4.1	-4.7	-0.1
Fiscal deficit	-2.4	-6.1	1.4
Current Account	8.1	-14.2	-3.4
Unskilled income	-4.2	-6.7	-0.4
Skilled Income	0.4	-2.3	-0.1
Profit Income	3.4	-7.1	-0.9
Consumption	1.2	-0.5	-0.2
Inflation (CPI)	17.1	-0.5	2.2
Deforestation	**1.1**	**0.9**	**0.5**

As expected, this scenario encourages exports and discourages imports. The strengthening of the balance of payments induces a fall in government foreign borrowing needs. At the same time, the rise in import prices induced by the accelerated devaluation is very inflationary, leading to an increase in the rate of inflation of 17.1 percent. Interestingly, GDP growth is higher than in the base year by 4.1 percent, largely because of the favourable balance of payments repercussions. Communal agriculture also benefits from the devaluation, since its prices are tied in part to world market prices. Communal farmers respond to the direct price stimulus induced by devaluation, extending into new farmland. Unfortunately, these are marginal lands well beyond their carrying capacities and would be unable to sustain continued production. As a result deforestation increases. The increase in exports after a devaluation is driven mainly by agro-exports including tobacco, cereals and horticulture products. This may increase the rate of deforestation as farmers rely to some extent on wood for their energy requirements. Further, timber exports have begun to feature prominently in total exports, suggesting increased commercial logging.

These results have some important policy implications. They suggest that a devaluation may inadvertently raise the rate of deforestation. In isolation, devaluation increases deforestation

because it boosts primary exports output without reducing sectoral distortions. The new price incentive structure ushered in leads to further margin extension. Finally, devaluation induces inflationary pressures on the economy, which may make it incompatible with macroeconomic sustainability.

Experiment 2, Removing input subsidies (fertiliser)

In this experiment, we interpret the removal of fertiliser subsidies as a 50 percent increase in the selling price of fertiliser. Removal of input subsidies leads to more efficient use of the input. However, its impact on relative prices is critical in determining the sectoral bias of the policy, and hence deforestation. The model-calculated effects of doubling fertiliser prices would drive up the cost of living by 12 percent. The third row of the Table shows that the ensuing decrease in aggregate demand would reduce real GDP by 4.7 percent. Food imports themselves would fall by 10 percent, although the balance of payments would improve as a result of the overall contraction in the economy.

The elimination of fertiliser subsidies leads to extensive agricultural land clearing, just to keep total yields at the pre-reform levels, and hence deforestation. This finding is corroborated by actual outcomes in the economy since 1991. Since the inception of reforms, certainly the pattern of agricultural development, particularly the choice of crops, has been influenced by government policies and global trade and price trends. The increase in producer prices of crops, however, did not result in a positive output response since there was a general decline in communal crop output at the rate of about 2 percent annually in the 1990s. Maize declined at a rate of about 2 percent, sorghum at 3.3 percent, groundnut at 6.1 percent and soybeans at 4.8 percent. These declines are mainly explained by declines in crop yield per hectare among the communal farmers. This reduction was due to substantial reduction in the use of fertiliser and other agro-chemicals following the removal of subsidies on these inputs, which led to price increases of over 300 percent in five years. As a result, farmers' ability to buy and use these inputs was reduced. Fertiliser use by smallholder farmers declined as a share of national fertiliser consumption from 24 percent to 22 percent between the pre-reform and reform period. Paradoxically, the period has also been characterised by increases in total area cropped and decreases in per capita cropped land holdings, suggesting that a process of deforestation is at work. The model results show an increase in deforestation of 0.9 percent from the base case due to the removal of fertiliser subsidies.

Experiment 3, Land Reform

A topical issue in present day Zimbabwe is resettlement. This typically involves moving communal farmers out of communal areas into commercial farms and state land. The reasoning appears to be that not only will this move reduce pressure on the fragile lands by absorbing more communal labour but it will also raise output, especially food, through increased crop yields. Detractors of resettlement raise fears that there will be a dramatic output shift from agro-exports to food and a change in agricultural practices. Extreme pessimists even argue that productivity will fall dramatically. Assuming that these structural shifts were indeed to take place, what would be the impact on the rest of the economy and on deforestation?

The shift away from large-scale commercial farming will not necessarily be environmentally beneficial especially if unaccompanied by land tenure reforms and complementary inputs. Resettled farmers are less prepared to invest in deforestation reduction because of the nature of incentives facing them. As Table 1 shows, the trade balance worsens in the short run although there is no noticeable effect on output (there has only been a reallocation from agro-exports to food production). Deforestation in the communal lands declines, in sympathy with the reduced population pressure and reduced food prices induced by resettlement. However, this gain is mirrored by a corresponding loss in the resettled areas. Food output has gone up because previously non-food growing areas have been brought under food production by the resettled farmers. However, this food production is done using the old log linear technology to clear the land. With the issue of tenure still not addressed, the underlying market failures present in the communal areas still remain, and unabated forest depletion, this time on virgin lands, continues. The tenure aspect in the land reforms as well as issues pertaining to access to various agronomy requirements (technology, credit, extension etc.) require to be addressed if rampant land clearing is to be avoided.

d) Conclusions and Policy

A CGE model was used to explore the impact on deforestation of macroeconomic and sectoral policy reforms and the economic impact of environmental feedback from these reforms. Examples of policy reforms simulated in the model include a currency devaluation, removal of fertiliser subsidies and land reform (coupled with improvements in land property rights).

Several policy requirements stand out from the model's results. First, if economic reforms continue without modification of their social and environmental impacts, deforestation is likely to continue. There is urgent need to address social forces and pressures driving poverty and deforestation. Such measures will have to deal with proposals for basic changes in land tenure, resource access and diversification. There is need for investment in a wide range of areas including afforestation programmes and people (especially education). Second, there is need to improve property rights and tenure for agriculture and forestry resources in order to promote conservation measures and sound resource use. Third, in order to prevent increased deforestation during reforms, macroeconomic stability is a precondition for effective integration of environmental and economic policies.

CASE STUDY 3: Environmental Accounting as a Tool for Policy Analysis

Examples from Namibia[19]

a) Natural Resource Accounts in southern Africa

Namibia is, like many African countries, heavily dependent on its natural resource base, but before independence in 1990 natural resources were exploited with little planning for the provision of future income. In 1995, Namibia began constructing natural resource accounts (NRA) in order to facilitate more sustainable use of natural resources. In addition to minerals and fisheries, the two resources studied here, accounts have been constructed for water (Lange, 1997, 1999), livestock, land and land degradation (Lange, Barnes and Motinga, 1997), forestry (Björkman, 1999), energy (Stage and Fleermuys, 1999) and work is in progress on wildlife.

Building on the success of their respective pilot projects in this area, in 1998 Botswana, Namibia and South Africa established a joint NRA initiative to co-operate on technical assistance, training and long-term capacity building from several donors, mainly Sida and USAID. The domestic partners to this project in each country include Ministries of Environment, other resource-based ministries, national statistical offices, universities, policy research organisations and environmental NGOs.

This regional effort aims to integrate the construction of NRA with practical demonstrations of their policy applications, while establishing and extending the long-term capacity to absorb and maintain this work.

b) Resource Rents in Namibia's Mining and Fisheries

Mining and fisheries are important contributors to both Namibian GDP and export earnings. Indeed, the combined contribution of mining, fishing and fish processing peaked at over 40 percent in 1980, but has since declined to 20 percent due to the rapid growth of other sectors. Following Independence, the economic importance of fisheries broadened while mining shrunk, such that they now contribute roughly equal shares to GDP. Interestingly, the share of

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exports has not changed very much during the same period; the combined contribution has only decreased from a peak of 80 percent (in 1986) to 70 percent, with the share of fishing increasing considerably after Independence.

Industries working with extractive resources such as minerals and fisheries normally generate profits, which are higher than the average for the economy, because of the scarcity of these resources relative to the demand for them on the world market. After costs for labour, intermediate inputs etc. have been covered, the return to capital invested in these industries is generally higher than the return to capital invested in other industries. The difference between the profit in a resource-based industry and the opportunity cost of the invested capital, that is, the profit that could have been made by investing that capital in some other industry, is called the resource rent.

Non-renewable resources like minerals will eventually be exhausted, and the employment and incomes currently generated by mining will end. Government should therefore strive to quantify and capture the rents from mining and re-invest them in other assets or economic activities which can replace the employment and incomes of the mining industry once the minerals are exhausted. In this way, mining can become economically sustainable – by creating a permanent source of income – even though non-renewable resources are, by definition, not biologically sustainable.

Renewable, open-access resources such as Namibia's marine fisheries are capable of providing an income for all future generations, but in the absence of sustainable management practices, are often subject to overexploitation and eventual exhaustion. By setting fish quotas at the level of fishing which maximises the resource rent, and levying quota fees which capture the resource rent at this level of fishing, government can make it unprofitable to fish at levels that deplete the stock. Thus, NRA plays an important facilitating role in the sustainable management of fisheries.

Importantly, government recovery of resource rent is necessary for a more equitable use of resources, which belong to all Namibians. The excess profits earned from these resources should be used for the benefit of all Namibians, not simply accrue to the mining or fishing companies, many of which are foreign-owned or controlled. One of the first uses of the Namibian natural resource accounts (Lange and Motinga 1997) was to estimate resource rents

from mining and fisheries and to examine the extent to which rents were being recovered by government through taxes and levies.

c) Theory

The Namibian natural resource accounts generally follow the United Nations' System of Integrated Environmental and Economic Accounts, SEEA (United Nations 1993). However, it is strongly influenced by the Norwegian (Alfsen *et al*. 1987, Alfsen 1996) emphasis on compiling a detailed physical database and integrating the NRA with economic models for policy analysis.

Namibia's natural resource accounts for minerals and fisheries include stocks as well as annual extraction, or use, of resources. The stock accounts record the estimated reserves of major minerals and the estimated adult biomass of major commercial fish species. The use accounts record the annual extraction of major minerals and fish landings for the major commercial species. Accounts are compiled in physical units and, where possible, in monetary value. Although the stocks of minerals in the ground or fish in the sea do not generate any income until they are extracted and sold, they have an economic value because of the potential income they can generate. There are three methods of calculating this value: the discounted (present) value method, the user-cost allowance method and the net-price method.

The discounted value method entails forecasting the net income from a resource in each year in which it is used and discounting it to the present. This method is rarely used in practice, since it is difficult to make accurate predictions about future prices and future technology and there is contention over the correct discount rate to employ.

In the user-cost allowance method (which is only applicable to non-renewable resources), it is assumed that the net annual returns and the rate of extraction are constant over the lifetime of the resource (El Serafy 1989, 1991). With this method, only the discount rate and the lifespan of the resource need to be determined. This method would have been interesting to use on the mineral sector, because it separates the amount of the resource rent which must be reinvested in order to guarantee a constant stream of income, from the amount which can be consumed immediately. Unfortunately, this proves impractical since it requires detailed information both on stocks and value-added of each mineral separately (which cannot be publicly

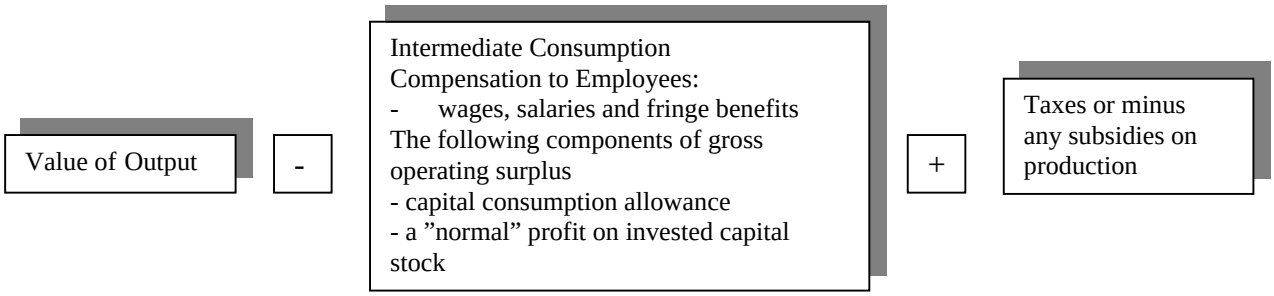
reported in Namibia's case, since the stocks of diamonds and uranium are confidential), as well as on capital stocks used in the mining of each mineral (which there is no information on).

The net-price method (Repetto *et al.* 1989) builds on the work of Hotelling (1931) and assumes that the value of a resource stock is always equal to the current per-unit rent multiplied by the stock of the resource; hence, eradicating the need to discount future net earnings. It is likely that this assumption does not always hold, but given the problems in forecasting volatile mineral prices and changes in technology, this simple assumption may yield results as good or better than other methods. This method was, therefore, chosen.

d) Employing the Net-Price Method in Namibia

When using the net-price method the marginal costs for exploiting a resource, including the opportunity cost of capital invested in the business, should be subtracted from the market price of the resource. In practice, data on marginal costs and opportunity costs are rarely available. Average cost is therefore used as a substitute for marginal cost, but it should be noted that since marginal costs are normally higher than average costs this tends to exaggerate estimates of resource rents. As a substitute for the sector-specific opportunity cost of invested capital it is common to use the average return on capital in the whole economy, usually combined with a sensitivity analysis where alternative rates of return are used.

Using the net-price method with these modifications, the resource rent can be calculated with data from the national economic accounts in the following manner:



Per unit rent = Total rent/Quantity of output

Value of resource stock = (Per unit rent) x (Quantity of economic reserves)

All the data required to calculate the total rent are reported in the national accounts statistics except for the 'normal' profit earned on invested capital, which had to be estimated separately (Central Statistics Office 1996a, 1996b). The average net return to capital has varied considerably in Namibia from year to year, but the long-term average lies slightly under 20 percent. In order to examine the sensitivity of the results rents were estimated for profits of 10 percent and 20 percent, separately – 10 percent is closer to the normal profit used for similar calculations in most other countries. In many countries the gross operating surplus may include the earnings of self-employed business owners, and an attempt must then be made to separate the return on time spent working in the business from the return on the capital invested in the business. Fortunately, this issue can be ignored in studying the Namibian mining and fishing sectors, because both industries are dominated by large companies rather than self-employed operators.

In Namibia, the fishing and fish processing sectors are closely integrated, and although the national accounts attempt to differentiate between the two this is difficult to do in practice. The annual rates of return on capital have been far higher in fish processing than in any other economic sector throughout the 1980s and 1990s, indicating that the value used to price fish as an input to fish processing has been too low and that, consequently, a large part of the resource rents from fisheries is transferred to fish processing. In order to calculate the resource rents from fisheries, data for the two sectors were therefore aggregated and treated jointly.

e) Results

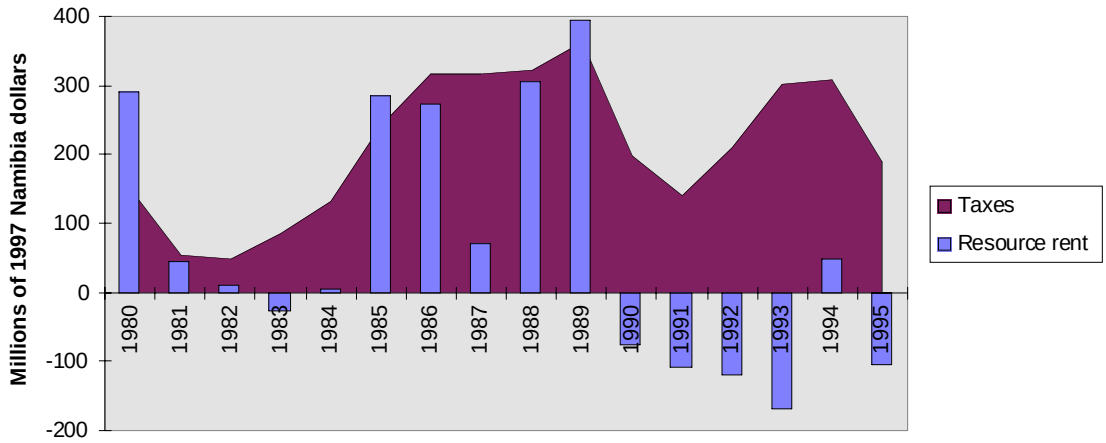
The period 1980–95 was studied for both sectors. In the mining sector, it was not possible to calculate rents for each mineral separately, due to the problems noted above with confidentiality and data availability. In the fishing sector, species-specific data are available on revenue, but not on costs. It was therefore impossible to estimate rents separately for each species and, consequently, to estimate the value of the depletion of the various fish stocks. Rents were therefore calculated for the entire mining and fishing sectors aggregated, and although physical accounts were compiled for the stocks of various minerals and fish species the monetary values of these stocks could not be calculated.

Assuming a normal profit of 20 percent, resource rents in the mining sector turned out to be negative for most years in the 1990s. Short-term downturns are not unusual in capital-

intensive industries such as mining, but it should also be noted that tax revenues including royalties, levies and special taxes have been greater than the resource rents in most of the years studied (Figure 1). This indicates that government has been highly successful in recovering the resource rents from mining.

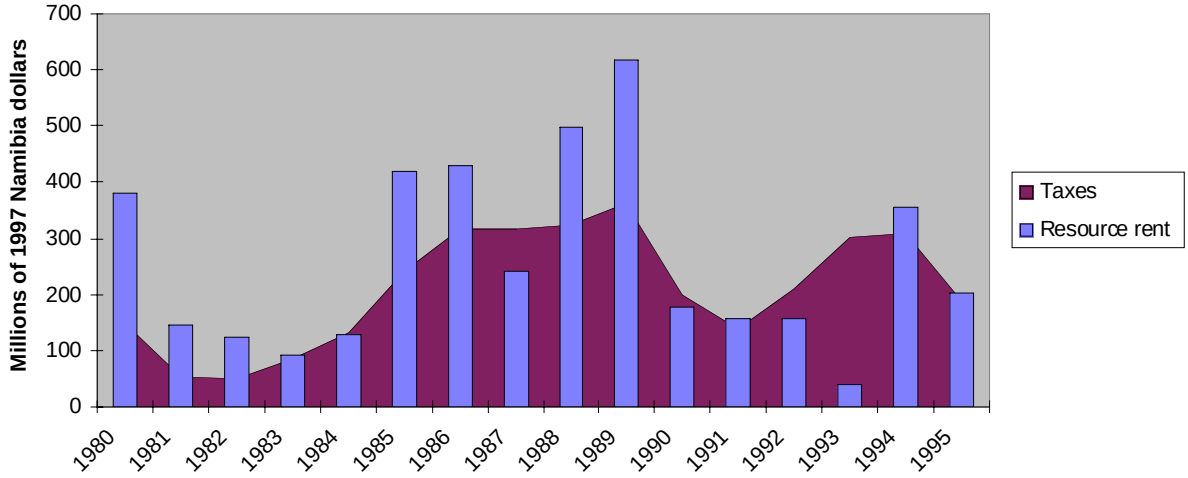
Assuming a normal profit of 10 percent, resource rents become positive throughout the period studied and greater than taxes in 11 of the 16 years studied (Figure 2). Possibly, the opportunity cost of capital may be lower in the mining sector than in other parts of the Namibian economy and hence closer to the rates of return in other countries.

Figure 1: Resource rent and taxes from mining assuming a 20 percent return to capital invested, 1980–95



Source: Lange and Motinga (1997).

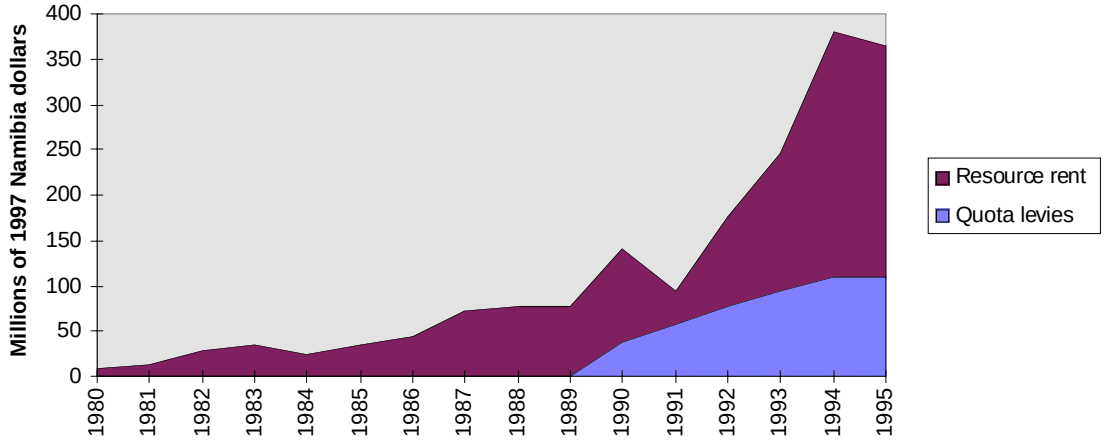
Figure 2: Resource rent and taxes from mining assuming a 10 percent return to capital invested, 1980–95



Source: Lange and Motinga (1997).

In the fishing sector, resource rents have been positive throughout the period studied, even with a normal profit of 20 percent (Figure 3). Levies and special taxes were introduced in 1990, and before then all resource rents accrued to the fishing industry. From 1990, when fishing became regulated and domestic operators began to enter the industry, resource rents rose dramatically, and although government is recovering some of these rents through levies and taxes there is still a substantial part accruing to the private sector – most of which is in foreign hands (Manning and Lange 1998).

Figure 3: Resource rent from fisheries and fishing quota levies assuming a 20 percent return to capital invested, 1980–95



Source: Lange and Motinga (1997).

f) Policy implications

These results indicate that government has been highly successful in recovering the resource rents from the mining sector; mining is a well-established activity in Namibia and there is much experience in dealing with the domestic mining industry. It is more difficult to judge whether these captured rents from mining are being invested in an economically sustainable manner. However, over 30 percent of the government budget is for education and health expenditures, and it could be argued that this investment in human capital is enough to offset the depletion of natural capital.

Government has deliberately sacrificed some of the resource rents from fishing in order to encourage more Namibian firms to enter the industry. Although this creates an incentive for excessive entry, the fishing sector is not only controlled through economic incentives but also through fishing quotas, decreasing the risk of overfishing. As the domestic fishing sector develops it should become possible for government to recover an ever-larger portion of the resource rent, for instance, by auctioning off fish quotas.

CASE STUDY 4: Trade and Environment[20]

a) Introduction

Two issues that have topped many international policy agendas in recent decades are trade liberalisation and environmental conservation. The debates over the Uruguay Round of the GATT and the North American Free Trade Agreement (NAFTA) between the U.S. and Mexico have involved significant issues of environmental protection, industry flight, competition through more lax environmental policies, and the use of environmental policies as non-tariff trade barriers[21].

There are four important issues within the trade and the environment debate that relate to economics:

- The effects of trade liberalisation (e.g. tariff and subsidy reductions) on the environment;
- The effects of environmental regulations on trade flows, i.e. on comparative advantage, specialisation, and plant locations;
- A possible negative effect on the enactment, improvement, and enforcement of environmental policies of globalisation and the increased competition on world markets (a "race to the bottom"); and
- The use of trade restrictions to achieve environmental goals.

b) Conceptual Issues

The impact of trade liberalisation on pollution levels is not clear, and is country-specific. It can help or hurt the environment depending on which sectors expand or contract and by how much, and on the type of environmental policies in place. It is useful to separate three effects by which a liberalisation of trade policy can influence the level of pollution and the rate of depletion of scarce environmental resources:

The first effect is the *scale effect*, which is due to the fact that more open trade creates greater economic activity, which raises the demand for all inputs such as raw materials, trucking transportation services and energy (e.g. fossil fuels). If output is produced and delivered by

[20] Material drawn from EDI (1998).

[21] See Dean (1992) and Jaffe *et al.* (1995) for surveys of various aspects of the literature. See also Zarrilli *et al.* (1997) for an overview of various issues.

the prevailing methods, an increase in emissions must follow and this has been labelled a scale effect (see Grossman and Krueger 1993).

Second, the *composition effect* stems from the changes in the relative size of an economy's sectors that follow a reduction in trade barriers. Countries tend to specialise in sectors in which they have a competitive/comparative advantage. If environmental regulations are important in determining competitive advantage, a country with lax regulations in all sectors will end up specialising to a greater degree in the more polluting industries. If, however, the base for international competitive advantage are differences in labour and capital abundance or technology differences, then the result of the changing sector composition due to trade liberalisation on environmental quality is ambiguous. Since more open trade makes a country shifting into sectors using heavily its relatively abundant factors. The final effect depends on whether the new sector composition is more or less polluting than the original one. Developing countries tend to have a comparative advantage in labour intensive sectors, and these sectors are in general relatively cleaner than capital intensive sectors.

Third, the *technique effect* refers to changes in the production method that follow trade liberalisation. Pollution emissions per unit of output do not necessarily stay constant. First, trade liberalisation is widely credited for generating increased income levels, and this will increase the demand for environmental quality. Assuming that this leads to political pressure for more stringent policies, the per unit pollution load will be lower. Second, if investment liberalisation also takes place, foreign investment will bring modern technologies likely to be cleaner than the old versions[22].

c) The Export-Import Ratio

A simple way to look at environment-trade issues is the *export-import ratio*. The export-import ratio for polluting goods can shed some light on the question if developing countries are net exporters, and developed countries net importers, of pollution-intensive goods. For a given country, this is the ratio of the total value of exports to the total value of imports of the products of the six most polluting industrial sectors. These sectors were identified, first, by ranking the pollution control expenditure per unit of output across industries in the United States and other OECD economies, and secondly by ranking the emissions intensities (in

[22]As Birdsall and Wheeler (1992) note, if foreign technology is cleaner, or exports must be cleaner to meet higher foreign standards, then more open economies would see cleaner growth.

terms of air pollutants, water pollutants, and heavy metals) across industries in the United States. The six sectors resulting from this ranking are (some highly polluting sectors such as low technology coal-fired thermal power stations that are basically 'domestic' in orientation are not included):

- Iron and steel ;
- Non-ferrous metals;
- Industrial chemicals;
- Petroleum refineries;
- Non-metallic mineral products; and
- Pulp and paper products.

Table 1 shows the calculated export-import ratio for all countries which data was available for in 1986 and 1995. A ratio greater than one indicates that the country is a net exporter of polluting products. Contrary to a common perception, the results show that with few exceptions, developing countries tend not to specialise in heavily polluting industries. Instead, exports are lower than imports for the polluting sectors and the export-import ratio is less than one.

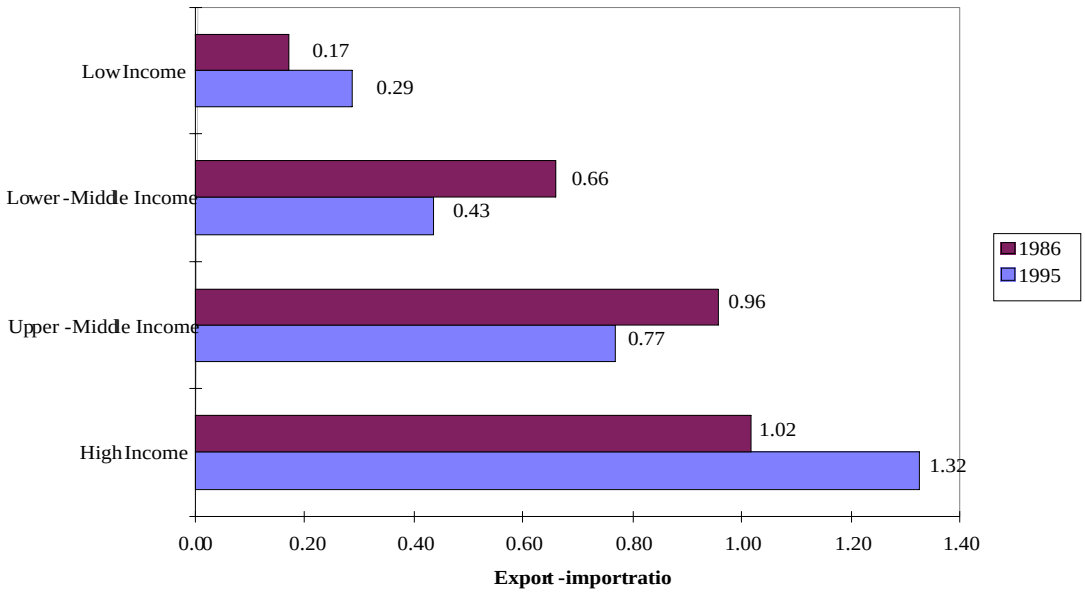
Figure 1 shows that lower income countries tend to have lower export-import ratios. Most high-income countries have ratios near to, or greater than, one. These countries, particularly those with large resource sectors, appear to be the source of polluting goods.

Table1: Export-import ratios

NO	*COUNTRY*	*1986*	*1995*
1	ALGERIA	1.01	0.95
2	ARGENTINA	0.60	0.58
3	AUSTRALIA	1.00	1.11
4	AUSTRIA	1.29	1.21
5	BARBADOS	0.12	0.13
6	BELGUIM-LUX	2.62	2.04
7	BOLIVIA	1.24	0.51
8	BRAZIL	1.57	1.02
9	CAMEROON	0.23	0.53
10	CANADA	1.91	2.05
11	CHILE	2.75	2.52
12	COLOMBIA	0.35	0.34
13	COSTA RICA	0.18	0.18
14	CYPRUS	0.18	0.08
15	DENMARK	0.42	0.53
16	EGYPT	0.20	0.35
17	EL SALVADOR	0.19	0.20
18	FINLAND	2.42	2.81
19	GERMANY	1.14	1.18
20	FR.GUIANA	0.02	0.03
21	GREECE	0.55	0.48
22	GUATEMALA	0.09	0.15
23	HONDURAS	0.03	0.03
24	ICELAND	0.86	0.67
25	INDIA	0.13	0.37
26	INDONESIA	0.48	0.43
27	IRELAND	0.69	1.08
28	ISRAEL	0.69	0.57
29	ITALY	0.77	0.71
30	JAMAICA	0.66	1.05
31	JAPAN	1.26	1.19
32	JORDAN	0.32	0.41
33	KOREA	0.65	0.68
34	KUWAIT	0.39	0.31
35	MADAGASCAR	0.06	0.05
36	MALAYSIA	0.39	0.36
37	MAURITIUS	0.03	0.04
38	MEXICO	0.82	0.71
39	MOROCCO	0.82	0.66
40	NETHERLANDS	1.91	1.33
41	NEW ZEALAND	0.46	0.80
42	NICARAGUA	0.04	0.04
43	NORWAY	1.26	1.19
44	OMAN	0.11	0.27
45	PAKISTAN	0.06	0.02
46	PANAMA	0.04	0.07
47	PERU	0.92	1.01
48	PHILIPPINES	0.44	0.20
49	POLAND	0.95	0.98
50	PORTUGAL	0.69	0.60
51	SENEGAL	0.92	1.16
52	SINGAPORE	1.63	0.65
53	SPAIN	1.00	0.77
54	SWEDEN	1.60	1.65
55	SWITZERLAND-LIECHT	0.82	1.01
56	THAILAND	0.16	0.17
57	TRINIDAD TOBAGO	2.66	6.61
58	TUNISIA	0.80	0.67
59	TURKEY	0.55	0.41
60	UNITED KINGDOM	0.89	0.85
61	URUGUAY	0.22	0.24
62	USA	0.51	0.89
63	VENEZUELA	2.61	0.95
64	ZIMBABWE	0.89	0.56
	WEIGHTED AVERAGE	**0.97**	**1.16**

Source: The World Bank

Figure 5.1: Trade of Dirty Industries by Income



Has trade liberalisation in 1986-95 influenced this pattern? Whereas middle-income countries' average export-import ratios fell, those for high and low income countries increased (Figure 1). For high-income countries, the ratio increased by 29 percent to 1.32. For the United States, the increase was 75 percent. For low-income countries, the increase was 71 percent, possibly the result of the rapid export growth typical of the early stages of industrialisation. Mexico, which has brought down trade barriers swiftly, has a lower export-import ratio in 1995 (0.71) than in 1986 (0.82), signalling a shift away from specialisation in highly pollution intensive goods.

As discussed above, there may be several explanations for these results. Environmental protection costs may be lower than wage and capital costs, so that specialisation is driven largely by already entrenched technologies and by economies' relative abundance of labour and physical capital. Countries with a large labour supply tend to specialise in relatively "clean" labour-intensive sectors, whereas physical and human capital intensive countries specialise in more-polluting sectors.[23]

[23] World Bank research finds that the traditional five most pollution-intensive sectors are approximately three times more energy intensive, twice as physical-capital-intensive (both in terms of capital/output and investment/output), and on average 2.5 times less labor intensive than the 5 cleanest sectors [see Mani and Wheeler (1997)]. However, some sectors such as leather products are highly pollution intensive (ranking ninth in overall emission intensity)

The tendency of countries to specialise in sectors in which they are relatively well endowed with factor inputs is reinforced by lower trade barriers. Given that the most capital-intensive economies are in the OECD, this implies that pollution-intensive production increasingly takes place in countries with relatively stringent regulation.

However, as environmental regulations become stricter this may shift comparative advantage. Moreover, some of these industries tend to be relatively immobile, given their heavy dependence on a natural resource as a main factor of production. This cannot explain the changes in the export-import ratio over time, however. In addition, some resource dependent sectors such as petroleum refineries, tend to be close to the market rather than to the source of the input. Finally, various subsidy policies may be important for the explanation. A recent theory proposed by Eliste and Fredriksson (1998) suggests that industries with high abatement costs have enjoyed great subsidies as compensation for these costs. Therefore the expected changes in trade patterns have been mitigated.

c) Policy Issues

The key to ensuring that trade liberalisation improves the environment as well as increasing real incomes is to have sound environmental policies in place. These policies need to deal with the spillovers that are at the root of most environmental problems. Key policy reforms needed in developing countries include the establishment of secure land tenure to encourage sustainable use of land and resources such as forests and fisheries, and the introduction of policies based on the Polluter Pays Principle to deal with pollution problems. Strong environmental legislation, clear environmental standards and the ability to enforce these are also important. A package of economic incentives and appropriate penalties for poor performance are required.

When are trade restrictions appropriate for achieving environmental goals? If they are to be used at all, trade restrictions should only be used with extreme caution in support of environmental goals. In general, trade policies are not the best policy measures for environmental objectives. Even if trade policies are environmentally beneficial, they will generally be inferior to policies

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and labor intensive. The latter sector often consists of many small production units, making efficient environmental regulation difficult.

targeted directly at an environmental problem. Where consuming a good causes pollution, an import barrier will reduce consumption, but it will also create a distortion that favours domestic production of that good. By contrast, a consumption tax will reduce consumption without creating an incentive to expand domestic production of that good.

Allowing unilateral trade sanctions against local pollution in another country would fundamentally shift the trading system towards one based on power, rather than rules. Unilateral sanctions are only be likely to be effective when imposed by large countries against small countries. As a consequence, only the concerns and preferences of large countries would have any chance of redress, and this redress would be achieved at the expense of the sovereignty of the small countries forced to submit. Many developing countries view such policies as a move toward “eco-imperialism” and policies frequently are strenuously opposed both by developing country governments and by environmental groups in developing countries. Further, unilateral trade sanctions are incomplete as environmental policies; they are likely to address only environmental concerns in the export sector, ignoring damage occurring in the rest of the economy.

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