Trade and the Environment

A case study of the South African iron and steel industry

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Abstract

The aim of this dissertation is to analyse the trade and sustainable linkages in industry, using the South African iron and steel industry as a case study. That particular sector has been chosen because of its importance to the South African economy, and its vulnerability to trade measures.

The case study outlines the economic profile of the industry, trade profiles and the structure of trade policies within the sector. International trade agreements affecting the iron and steel industry, and their structures in terms of creating incentives or disincentives for exports or imports, are discussed.

An overview is presented of the environmental profile within which the sector is currently operating. The study gives consideration to environmental impacts generated within this sector as a result of its production activities, and outlines abatement measures for individual companies, as well as for government. Different public and private abatement instruments are described, and the level of South African environmental standards is compared with international standards.

Scenarios are explored to assess the potential implications of 'green' trade barriers and harmonisation of environmental standards for the iron and steel industry. The last section of the document addresses the possible impacts of international trade and environmental agreements on sectoral behaviour. The impacts of regulation on the competitive advantage of the sector, employment and choice of geographical location are presented. Further, some of the main driving forces of environmental reform are explored, and the extent to which trade and sustainability issues have been addressed in terms of policy and regulations is discussed.

1. Introduction

This dissertation does not present an argument in terms of the advantages and disadvantages of trade and its affects on the environment. Instead, it looks more specifically at the implications of environmental measures aimed at internalising externalities associated with trade. The dichotomy that exists in the enforcement of environmental measures is shown by reference to specific case studies in which the motivation for such measures is in some cases clearly based on protectionist sentiments. The implications of environmental measures for local industries are examined without making specific inferences about the motivation for such action. International trade action is rather treated as an exogenous effect that requires internal adjustment in order for the industry to remain competitive.

The South African basic iron and steel industry is used here to illustrate the importance that trade-related environmental measures may hold for developing economies in the future. The sector contributed 16.9 per cent to manufacturing exports in South Africa during 1997 (SAISI, 1998). Although the growth rate of this industry is not increasing significantly, its contribution to manufacturing GDP is 7.2 per cent (Rosenthal, 1998).

Local steel producers have been accused of dumping steel on the global market. Steel producers in importing countries assert that historical subsidisation in the steel industry is causing international trade distortions which lend South African steel producers an unfair comparative advantage. As a result, various calls have been made in recent years for countervailing and anti-dumping duties to be imposed against South African producers. Environmental regulation, as an anti-dumping measure, has become a hotly debated topic in both trade and environmental circles. Counter-arguments have been made that the motivation for such actions is protectionist in nature.

It is, however, crucial that South Africa's vulnerability to various trade measures be investigated. If South African producers are gaining a comparative advantage at the expense of the more stringent environmental policies of their international competitors, there is the possibility that the injured parties may seek retribution from international trade or environmental forums. The impact that potential measures such as countervailing and anti-dumping duties may have for the economy as a whole therefore has to be considered.

This dissertation gives an brief overview of the debate and conflicts around trade and the environment, and then presents a detailed case study of the South African iron and steel industry. It examines possible scenarios where differences in process and production methods (PPMs) between countries are used to motivate the implementation of trade measures against countries which apply less stringent environmental regulations. The implications of potential trade-related environmental measures that may be imposed on a typical export industry are addressed.

Chapter 2 presents a brief background to the international debate on trade and environmental issues. It covers some of the main examples where trade measures are used for environmental purposes and discusses why these measures are being used. The economic importance of the iron and steel sector is discussed in Chapter 3 in terms of general productivity, and contributions to GDP, employment and trade.

Chapter 4 provides the reader with a technical background to the iron and steel industry. The environmental risks associated with various stages of production are outlined in detail. In order to show the links between each phase of production and its associated range of pollutants, the two standard production processes for steel are described in Section 4.1. Abatement options applicable to industry in general, but also those connected specifically with the iron and steel industry, are discussed in Chapter 5. Private as well as public mitigation options are identified.

Chapter 6 compares current international environmental standards with local standards and regulations. The implications of environmental regulation for trade and the environment are investigated in Chapter 7. Two specific instances (the harmonisation of standards and the imposition of green trade barriers), where international action may be taken in future, are investigated, and likely scenarios developed. Basic input-output analysis was used to determine the overall economic implications of reductions in trade of products originating from the basic iron and steel industry. General questions raised in the debate over trade-related environmental regulation are further addressed.

2. Background to the Trade/Environment Debate

2.1 *Introduction*

This chapter presents a brief survey of the literature surrounding the trade and environmental debate. More specifically, the chapter sets the background for the case study of the basic iron and steel industry by summarising the complexities surrounding externalities related to process and production methods (PPMs). The potential for protectionist use of environmental regulatory measures ostensibly aimed at these externalities is illustrated with an overview of the conflicts between current global trade agreements and multilateral environmental agreements, with reference to extra-territorial externalities.

The interactions between trade and the environment are explored. Conventions, agreements and regulations intended to protect either trade or the environment are highlighted, and their implications are discussed briefly. Existing mechanisms for dispute settlement are then considered. The last section of the chapter discusses the use of trade measures for environmental purposes. Reasons why trade measures are applied to global environmental problems are explored, and some of the associated problems are discussed. Externalities are examined in more detail, and the legitimacy of the application of trade measures to certain extra-territorial externalities are summarised. Lastly, economic instruments and specific trade measures used or proposed as means to deal with trade-related environmental problems are covered, with specific focus on trade measures aimed at process and production methods (PPMs).

2.2 *The advantages of trade liberalisation and its environmental implications*

This section discusses key concepts with regard to trade liberalisation and its potential for environmental degradation. Arguments in favour of an environmental Kuznets curve (EKC) are presented, together with specific criticisms of this school of thought.

As Daly (1994) points out: "No economic doctrine is more widely accepted among economists than that of free trade based on comparative advantage". Economic arguments in favour of free trade originated in the work of Adam Smith, who argued that prosperity is inherently dependant on specialisation of labour: the increased efficiency resulting from specialisation gives rise to higher productivity. Ricardo later outlined the principle of comparative advantage, which has become the theoretical rationale underlying international trade. According to Ricardo, a nation has a comparative advantage over another nation in the production of a particular good if the cost of producing this good, relative to the cost of making other goods, is lower in the first nation. Trade therefore allows nations to specialise in the production of goods and services in which they are most efficient, and thus allows them to optimise production given restricted inputs (Daly, 1994).

The removal of distortionary subsidies and pricing policies, and improvement of efficiency of resource allocation, are further advantages of trade. Trade liberalisation creates new market opportunities and enhances economic activity (Schlagenhof, 1995). As an important and increasing component of demand, trade can raise output through export-led growth (Brack, 1998), and results in an improvement of the overall welfare of the country concerned.

More than ever before, globalisation has become the context wherein markets function. Countries across the world are increasingly turning to outward-oriented policies in pursuit of growth (Bagwati, 1993). Protectionist measures such as quotas, subsidies and tariffs are being phased out internationally, and much pressure is being exerted on developing countries to comply with these measures in return for debt relief. The importance of ending economically distortionary practices such as subsidies for agriculture or the energy sector is widely recognised, in that it benefits both trade (improving allocative efficiency) and the environment (removing support for environmentally unsustainable activities). There is also broad consensus that the practice of tariff escalation, whereby developing countries face higher tariffs against exports of manufactured and processed goods than for raw materials and primary products, needs to be phased out. This will enable developing countries to diversify economic development and reduce reliance on the export of natural resources (Brack, 1998).

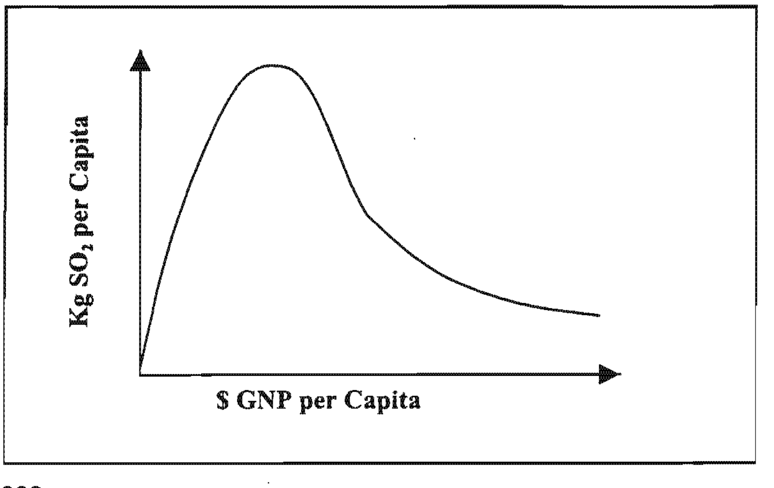
Trade liberalists often argue that trade in itself does not cause environmental damage, and can promote development through increased market access in pursuit of economic growth, whereas a lack of development will lead to further environmental decline. Free trade still operates with the implicit assumption that production will occur where comparative advantage is greatest. According to Brack (1998) increased efficiency, an implicit criterion for competitiveness, is by its nature less demanding on the environment, uses less raw material and creates less waste and emissions. These improvements are effected through positive measures such as sound environmental policies, capacity building, and technology transfer.

There are, however, caveats to the advantages of free trade which have important implications for developing countries and their environments. Trade is based on the assumption of perfect market conditions. Economic pricing does not include social costs associated with the environmental externalities and resource depletion resulting from higher levels of production and trade.

Environmentalists warn that trade has negative implications for the environment if it is not well co-ordinated, and if appropriate environmental policies are not in place (Robins, 1998). In this regard, international trade serves to magnify unsustainable resource degradation and waste generation by increasing production volumes and associated activities.

It is widely accepted that the protection of nature and natural resources has become a basic requirement of sustainable development and longer-term economic growth. The implications for the environment of increased trade and resulting economic growth have been discussed in great detail. Some of these arguments are best illustrated with respect to the Kuznets curve. The environmental Kuznets curve (EKC) hypothesis states that an inverted U-shape relation exist between environmental degradation and income *per capita*. The basis for this hypothesis is that the environmental damage caused by early stages of economic development are likely to be redressed in subsequent stages of economic growth (Stern, 1998). Figure 1 illustrates a typical example of an EKC.

Figure 1 The environmental Kuznets curve



Source: Stern, 1998

According to supporters of the EKC (such as Panaytou, 1993, cited in Stern, 1998), environmental impacts are low at very low levels of economic activity, whereafter rates of land clearance, resource use, and waste generation *per capita* increase rapidly as economic development takes off. At higher levels of development a significant levelling-off and subsequent decline of environmental degradation occurs. This is generally ascribed to structural changes within the economy concerned, as industries and services become information-intensive. The World Bank's ***World Development Report*** (1992) states that "As income rise, the demand for improvements in environmental equality will increase, as will the resources available for investment" (Stern, 1998). Bagwati (1993) also supports this view, arguing that the advantages of increased income *per capita* include direct reduction of poverty and indirect curbing of poverty by 'basic needs' programmes, funded by increased public earnings. The latter would also contribute to funding for pollution control and remedial clean-up.

Higher levels of income are therefore associated with increased environmental awareness, enforcement of environmental regulations, more efficient technology and higher environmental expenditures (Brack, 1998; Stern, 1998). Further indirect benefits of income growth for the environment are lower population growth rates and increased levels of employment.

Critics of the EKC concept have countered that the empirical evidence for the EKC is weak, statistical techniques are inappropriate, and that only a subset of relationships have been found for which the EKC relationship holds. Moreover, static comparison between rich and poor countries does not necessarily reveal the dynamic outcomes occurring as countries experience economic growth (Arrow, 1995; Stern, 1996).

The levels of many pollutants per unit of output in specific processes have declined in developed counties over time due to stringent environmental regulations and technological innovations. However, Stern (1998) observes that a shift in effluent mix has occurred: while sulphur and nitrogen oxide emissions have declined significantly, there has been a compensating increase in carbon dioxide emissions and solid waste *per capita*. Thus far, no EKC relationships have been suggested for greenhouse gases or for energy use *per capita* (Suri, 1997).

In addition, as Bagwati (1993) points out, the reduced levels of pollution in highly industrialised countries may still be higher, in absolute terms and also as a proportion of GNP, than in poor countries. The increase in the supply of pollution has not been equalled by effective demand to reduce environmental damage. Although growth may result in the reduction of specific pollutants such as sulphur dioxide, no such assertion can be made for pollution in general.

Another criticism of the EKC theory relates to the implications of trade for the environment. The Hecksher-Ohlin model of free trade predicts that countries would specialise in production of goods that are intensive in the factors that they are endowed with in relative abundance. Developing countries would specialise towards production of goods intensive in labour and natural resources, while developed countries would specialise in production intensive in human and manufactured capital. Trade is therefore likely to increase environmental impacts in developing countries while reducing them in developed countries. The difference in stringency of environmental regulations between countries may also cause polluting activities to gravitate towards developing countries (Lucas, 1992; Suri, 1997; Hettige, 1992).

An implication of the Hecksher-Ohlin model is that EKC relationships currently observed for developed countries are supported by imports of resource-intensive products from developing countries. It is, however, unlikely that a similar EKC relationship between environmental damage and income growth will be apparent as developing countries attain similar growth levels. The poor countries of the present will not have the luxury of importing resource-intensive products from less developed countries to sustain their growth patterns. Where industrialised countries today have the opportunity to shift their environmental problems unto less developed countries, poorer countries will face the costly and difficult task of abatement, as they attempt to align environmental regulation with the industrialised world (Arrow, 1995; Stern, 1996).

2.3 Trade and environmental agreements

This section examines the development of international trade and environmental agreements. Uncertainties in the GATT around the use of trade measures for environmental purposes are discussed, along with areas in which conflicts have arisen.

2.3.1 The signing of the GATT and founding of the WTO

Trade agreements with built-in structures to reduce tariffs and dismantle trade restrictions have largely shaped the profile of present-day international trade. In 1947 the globalisation of the world economy was accelerated by the creation of the General Agreement on Trade and Tariffs (GATT). The GATT was in principle erected in honour of economic efficiency and comparative advantage. This revolving contractual agreement between governments is formulated around simple trade rules to prevent discrimination between countries.

During the Uruguay Round extension of the GATT in 1995, the World Trade Organisation (WTO) was founded to augment and take further the work that was initiated under the guise of the GATT. The meeting in Marrakech (1994) that preceded the official signing of the GATT concluded with approval of the results of the Uruguay Round by trade ministers from around the globe. A significant decision was taken at the Marrakech meeting to begin a comprehensive work programme on trade and environment in the WTO.

2.3.2 Multilateral environmental agreements and environmental regulations relevant to trade

As a result of increasing international trade, multilateral solutions to trans-boundary or global environmental problems have had to be sought. Multilateral Environmental Agreements (MEAs) are favoured as the most tenable solution to international environmental problems, and are increasingly being used to enforce the internalisation of global environmental externalities (Brack, 1998).

Drake-Brockman and Anderson (1994) have suggested that it may in future be necessary to create a multilateral environmental organisation which could set rules, incorporate existing environmental agreements and settle disputes, similarly to the way in which the GATT had hitherto presided over trade issues. The primary advantage of such an organisation would be to avoid the use of trade measures to account for externalities, but instead to ensure the implementation of more appropriate policy instruments for achieving environmental objectives.

Significant consequences for trade have emerged during the past decade as a result of the 'greening' of world politics. In 1987 the World Commission on Environment and Development defined the principles on which sustainable development is based. During the UN Conference on Environment and Development (UNCED) or "Earth Summit" in Rio de Janeiro in 1992, the world community identified an extensive set of issues known as Agenda 21, requiring international co-operation in the pursuit of sustainable development. It was recognised success in national and international attempts to secure the sustainable utilisation and development of environmental resources necessitated an equitable and non-discriminatory multilateral trading system (Bagwati, 1993).

A second major step in aligning world trade and sustainable development stemmed from the Uruguay Round of multilateral trade negotiations at Marrakech in 1994, with the establishment of the World Trade Organisation (WTO), which has superseded the GATT. One of its main objectives is to expand production and trade, while allowing for optimal use of the world's resources in accordance with the objective of sustainable development (Drake-Brockman and Anderson, 1994).

In 1995, with the coming of age of the WTO, a subsidiary Committee on Trade and the Environment (CTE) was established. The role of the CTE has been to take forward the work carried out by the GATT Working Group on Environmental Measures and International Trade. Although the committee was intended to co-ordinate policies in the fields of trade and the environment, its mandate was limited to trade policies and environmental policies which may result in significant trade effects (Drake-Brockman and Anderson, 1994).

Other existing MEAs which deal specifically with trade include the Basle Convention on hazardous waste, the Convention on International Trade in Endangered Species (CITES), the Montreal Protocol on ozone-depleting substances and the Kyoto Protocol to the Climate Change Convention (Brack, 1998).

Trade measures also have potential for the enforcement of international environmental agreements. The Montreal Protocol (aimed at phasing out of chloro-fluoro-carbons [CFCs] which damage the ozone layer) is an example of an MEA which used trade provisions both to reward compliance and penalise non-compliance. One of the features making trade policy attractive to environmentalists is that trade measures, or even the threat of trade measures, are relatively easy to use and are immediate in their impact (Drake-Brockman and Anderson, 1994).

2.3.3 Uncertainties relating to the environment in the GATT

Although GATT rules and environmental policies interact indirectly in many areas, GATT's main objective has been the liberalisation of trade between contracting parties. The CTE has also maintained that it is the role of national governments and international environmental organisations to focus on environmental priorities, set environmental standards and develop environmental policy. Their approach has been that the competence of the WTO in policy co-ordination is limited to trade, while acknowledging that trade-related aspects of environmental policy may have significant implications for the trade of member countries (Brack, 1998).

An imperative for the WTO is that if any steps are taken by the CTE to resolve trade-related environmental problems, these steps must be in accord with the principles of the multilateral trading system, formulated during the Uruguay Round of negotiations (Shaw, 1998). Further, the WTO supports multilateral solutions to global and trans-boundary environmental problems, and urges that unilateral action in this context should be avoided.

A major conflict of interest between trade and the environment has been the lack of agreement in the international forum regarding environmental measures (i.e. taxation, regulation and/or standards) that seek to internalise environmental externalities. Some GATT rules are open to varying interpretations that can give rise to trade friction and protectionist abuse. Issues prone to uncertainty with regard to environmental policies under present GATT rules include:

- the extra-territorial application of certain types of domestic environmental policies;
- the application of standards in trade;
- the use of subsidies;
- the use of trade sanctions to achieve environmental goals; and
- the overall relationship of international environmental agreements to the GATT (Brack, 1998).

These concepts have not been defined in sufficient detail, and in many ways this is new territory for international case law (Sorsa, 1992).

The main parts of GATT having implications for the treatment of global and national environmental priorities are Articles I and II, which include the basic rules on border adjustments, most favoured nation treatment and like products. Under the most favoured nation principle, any trade advantage extended by one trading nation to another must automatically be extended to "like products" of all GATT members.

Article XX sets out general exceptions to GATT principles, and among other things requires countries to adopt the least trade-distorting policies available, and to apply them in a non-discriminatory way. Interpretation of this text is, however, open to confusion, as the concepts used are vague and remain open to dispute. A key issue that has been debated as regards environmental policies is the legitimacy of restrictions on imports on account of differences in process and production methods PPMs (Sorsa 1992).

Environmental exceptions also fall under Article XX, including exceptions for public policy goals, the Standards Code, and rules on dumping and subsidies. The Agreement on Technical Barriers to Trade (TBT), also known as the Standards Code, makes provision for the use of certain environmental measures in that it recognises the precedence of public policy goals over free trade under certain circumstances. The Code is unclear regarding extra-territoriality and PPMs. The GATT ruling in favour of Mexico in the tuna/dolphin dispute implies that environmental measures are justified only where harmful environmental effects of "related" process and production methods is incorporated into the *product* (Steward, 1998).

In an attempt to enhance competitiveness between countries, GATT sets limits to the use of subsidies towards environmental policies. The Agreement on Subsidies and Countervailing Measures makes provision for government assistance to industry in order to absorb the cost of adapting existing facilities to new environmental legislation. Governments have the option of providing non-actionable subsidies of up to 20 per cent of the adaptation costs (Shaw, 1998).

According to GATT, countervailing duties can be imposed if there is injury to a domestic industry and evidence of a subsidy. Provided that measures are in compliance with GATT principles of non-discrimination and national treatment, GATT allows countries to impose product controls in furtherance of the environmental and health objectives of those countries. Unfortunately the provisions are not clearly defined, and are open to abuse for protectionist purposes.

2.3.4 Disputes

Conflict between trade liberalisation and sustainable development has occurred as a result of regulations and MEAs formulated in pursuit of environmental sustainability. Measures aimed at rectifying market failures which fail to internalise environmental externalities resulting from trade and production are increasingly being challenged on the grounds that they are barriers to trade. Disputes have arisen between trading parties where importing countries have introduced measures aimed at environmental protection. The legitimacy of such trade measures is often challenged on the ground that they violate fundamental GATT principles.

The WTO has in some cases served as an arbitration panel for trade/environmental conflicts between countries (see Section 7.1). Invariably, these cases are drawn out, and the lack of timely dispute resolution has led some industries to suffer enormous losses in the interim. Previous disputes have been settled on a case-by-case basis, and the confusion surrounding the GATT exceptions have not been clarified sufficiently by any of the WTO rulings.

The most crucial and pivotal disputes subjected to WTO rulings have been the tuna/dolphin and shrimp/turtle cases, both of which involved the USA and its trading partners. Both cases are discussed in some detail in later sections.

2.4 The use of trade measures to pursue environmental goals

This section suggests reasons why trade measures such as standards, taxation and sanctions are increasingly being proposed as solutions to multilateral environmental problems. Externalities are classified as uni-directional or mutual; the latter is further subdivided into consumption- or product-related externalities, and production-related externalities.

The lack of international consensus with regard to environmental measures seeking to internalise externalities has become one of the major sources of conflict between trade and the environment. Support for the application of trade-restrictive regulations on environmental grounds is growing among WTO member countries. These arguments are strengthened by measures aimed at controlling air pollution and hazardous chemicals. Any restrictive trade measure imposed under the guise of environmental protection threatens trade liberalisation if it risks being used for protectionist purposes (Brack, 1998).

In general, either punishment or reward strategies can be used to induce enforcement of environmental policies. Traditionally, unilateral action and enforcement of policies are limited by sovereignty, and co-operative measures aimed at adoption of policies across countries have to be resorted to if global commitment to environmental objectives is to be secured (Sorsa, 1992).

A major attraction of trade measures is the relative ease with which such measures can be used to enforce international environmental agreements designed to protect the global 'commons'. Trade measures have the additional advantage of resulting in immediate impacts. In practice, countries can be pressured into joining an international environmental agreement and complying with its rules merely by being threatened with trade sanctions (Drake-Brockman and Anderson, 1994).

Trade policy measures aimed at internalising costs associated with environmental damage are reputed to be highly inefficient, and are often responsible for disputes and retaliation between trading parties. Brockman and Anderson (1994) believe that trade restrictions fail to provide incentives for sustainable improvement, and generally do not eradicate the root causes of environmental problems. These measures could be sufficiently inappropriate to the extent that they may decrease the welfare of many export-oriented developing countries (Drake-Brockman and Anderson, 1994).

In order to illustrate how trade restrictions are used for environmental purposes, it is necessary to distinguish between the origins and destinations of different externalities. Pearce (1991) distinguishes between **uni-directional externalities**, which arise when the exporter of a good imposes an environmental cost on the importer of a good, and **mutual externalities**, which arise when pollution from an exporting nation affects a common resource such as the ozone layer, the atmosphere or the oceans.

Uni-directional externalities can be categorised in terms of :

1. consumption- or product-related externalities; and
2. production-related externalities.

Consumption-related externalities arise when the imported product fails to meet domestic environmental standards. Production-related externalities arise when environmental damage resulting from production in an exporting country is responsible for a perceived loss in welfare of the importing country. These externalities occur when the importing country takes on the role of caretaker of the global commons, while the exporting country does not value degradation of the environment as a significant loss in welfare to itself.

Mutual externalities or trans-boundary externalities are normally also production-related. However, process methods can be responsible for national and trans-national pollution. There are a variety of process and production methods perceived as environmentally damaging. These may have externalities such as damage of the ozone layer by CFCs, emission of CO_2 which may contribute to global warming, and emission of SO_2 which leads to acid rain.

Externalities arising from process and production methods have become the most important challenge to the GATT. As Pearce (1991) notes, controlling these externalities typically requires an international agreement (MEA), and subsequent enforcement of these agreements may involve the use of trade restrictions. As noted in the previous discussion on GATT uncertainties, trade actions aimed at curbing production-related externalities are clearly not allowed. There is, however, significant uncertainty with regard to the GATT exceptions, and WTO rulings on disputes related to PPMs have not provided conclusive guidelines for the treatment of these cases.

The application of trade sanctions to trans-national environmental problems is of major concern to parties involved in GATT negotiations. The interpretation of extra-territoriality in Article XX has led some to argue that trade restrictions would be justifiable in the case of trans-national pollution (Sorsa, 1992). Sorsa cautions against provision for unilateral trade sanctions under any circumstances, due to the difficulty involved in measuring the extent and existence of trans-national problems, the subjective value judgements involved, and uncertainty with regard to scientific evidence. The exact source of trans-national environmental damage is not easily determined, and the effectiveness of unilateral trade measures in themselves is in doubt. It can further be argued that the importer would have to apply the measure to all sources of environmental damage, in compliance with GATT requirements of non-discrimination. Unilateral trade action also present opportunities for protectionist abuse (Sorsa, 1992).

The concepts of externalities that are national *versus* those that result in trans-boundary impacts have remained a major point of contention for international trade. As a consequence of different environmental priorities in different countries, the standards and required mitigation costs incurred can differ significantly between countries. Environmental groups have suggested the use of countervailing duties to offset differences in environmental standards between countries (Charnovitz, 1993).

Gerardin argues that differences in the stringency of process standards among member states distort competition. Producers located in member states enforcing strict process standards will suffer a comparative disadvantage compared with producers located in member states enforcing less strict standards. All things being equal, this may result in increased sales, market share and profitability for those producers located in low-standard member states (Gerardin, 1998).

Drake-Brockman and Anderson (1994) note that there is a tendency for environmental groups to join forces with industries seeking compensation for declining competitiveness resulting from costs imposed by relative increases in domestic environmental standards. The loss of competitiveness can be offset by import restrictions on products from lower-standard countries. Such restrictions can at the same time remove opposition by local firms to higher standards at home and increase the incentive for foreign firms and their governments to adopt higher standards abroad. The use of trade policy in this context is inherently, and sometimes deliberately, protectionist.

2.5 Types of instruments used

Economic instruments that are typically used as complements to regulatory instruments and voluntary agreements include taxes and charges, tradable permits, deposit refund systems, and subsidies. These instruments are generally more transparent than simple regulatory measures and voluntary agreements. In principle, they aim to ensure that environmental externalities are incorporated in decision-making. This section discusses some of these instruments and the contexts wherein they are used.

2.5.1 International restrictions

The potential use of discriminatory trade restrictions as enforcement mechanisms within international environmental agreements has been provided for in trade agreements (such as the Montreal Protocol), and may increasingly be used to enforce compliance of signatories to these agreements. It has been argued that such trade measures violate the GATT Most Favoured Nation principle, in that they aim to protect resources that clearly do not fall within the national jurisdiction of the parties involved. These agreements are further said to discriminate between parties and non-parties to the agreement.

2.5.2 Product-related standards

The production of environmentally friendly products due to increasingly discerning consumerism, has spawned the concept of '**eco-labelling**' (Canning, 1998). Eco-labelling programmes, which includes environmental packaging, labelling and recycling requirements, have become important environmental policy instruments that induce the internalisation of environmental costs and encourage lifecycle management of products.

Provided that measures are in compliance with GATT principles of non-discrimination and national treatment, GATT allows countries to impose **product controls** in support of the environmental and health objectives of those countries. Shaw claims that well-designed eco-labelling programmes can be affective instruments of environmental policy (Brittan, 1998). Others believe that eco-labelling is yet another form of technical barrier to trade (Drake-Brockman and Anderson, 1994).

The demand for environmentally friendly products has been growing at a rate of approximately 8 per cent per year. The European Union has urged the WTO to re-organise voluntary eco-labelling schemes based on the life-cycle approach (LCA). Some observers (Brittan, 1998; Shaw, 1998) believe that labelling is a low-cost and transparent means of informing an increasingly discerning consumer about the environmental acceptability of the product.

2.5.3 Process and production method standards

The more complex component of environmental regulations has proven to be process and production method (PPM) standards, which primarily control production externalities.

Together with a global trend towards environmental protection, the development of more advanced technology has also lead to an ideology of **cleaner production processes**, as well as more effective management of raw materials, energy and waste. PPM-based controls rely on the co-operation of the exporting country and the country of origin in certifying how goods are produced (Brack, 1998). The current trend is for companies to prove their compliance to international standards through **voluntary** third-party certification of environmental systems, as with ISO 14001 (Robins, 1998). PPM standards, however, leave the potential for discrimination between countries on the basis of differing standards. Local companies wishing to sell their products to industrialised markets may potentially be forced to adhere to international standards.

During the US-Mexico tuna-dolphin dispute in 1991, GATT's 'like product' provisions were implemented by the dispute panel in charge. It ruled that the trade restriction in question (the US import ban on Mexican tuna caught with dolphin-unfriendly nets) was in breach of the GATT because it discriminated against a product on the basis of the way in which it was produced, not on the basis of its own characteristics. GATT specifically restricts border adjustments to "like product" to prevent artificial differentiation based on production methods. The implication of this is that countries cannot devise taxes or regulations for imports based on differing methods of processing (Sorsa, 1992).

The ability of countries across the world to assimilate pollution varies significantly depending on factors such as climate, population density, existing levels of pollution and risk preferences. In the light of these diverse circumstances of countries involved in trade, the enforcement of PPM-based environmental trade measures becomes difficult to justify (Brack, 1998). Trade measures based on PPMs seeking the unilateral harmonisation of standards may seem appropriate to industrialised nations, with high population densities and environments that have suffered pollution at the expense of growth for centuries. For developing countries with lower population densities, abundant natural resources and inherited pollution levels, harmonisation of standards may not be viable, and may seem unjust.

Many newly-industrialising countries fear the protectionist agenda of enforcing similarity of PPMs. Some have argued that harmonised process and production method standards can deny the very basis for comparative advantage, which rests on the proposition that countries possess different cost structures for the production of various goods (Brack, 1998).

OECD countries are beginning to recognise the need for PPM-based trade restrictions in particular cases, especially where trans-boundary externalities are concerned. Due to the problems involved in determining the particular PPM used from physical inspection of a product, the OECD has called for the development of verification and certification systems and for the mutual recognition of such systems (Brack, 1998). Schlagenhof (1995) argues that the ability to deny market access for products produced in an environmentally unsustainable manner is an essential instrument for encouraging sustainable production and development.

With the more recent turtle/shrimp dispute between the USA and shrimp exporting countries such as India, Malaysia, Pakistan and Thailand, it became clear that issues around the use of trade barriers for environmental purposes have not yet been resolved internationally. It appears that PPMs can be a double-edged sword, with very different implications for sustainable development from one scenario to the next.

2.5.4 Harmonisation

Implementation of similar product and process standards between countries may present a solution to trans-boundary environmental problems, given that differences in standards can represent important technical barriers to trade. Support for harmonisation of standards across countries has grown in the face of concerns that higher environmental standards in one country will lend comparative advantages to another. Firms in industrialised countries with high environmental standards and cost of compliance are concerned by the lack of global harmonisation with regards to standards. It has been suggested that countries with relatively lower environmental standards gain an unjustified comparative advantage based on cost and pricing structures. Importantly, these pricing structures do not reflect the costs of environmental externalities of production.

The main concern is that as environmental regulation becomes more stringent, firms will uproot and relocate to sites of more relaxed controls. Such relocations would occur at the cost of the domestic labour force of countries with high environmental standards, and at the cost of the environment of countries with less stringent environmental controls ("pollution havens"). An underlying assumption built into debates relating to the impact of environmental regulations on trade is that investment flows along gradients from sites of strict regulation to sites of more relaxed regulation. Barton (1998) argues that this assumption may be logical given optimal and rational decision-making by firms. In practice, however, firms behave in ways that are not always rational, and the assumption of free movement across global markets is not always valid.

Research into the impact of environmental regulation on global investment has shown that it seldom enters into the locational decision-making of multinationals. Appropriate adjustments by firms for environmental regulation typically constitutes up to 1.5 per cent of total operation costs (Jha, 1998).

Another argument put forward in favour of harmonisation centres around unfair comparative advantages created by disparate standards of trading partners. Importing countries faced with the prospect of their industries suffering a competitive disadvantage when compared with companies located in low-standard jurisdictions may choose not to elevate environmental standards, or may even relax current standards in a 'race to the bottom' (Gerardin, 1998).

As things stand, there may be significant pressure on countries with lower standards to comply with prevailing international standards. The pursuit of trade and therefore extended markets may be one of the main incentives for countries to upgrade their environmental standards in order to deliver products to countries with high standards for like products. The positive implications are that higher environmental standards in industrialised countries act as an incentive for export-oriented developing countries to become more innovative, efficient and competitive. The negative implications are that as costs of compliance rise for especially energy-intensive manufacturing and processing, the issue of competitiveness may become increasingly more complicated both for developing and industrialised countries (Barton, 1998).

2.5.5 Border adjustments

Border adjustments ensure that imported and exported products can compete under the same conditions in each particular market by imposing taxes on imports, and rebate taxes on exports, so that domestic producers and exporters are not undercut by foreign producers. WTO members are permitted to adjust **tax at the border** inasmuch as these are applied to traded products. Until now, however, taxes and charges related to PPMs have not been permitted.

A related issue is the extent to which rebates or exemptions from domestic process-related taxes should be allowable for exported products. Drake-Brockman and Anderson (1994) suggest that domestically imposed environmental taxes or charges (designed to internalise environmental costs) may have significant impacts on trade and competitiveness. Carbon or energy taxes imposed on activities releasing carbon dioxide have been proposed by the European Union as a useful tool to combat climate change. A significant factor delaying the implementation of such a tax may, however, be that EU member firms' products will become less competitive on the world market. Strong arguments have been made that adjustment of border taxes in the form of rebates or exemptions from domestic process-related taxes should also apply to exported products such as energy and carbon products and derivatives.

2.5.6 Countervailing action

Countervailing duties have been suggested as an appropriate measure to correct for disparate standards between countries in the global market in an attempt to prevent an overall lowering of standards. This argument has been voiced particularly in situations where imports from a country with lower standards cause injury to the domestic industry of a country with higher environmental standards (Schlagenhof, 1995). The main purpose of eco-dumping duties is therefore to ensure that exports from countries with lower environmental standards are subject to tariffs or duties to offset the implicit subsidy they enjoy from lower environmental costs (Brack, 1998). Various calls have been made for countervailing measures to be imposed on countries with less stringent environmental laws, and it is probable that environmental standards may be incorporated into the US Generalised System of Preferences (GSP) in future (Robins, 1998).

It is, however, necessary to distinguish between environmental standards justified by differences in a country's pollution levels and assimilative capacities, and environmental standards deliberately set artificially low for competitive reasons or for the attraction of foreign capital. It is also possible that countervailing duties may be imposed unilaterally under the guise of 'eco-dumping' by countries where higher standards prevail, when these duties are in truth protectionist in nature. Northern developed countries are increasingly acting unilaterally under the auspices of rulings associated with the WTO and MEAs.

The question of implicit subsidies to trade (lower environmental standards) has still not been addressed satisfactorily by the CTE, while many argue that failure to incorporate environmental costs is an implicit subsidy to trade, and GATT's Article VI specifies that imports are countervailable if subsidised imports cause material damage to domestic production. The **Subsidies Agreement** defines a subsidy as a "financial contribution by a government or any public body". Lax environmental standards are not a subsidy in terms of this agreement (Schlagenhof, 1995).

3. Overview of Economic Issues

3.1 Economic overview of the iron and steel sector

Section 3.1 briefly addresses the significance of the basic iron and steel industry to the South African economy in terms of productivity, employment and trade.

3.1.1 General

South Africa is ranked the 21st-largest steel-producing country in the world, and is the 10th-largest net exporter of finished steel (Chatzistergou, 1998). The steel industry is of considerable significance to the South African economy; it is a major contributor to GDP, employment and foreign exchange earnings (Rosenthal, 1998). Within manufacturing (which contributes 14.3 per cent to GDP) the iron and steel industry contributes 7.2 per cent.

Table 1 gives an indication of trends in iron and steel for the period 1997-98. Each of the headings shown here is discussed in more detail later in this chapter.

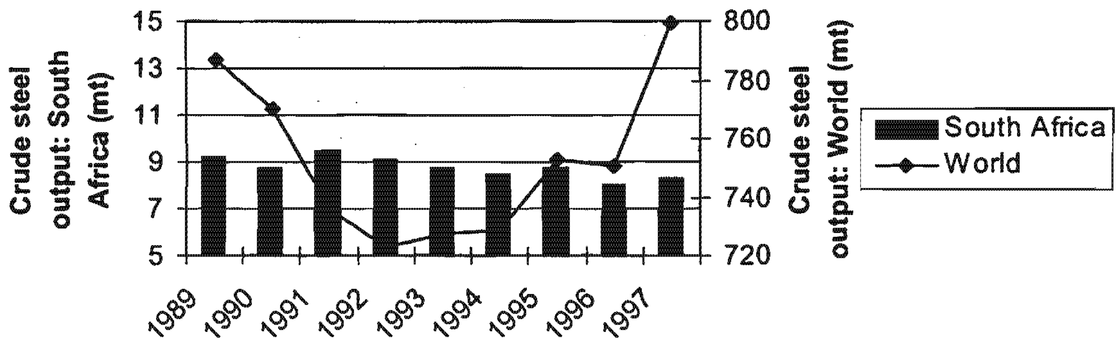
Table 1 Trend analysis - Semester 1 1998 compared to Semester 1 1997

Production	*Capacity utilisation*	*Employment*	*Exports*	*Imports*
⇓ 3.5%	⇓ 1.2% (abs. change)	⇓ 10.7%	⇑ 0.5%	⇑ 14.7%

Source: IDC (1998c)

Four steel companies dominate the South African industry: ISCOR, Highveld Steel, Scaw Metals and Davsteel. Of these the top two, ISCOR and Highveld Steel, contribute almost 90 per cent to total output. ISCOR is by far the largest producer, with 75 per cent of the South African market (Rosenthal, 1998). Figure 2 depicts the trend in South African crude steel production relative to that of world production.

Figure 2 South African and world crude steel production trends



Source: IDC (1998a)

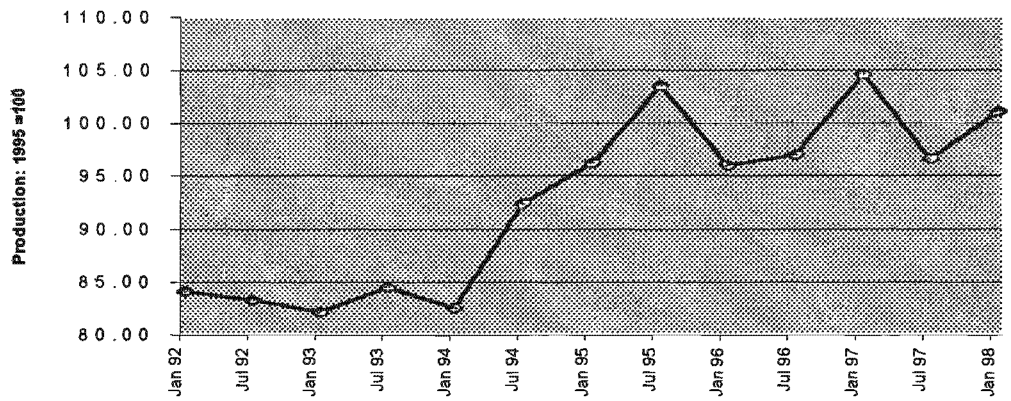
Internationally, growth in the steel sector is subject to strong import competition. Growth in most markets has slowed down as a result of knock-on effects of the Asian financial crises, which have led to reduction in output levels or price cuts. The contraction in demand ascribed to emerging market turmoil and increased external competition reduced local sectoral output by 0.3 per cent between 1997 and 1998 (IDC, 1998a). The local basic iron and steel producers have further suffered due to high interest rates.

The combination of depressed international markets and insufficient domestic demand has had negative effects for South Africa's steel producers. Although exports were expected to benefit somewhat from the weak rand, the 23 per cent decrease in net operating income for ISCOR for the six-month period ending December 31 1998 has been directly attributed to the collapse in international steel prices. Steel export prices have been at their lowest level in decades. Furthermore, domestic demand for steel products has been sluggish and is expected to decline (ISCOR, 1999). Figure 3 shows South African production volumes for crude steel.

South Africa produced 9.3 million tons (Mt) in 1989 and ended 1997 on 8.0 Mt, a fall of 14 per cent. This decrease relates to continuous rationalisation exercises which changed the production routes at the main steel producing works at ISCOR's plants in Vanderbijlpark and Pretoria.

The basic iron and steel industry is one of the main contributors to manufacturing production. It has, however, reported substantially lower average physical volumes of production over the last year, with physical volume of production for this industry dropping from 6.6 per cent of total manufacturing production in 1997 to 5.8 per cent in 1998 (IDC, 1998a). This is largely due to the recent slump in the steel market.

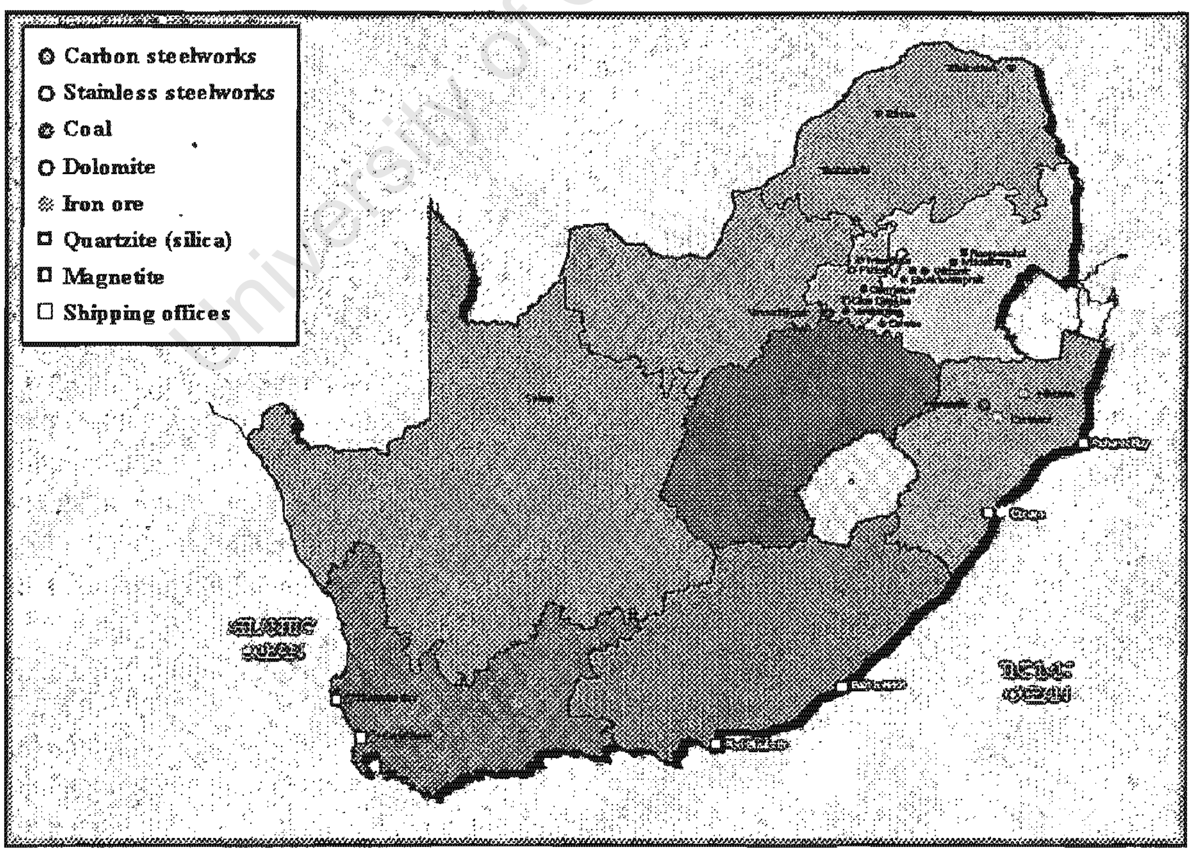
Figure 3 South African crude steel production



Source: IDC (1998b)

Figure 4 is a location map indicating the positions of the major carbon and stainless steel works in South Africa. The locations of raw material mining sites are also shown on this map.

Figure 4 Location of South African steel works



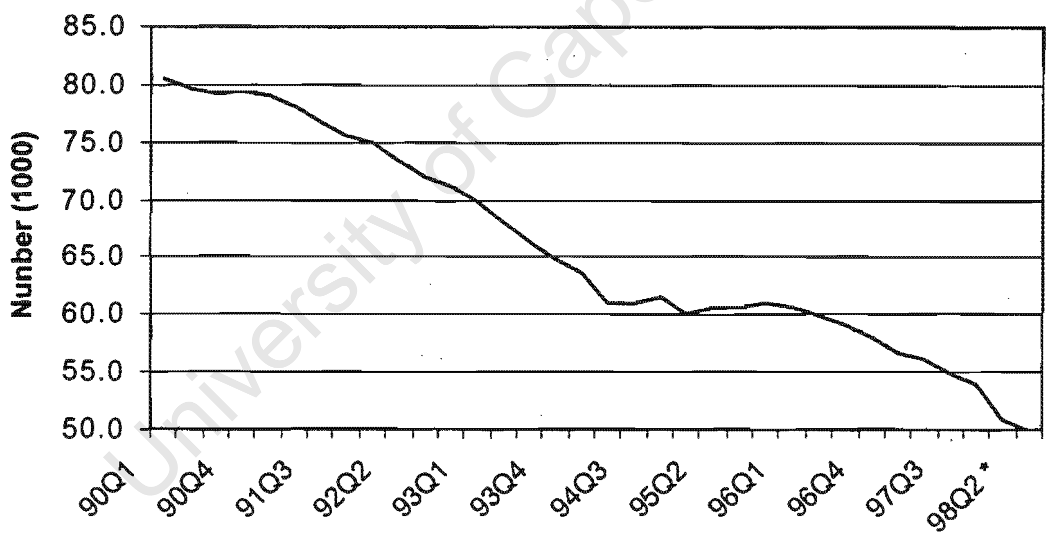
Source: SAISI (1999)

3.1.2 Employment

Although the proportion of total employment contribution to manufacturing has remained relatively stable at 4-5 per cent of manufacturing employment, total employment in this sector has been declining (Rosenthal, 1998). Employment at ISCOR (the largest producer) has been reduced by some 30 per cent during the last five years (ISCOR, 1997).

The decline in employment in the iron and steel industry has been attributed to automation, improved information and methodology, improved skill, and product rationalisation, indicating that adjustments by this industry to enhance competitiveness play a prominent role in workforce reduction (Rosenthal, 1998). Figure 5 gives an indication of employment trends within the iron and steel industry.

Figure 5 Employment trends within the basic iron and steel industry



Source: IDC (1998b)

Manufacturing everywhere is becoming capital-intensive rather than labour-intensive. This is not an attempt to cut back on labour, but because of technological incentives to improve competitiveness and quality (Chatzistergou, 1998). Improvements in economic conditions and training will affect growth prospects for the industry as a whole, but following world-wide trends, the steel industry and manufacturing in general is unlikely to create many new jobs in future. Technology has to be improved to remain competitive, and thus to prevent de-industrialisation that will have drastic implications for labour in the long-term.

The International Labour Organisation has reported that by international standards, South African labour costs are not particularly high. Advantages are often based on relatively low wages, but are impaired by low productivity, which often results in a labour-cost-per-unit disadvantage. According to ISCOR management the high labour-intensity of the South African steel industry can be ascribed to the literacy level of the workforce (30 per cent illiteracy), leading to a greater need for supervision and lower productivity. It requires six to seven hours of work in the company's integrated plants to produce a ton of steel. The international benchmark is about three work hours (Rosenthal, 1998).

3.1.3 Trade

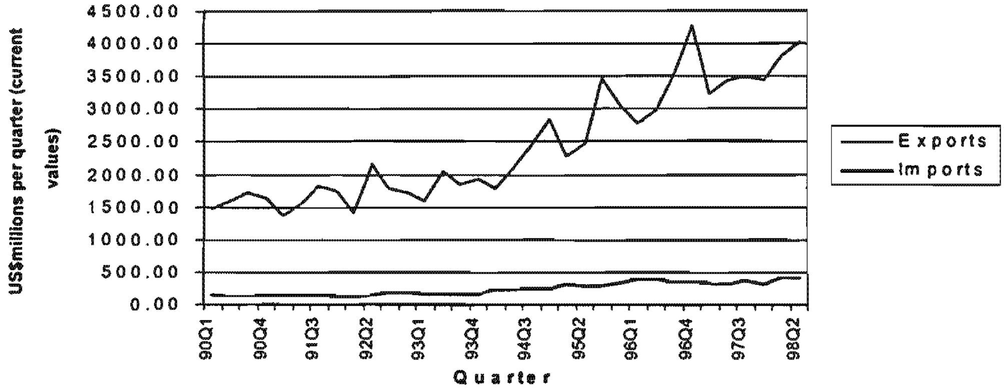
There has been a sharp increase in export earnings from iron and steel since April 1998. The recent depreciation of the rand against the currencies of South Africa's major trading partners augers well for the trade balance in general. The devaluation of the rand has, however, not boosted steel exports sufficiently, and major setbacks have been endured due to the collapse in international steel prices.

Against all odds, the industry has maintained a positive trade balance. Local market consumption was 4 Mt of steel, of which 0.3 Mt was imported, while 2 Mt of local production was exported. This ranked South Africa the 10th-largest net exporter of steel in the world (Chatzistergou, 1998). The contribution to total value of manufacturing exports has been between 11.1 per cent and 20.2 per cent (IDC, 1998). The industry is an important player on the African continent, accounting for about two-thirds of steel production and 80 per cent of steel exports. South Africa also produces specialised steels that are rarely made in Africa (Rosenthal, 1998). Figure 6 gives an indication of the differences in export and import trends in the local steel industry.

The difference in the rates of export and import growth is remarkable and bodes well for the balance of payments in the iron and steel sector. Basic iron and steel imports comprised 1.2-1.4 per cent of total imports for the last two years (IDC, 1998b). Figure 7 lists the most important countries of origin and destination of trade (1998: Semester 1).

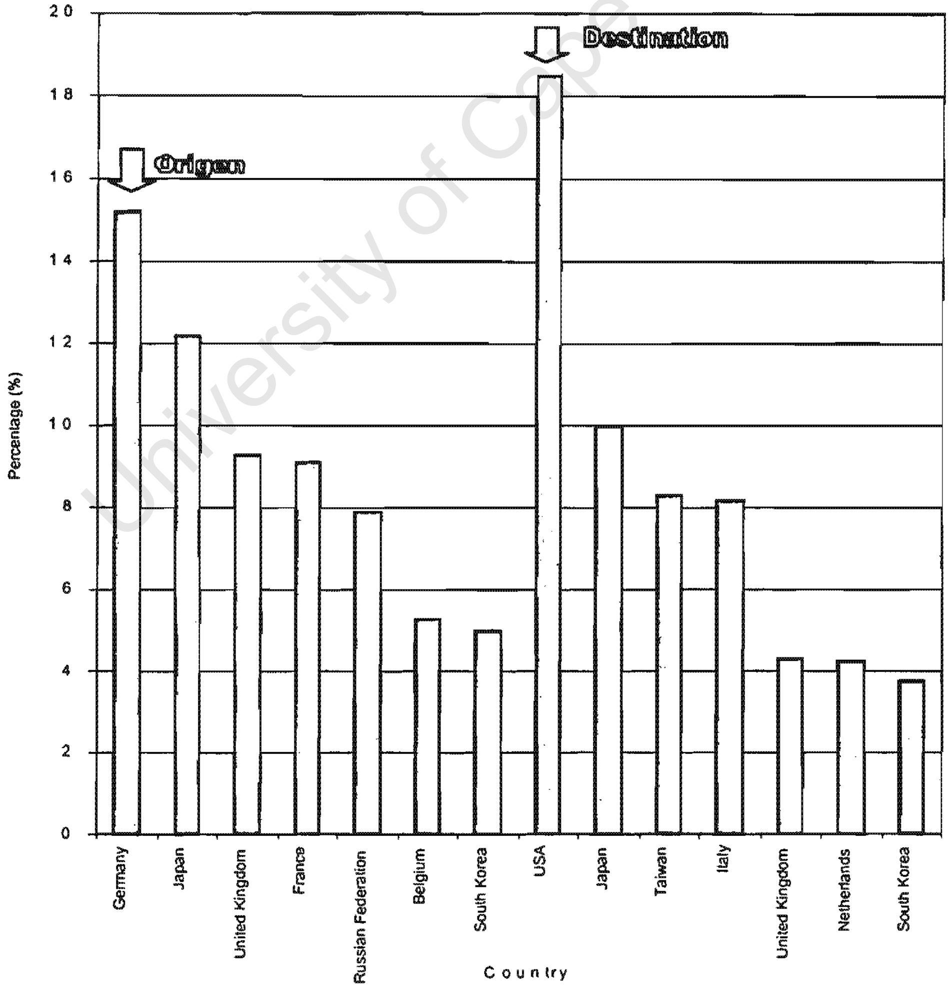
The major countries of origin of imports (Germany, Japan and the United Kingdom) provide highly specialised products to various local industries. The main export destinations are USA, Japan and Taiwan, and Italy.

Figure 6 Trade trends within the iron and steel industry



Source: IDC (1998b)

Figure 7 Countries of origin (imports) and destination (exports) in trade



Source: IDC (1998b)

The rand-dollar exchange rate makes exports attractive to countries with strong currency, adding to the competitive advantage for domestic steel exports (Chatzistergou, 1998). According to Marthinus Havenga (IDC downstream steel cluster manager), international benchmarking has revealed several of the country's downstream carbon steel industries to be cost-competitive largely because of the substantial depreciation of the rand and not as a result of inherent competitiveness (Chatzistergou, 1998).

The slump in international market prices is presenting a major problem for local steel exports. As a result of increased international competition and decline in global demand due to the economic crises, various countries are attempting to protect their domestic markets against flooding from foreign imports by calling for countervailing and anti-dumping duties. Various countervailing suits have been lodged against South African producers over the last few years. In the United States, pressures are building in Congress for the introduction of trade measures aimed at restricting steel imports. Foreign imports are now estimated to account for roughly one-half of the United States steel market. The further surge of foreign imports to the US due to the Asian financial crises is fuelling protectionist sentiment in the US (Financial Times, 1999). In North America, anti-dumping cases filed by hot-rolled plate producers were finalised this year, and South Africa's attempts to be "decumulated" from other producers in China, Russia and the Ukraine failed. The dumping duties applied to South African producers are prohibitive and will effectively block the group's plate exports to North America (Financial Times, 1999).

More pleas by steel producers for action against dumping of steel in UK markets are currently being made. A collapse in prices in the third quarter of last year is likely to cause demand and prices to fall across the European Union. There is a general move for the European Union to install tariffs against hot-rolled coil products and other steel products that are "flooding the market and threatening British jobs". Various steel producers from emerging markets have been accused of exporting their steel at lower prices than what is being charged for these products in their own domestic markets. Eurofer, the European steel producer's association, has been making an inquiry into the alleged dumping of hot-rolled coil by Bulgaria, India, South Africa, Taiwan and Yugoslavia (Financial Times, 1999).

Other countries are implementing or considering protectionist measures also as a result of the collapse in demand for steel in much of Asia, formerly one of the world's biggest importers of steel products (Financial Times, 1999).

4. Production Methods and Environmental Impacts

This chapter presents a technical overview of production processes used in the manufacturing of basic iron and steel, highlighting specific environmental problems associated with these processes.

Steel has a positive environmental profile in many respects, particularly with regard to its recyclability. Its production process can, however, be polluting. Environmental issues facing the iron and steel industry may be national or trans-boundary and can include air emissions, habitat protection, effluent discharges, safety incidents, and soil and groundwater contamination (UNEP and IISI, 1997). The specific approach followed, in order to obtain a holistic understanding of the implications of negative externalities caused by industry, is the materials balance or life-cycle approach (LCA), whereby all raw material/energy inputs and outputs are considered. Waste generated at each stage of production is identified and associated impacts are quantified as far as possible.

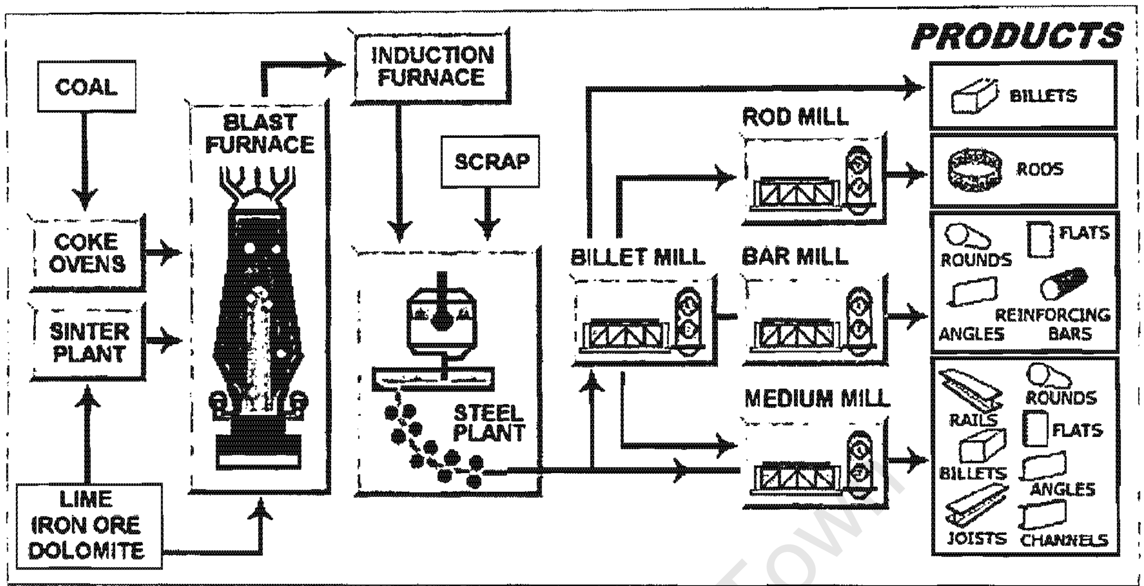
Commonly used production processes and associated raw materials are reviewed below. By- products released and materials recycled or transferred off-site are identified. This LCA approach to environmental externalities associated with production allows the identification of specific places along the production cycle more prone to pollutants. Externalities generated in the mining and transport phases, although part of a true LCA, will not be discussed here.

4.1 Overview of production methods

The following section summarises the major industrial processes within the iron and steel industry, input materials and technology used, and the processes employed. This overview emphasises the inter-relationship between the industrial processes pertaining to iron and steel production and the associated pollutant outputs, mitigation opportunities, and regulations.

In Figure 8 a flowchart is used to illustrate the various stages in the production of steel. The blast furnace depicting the iron-making stage of production may be replaced with other production methods such as DRI and smelting reduction.

Figure 8 Flowsheet of the iron and steel industry



Source: ISCOR (1999), Website

Currently two routes dominate global steel manufacture, although variations and combinations of the two exist. These are the basic oxygen furnace (BOF) or integrated route, and the electric arc furnace (EAF) or "mini-mill" route. Although these two technologies use different input materials, the output for both furnace types is molten steel that is subsequently formed into steel mill products. The key difference between the two processes is that in an integrated works the feedstock is predominantly molten iron (produced in a blast furnace) with additional scrap and oxygen. The EAF works uses mainly scrap steel and electricity or, increasingly, other sources of metallic iron such as directly reduced iron (DRI) (UNEPand IISI, 1997).

Table 2 gives a breakdown of the major primary steel processing plants in South Africa. The associated capacities of these plants are included in the breakdown.

As can be seen from Table 2, the integrated production method accounts for approximately 57 per cent of total crude steel production in South Africa. The remaining 43 per cent is produced via the EAF process. The blast furnace route currently accounts for approximately 60 per cent of world iron production, and is expected to remain the dominant method of production iron production in South Africa.

Table 2 South African iron and steel production capacity

	Works	Crude steel		Iron		Sinter	
	Production facilities (In operation, under construction, mothballed or closed)						
1	Cape Town Iron & Steel Works (Pty)	180000	EAF x1	-		-	
2	Columbus Stainless	550000	EAF x1				
3	Davsteel	400000	EAF x1				
4	Highveld Steel & Vanadium	1000000	BOF x3	1000000	EAF x1	-	
5	ISCOR Ltd Vanderbijlpark	3500000	BOF x3	3824700	BF x4	1787400	x1
		1500000	EAF x3	720000	DRI x1		
	Dunswart			120000	DRI x1		
	Pretoria	800000	EAF x2	300000	Corex x1		
	Newcastle	2800000	BOF x3	1825000	BF x1	2555000	x1
	Vereeniging	345000	EAF x4	-		-	
6	Microsteel (Pty) Ltd	100000	Induction	-		-	
7	Saldanha Steel (Pty) Ltd	1300000	EAF x1	650000	Corex x1		
				804000	Midrex x1		
8	Scaw Metals	500000	EAF x2	235000	DRI x2		
	Total	12975000		9478700		4342400	

Source: SAISI (1998)

4.1.1 Integrated steel making

Integrated steel-making transforms raw materials into crude steel and finally into finished products. Coke, a refined form of coal, is combined with processed iron ore in a blast furnace to produce "pig iron". During the second stage of this process pig iron is transformed to crude steel in a second furnace, the basic oxygen furnace (BOF) (Moore, 1998).

The third stage of production involves casting. The continuous caster replaced ingot casting during the 1970s. The former is a much "cleaner" process that casts liquid steel directly into semi-finished products (Moore, 1998). Ingot processes involves casting of liquid steel in ingots and subsequent re-heating and breaking of the latter to semi-finished products called blooms, billets, and slabs. During the final stage semi-finished products are sent to rolling mills where they are worked into final steel products. Blooms are rolled into intermediate-sized products like beams. Slabs are used almost exclusively for the production of plate or sheet.

An important aspect of integrated steel-making is that this process generates important economies of scale. Integrated works are large (i.e. a 3 million tons a year plant may cover an area of 4-8 square kilometres). An efficient new integrated steelworks may have an annual capacity of about 7 million tons. The most critical feature of this process is its strong tendency for over-capacity during economic downturns due to the expenses associated with temporary shutdowns. Coke ovens and blast furnaces are extremely averse to shutdowns and demand near-continuous use once inaugurated (Moore, 1998). At periods of global depression in demand for steel, the market often becomes glutted due to this inflexible production process, causing world prices to plummet.

The production of steel in an integrated works involves a series of processes, each with different input materials and emitting various residual materials and wastes. The overall energy/materials balance of the major components is shown in Figure 9 (Moore, 1998).

Figure 9 Energy/materials breakdown for an integrated works

Primary input:
1500 kg iron ore; 610 kg coking coal; 60 kg mineral coal; 150 kg lump ore; 200 kg flux; 175 kg scrap; 5 m3 water

Intermediate output:
3 m3 waste water (ss, oil, NH3); 1.6 kg suspended solids; 150 g oil; 110 g ammoniacal nitrogen; 8g (phenols, meths, cyanides); 28kg CO; 2,2 kg SO2; 2,3 kg NOx, 2.3t CO2; 0.3kg VOC; 1.1 kg particulate; 65g other (metals, H2S); 455 kg slag; 56 kg dust/sludges; 16 kg millscale; 4 kg refractory; 0.8 kg oil

Final output:
1 ton of crude steel

Input energy breakdown:
19.2 GJ coal; 5.2 GJ steam; 3.5 GJ electrical (365 kWh); 0.3 GJ oxygen; 0.04 GJ natural gas

Source: UNEPand IISI (1997)

The integrated route of steel production is well established. The technology used is highly optimised, and it is unlikely that much improvement is imminent (Moore, 1998). For production capacities in excess of three million tons annually, the blast furnace/integrated route provides the lowest cost option, and will remain the dominant route for steel-making in the foreseeable future.

4.1.2 The electric arc furnace

The mini-mill or electric arc furnace operation is simple compared to that of integrated steel making. Outlays merely require a scrap yard, an electric-arc furnace (EAF), a continuous caster, and a rolling mill. Steel is made in EAF works by melting recycled scrap in an electric arc furnace (EAF) and adjusting the chemical composition of the metal by adding alloying elements, usually in a lower-powered ladle furnace (LF). This initial process is known as the "liquid phase", and has only scrap and electricity as material inputs. The cost ratio for crude steel derived from a modern mini-mill operation is approximately 60 and 13 per cent for scrap and electricity respectively (Moore, 1998).

The iron-making processes, operated on the integrated plant, are not required for the EAF process. Most of the energy of melting comes from the *electricity*, although there is an increasing tendency to replace or supplement electrical energy with *oxygen*. Coal and other fossil fuels are injected directly into the EAF. The second stage of the mini-mill process known as the "rolling phase," consists of a continuous caster, a re-heater, and a rolling mill and are similar to the downstream process found in the integrated route (Moore 1998).

An energy material balance showing the major inputs and outputs of the process is presented in Figure 10 (UNEPand IISI, 1997).

Figure 10 Energy/materials breakdown for a minimill operation

Primary input:
1130 kg scrap/DRI/hot/cold iron

Intermediate outputs:
2.5 kg CO; 60 g SO_2; 0.5 kg NO_x; 120 kg CO_2; 165 g particulate; 2m^3 wastewater (ss, oil, NH3); 146 kg slag; 19 kg furnace dust; 16 kg mill scale; 2.5 kg sludge; 17 kg refractories; 0.8 kg oil; 3 kg other

Final output:
1 ton of crude steel

Input energy breakdown:
5.5 GJ electrical (572kWh); 1.3 GJ natural gas (40 m^3); 450 MJ coal/coke (15 kg); 205 MJ oxygen (30 m^3); 120 MJ electrode consumption (3.5 kg)

Source: UNEP and IISI (1997)

In general, the electric arc furnace (EAF) route is much more electricity-intensive than the basic oxygen furnace route. This is, however, not to say that one process should be favoured above the other, as each has a number of competing advantages. For EAF technology, the iron-making processes of the integrated plant are not required. The total primary energy requirement for the integrated route is 28.24 Gj in comparison with 7.5 Gj for the EAF route.

By contrast with an integrated works, the classic mini-mill setup exhibits few important economies of scale. An efficient EAF operation is likely to have less than 1 million tons per year of raw steel capacity and may cover an area up to 2 square kilometres, depending on plant configuration. A second technological difference that lends superiority to the EAF method is that it can be turned off easily, unlike coke ovens and blast furnaces in an integrated works. In addition to this production flexibility, low fixed costs of a mini-mill operation enable complete shut down in times of low demand. This provides extremely important flexibility that can be useful in a cyclical market. The mini-mill process therefore allows for much more flexibility and efficiency, while it is easier to control in terms of pollution.

Another aspect in favour of mini-mill operations is that the geographical location of these plants are less constrained by raw material deposit sites than in the case of integrated mills. A mini-mill can thus be set up near the end-consumer or near scrap supplies, whichever is more economically viable (Moore, 1998).

A drawback to mini-mill operations is their reliance on scrap materials. High surface quality is critical for higher-end products, and impurities in scrap create surface area problems. In order to improve the overall quality of the liquid steel the input mix for the electric furnace charge can be altered by adding pig iron or directly reduced iron (DRI). DRI is becoming increasingly important where scrap availability is limited, where the impurity content of the scrap is high, or where a localised raw material resource is available. ISCOR and Scaw Metals each own two DRI plants that are responsible for a total of 1.072 million tons of iron ore per annum (11 per cent of total iron ore produced locally) (SAISI and Institute, 1998). DRI is expensive, thus removing one of the major advantages associated with EAF (avoidance of high capital costs associated with blast furnaces or DRI production facilities) (Moore, 1998).

For the BOF process, about 20 per cent of inputs are steel, whereas the EAF scrap input is 42 per cent and higher (approximately 300 million tons of used steel is processed and re-melted each year in the US). It is clear from Figures 8 and 9 that energy consumption associated with the EAF is much higher than that associated with the integrated or BOF route of steel production. The explanation for the large divergence between energy requirements for these processes is captured in Table 3.

Table 3 Net energy consumption of different iron-making processes – IISI reference plants

Process	GJ/t crude steel
EAF – scrap fed	7.5-8.5
EAF consuming DRI and scrap	20.5
Integrated plant with a BOF	19.2-28.2

Source: Granville *et al.* (1993)

The iron-making process contributes a large proportion of overall energy usage on steel plants. This is specifically significant to the South African production scenario, where iron-making is an important part of steel production as a result of a scrap shortage.

Alternative iron-making process such as DRI and smelting reduction present competitive characteristics that have grabbed the interest of industrial producers. A major advantage of these processes in the South African context is that coke is not required for the production of steel, as coal is the main reduction feedstock. Some other advantages of techniques such as DRI and smelting reduction are lower investment costs and greater environmental compatibility.

Direct reduction yields solid sponge iron from iron ore using reformed natural gas or coal and the reducing agent. Unlike the blast furnace that cannot operate without sinter but requires coke, the DRI process offers the ability to produce iron, without the need for coke production. The economics of this process demands an abundant low-price energy source (e.g. natural gas or coal). With the development of the international scrap trade, the demand for sponge iron and DRI processing did not perform as well as expected. Although DRI is not considered an alternative for blast furnace iron, it has an important role in South Africa as a supplemental iron source to scrap for the EAF.

Smelting reduction has seen the development of various processes, but only the COREX technology has reached industrial maturity and two plants are in operation world-wide (at Saldanha in South Africa, and in South Korea). Smelting reduction processes present a viable alternative where additional hot metal capacity is required (both for BOF and EAF), in areas where non-coking coals are abundant, where scrap is scarce, or where local conditions favour the installation. The off-gas co-generation potential of the COREX process is one of its major advantages (UNEPand IISI, 1997).

4.2 Externalities and impacts

This section identifies the main environmental externalities generated in the production of primary iron and steel, and explores their potential impacts for the environment and health. All externalities are addressed on a media-specific (air, water, terrestrial) basis.

It should be noted that the environmental externalities associated with steel production are highly correlated with differentiated steel products, and more pertinently with the methods of production. Factors that determine these impacts are the process stage, size and type of operation, the technology employed, and the nature and sensitivity of the surrounding environment.

With regards to production processes, differing methods for producing a single product may not exhibit equal efficiency in waste reduction. Furthermore, differing technologies of older and more recent plants often determine the degree to which companies have invested in capital equipment that prohibits environmental degradation. Additional aspects that influence the quantities of waste produced, the level of environmental impacts and the abatement costs involved, are the effectiveness of the planning, pollution prevention, mitigation, and control techniques adopted (UNEP, 1996b). Formulating an environmental profile of the steel industry thus remains a complex task due to various contributing factors.

For simplicity, environmental impacts of steel manufacture can be subdivided into three categories, namely atmospheric, aquatic and terrestrial impacts. Atmospheric impacts include particulate matter, ground-level ozone, nitrogen oxides, sulphur dioxide, heavy metals, organic emissions, radioactivity, carbon dioxide, CFCs, odour and noise. Effluent discharge may contain suspended solids, heavy metals, oils and greases, oxygen demand and organic compounds. Terrestrial externalities may be caused by disposal of refractories and sludge (UNEP and IISI, 1997).

Raw material inputs for the process include iron ore, coal, limestone, recycled steel scrap, energy and a wide range of other materials in variable quantities such as oil, air, chemical refractories, alloys, refining materials, water, etc. Resource depletion in itself is one of the impacts generated in the iron and steel production process.

In Table 4, pollutants associated with each process stage of steel manufacture and potential impacts of the release of these pollutants, as well as the problems associated with unsustainable consumption of resources, are discussed.

Table 4 Pollutant releases and potential environmental impacts of steel manufacture

Process stage	*Potential pollutant release*	*Potential environmental impact*
Raw Materials Handling	Dust	Localised deposition
Sinter/Pellet Production	Dust (inc. PM_{10}) CO, CO_2, SO_2, NO_x, VOCs, methane, dioxins, metals, radioactive isotopes, HCL/HF, solid waste	Air and soil contamination, ground-level ozone, acid rain, global warming, noise
Coke Production	Dust (inc. PM_{10}) PAHs, benzene, NO_x, VOCs, methane, dioxins, metals, radioactive isotopes, HCL/HF, solid waste	Air, soil and water contamination, acid rain, ground-level ozone, global warming, odour
Scrap Processing	Oil, heavy metals	Soil and water contamination, noise
Blast Furnace	Dust (inc. PM_{10}), H_2S, CO, CO_2, SO_2, NO_x, radioactive isotopes, cyanide, solid waste	Air, soil and water contamination, acid rain, ground-level ozone, global warming, odour
Basic Oxygen Furnace	Dust (inc. PM_{10}), metals (e.g. zinc), CO, dioxins, VOCs, solid waste	Air, soil and water contamination, ground-level ozone
Electric Arc Furnace	Dust (inc. PM_{10}),metals (e.g. zinc, lead, mercury), dioxins, solid waste	Air and soil contamination, noise
Secondary Refining	Dust (inc. PM_{10}), metals, solid waste	Air and soil contamination, noise
Casting	Dust (inc. PM_{10}), metals oil, solid waste	Air and soil contamination, noise
Hot rolling	Dust (inc. PM_{10}), oil, CO, CO_2, SO_2, NO_x, VOCs, solid waste	Air, soil and water contamination, acid rain, ground-level ozone
Cold rolling	Oil mist, oil, CO, CO_2, SO_2, No_x, VOCs, acids, solid waste	Air, soil and water contamination, ground-level ozone
Coating	Dust(inc. PM_{10}), VOCs, metals (e.g. zinc, C(VI)), oil	Air, soil and water contamination, odour, ground-level ozone
Waste water treatment	Suspended solids, metals, pH, oil, ammonia, solid waste	Water/groundwater and sediment contamination
Gas Cleaning	Dust/sludge, metals	Soil and water contamination
Chemical Storage	Different chemicals	Water /ground contamination

Source: UNEP and IISI (1997)

Some of the impacts referred to in Table 4 are primarily local. Soil and water contamination tends to be localised, except where rivers cross or form boundaries between countries. Externalities such as greenhouse gasses and ground level ozone have implications for local environments and communities, but also cause trans-boundary pollution.

Major pollutants of concern are the particulates SO_2, CO_2, CO and NO_x. Ammoniac is normally considered a potential hazard related to steel plants, but is of less concern in the Southern African context (Herbst, 1999). The stages of production responsible for the most severe releases of gaseous emissions are primarily the coke ovens, but also the steel-making furnaces (Haasbroek, 1998).

Primary iron and steel plants release effluent streams that could contain pollutants such as ammonia, phenols, cyanide, fluoride, heavy metals (including excessive iron) and salinity if not managed properly. The pollutant of concern in the coke oven stream is often NH_4. Based on average concentration, the variables of concern related to the coke oven stream are hardness, salinity, chlorides, fluoride, iron, nitrate, sulphate, ammonia, phenols and some oils and greases.

Sources for effluent generation from the production of iron are waste streams from electrostatic precipitators (ESPs) associated with the coke ovens and wet gas scrubbers that are connected to the blast furnace. Effluents from the steel-making process are mainly wastewater from the wet scrubbers connected to the basic oxygen furnace, process effluents from turbo circulators and demineralisation plant; boiler blowdowns; and cooling system bleeds. Most of the mills require quench water as part of the production process, although much of this water is lost through evaporation.

The water circulation systems installed in new plants are efficient, allowing for optimal recycling and effluent minimisation in the plant. The effluent from coke oven streams has to be monitored for NH_4 concentrations, but other than that a local case study has indicated that for a coke plant the effluent stream is within specification for 65 per cent of the time (DWAF, 1998). The slag dump effluent generally has high salinity with high concentrations of calcium, sodium and sulphates. Older plants tend be less equipped to deal with re-circulation of water in the plants, and as a result generate more effluent that is discharged. Until recently, irrigation of non-recoverable effluent was still practised in some plants, resulting in high levels of downstream salinity.

The impact of solid waste sites is generally related to a loss in aesthetic value of the landscape, but does not present major hazards if disposed of in appropriate waste sites. New plants are required by legislation to create landfill sites according to specifications or dispose of waste in appropriate municipal dumping sites. Most of the bigger producers use their own landfill sites, however. Many South Africa landfill sites do not comply with the requirement for solid waste disposal and, as a consequence, seepage is a major problem at some of the older plants, affecting groundwater quality. In extreme cases this has resulted in death, as well as pollution of agricultural water used for irrigation.

The exposure of steel-workers to pollutants generated within steel plants has been minimised due to development of processes and operating practices and training programmes aimed at reducing these risks, over a long period of time. Although advances made in on-site risk reduction make it unlikely under present practices for employees to be exposed to levels of pollutants that will give rise to health problems, exposure to some pollutants still occurs. Monitoring and continued surveillance is therefore imperative in ensuring that maximum limits are not exceeded (UNEP and IISI, 1997).

5. Abatement

This chapter provides an overview of procedures that can be followed to affect a reduction in existing levels of pollution. Some of the broader concepts around the abatement of pollution are discussed. These include the motives that different agents in society may have for wanting to "clean-up" the environment, the difference between abatement be private firms and public institutions, and also specific abatement instruments or "tools" that can be applied in different situations.

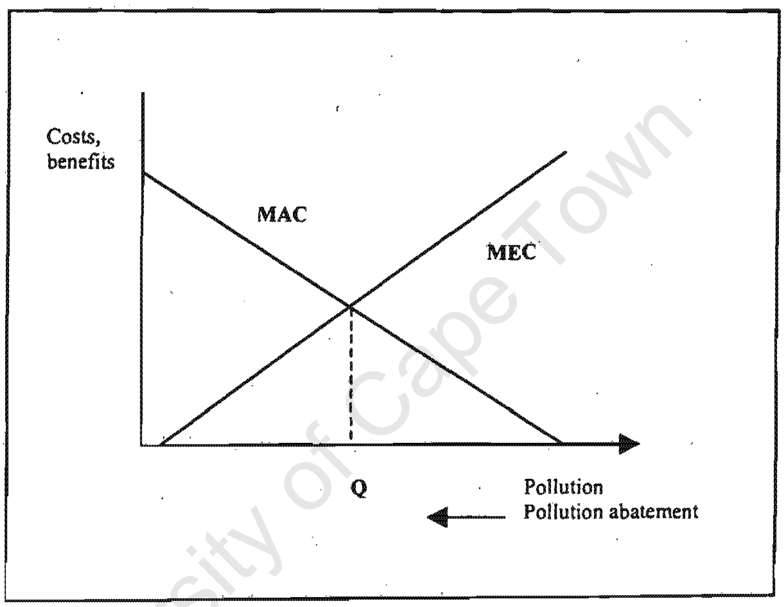
There are various options open to firms and public institutions to mediate for the negative social and environmental impacts caused by economic activities. Before discussing these options in more detail, it is perhaps useful to define the negative impacts or "externalities" in somewhat more detail.

There are two qualifying characteristics to externalities. Firstly, an externality is present when the utility or production relationships of individual A include real (non-monetary) variables, whose values are chosen by other persons or firms without particular attention to the effects on A's welfare. The second condition that characterises an externality occurs when the decision-maker, whose activity affects other's utility levels or enters their production functions, does not pay (receive) in compensation for this activity an amount equal in value to the resulting costs (or benefits) to others (Baumol and Oates, 1988). External costs therefor occur when the activity of one individual or firm causes loss of welfare to another individual or firm and this loss of welfare goes uncompensated.

Mitigation of environmental externalities, on the other hand, generally implies the alleviation or abatement of prevailing levels of pollution caused by economic or recreational activities. Creating an environment where there is no pollution at all would, however, equate to an environment where no economic growth occurs. A zero pollution target is therefore not an efficient solution to environmental management and sustainable development.

Choosing the optimal level of pollution when certain simplifying assumptions are made, is generally considered to be the level at which the marginal net private benefits (MNPB) from pollution by one firm, are just equal to the marginal external costs (MEC) of the receiving firm/community or environment. This premise is based on the assumption that only output reduction can be used to reduce pollution. In order to allow for reductions in pollution by means of abatement equipment, it is possible to replace the MNPB curve with the marginal abatement cost curve (MAC). The MAC curve shows the extra cost of reducing the level of pollution by expenditure on abatement. The lower the level of pollution the higher is the marginal cost of reducing it further. Figure 11 depicts the optimal level of pollution (Q) where MAC = MEC. For a proof of this proposition the reader should consult Pearce and Turner (1990, pp.89-91).

Figure 11 The optimal level of pollution



Source: Pearce and Turner (1990)

Estimating this point (Q) is not a practicable policy objective, due to data deficiencies and uncertainties involved in estimating the MAC and MEC curves. The regulator is generally unsure of the position of either the MAC curve or that of the MEC curve. It is therefore expected that some error will be made in estimating the optimal quantity of emission reduction. Baumol and Oates (1994, p.60) give a detailed overview of regulatory implications resulting from incorrect estimation of the pertinent curves. Policy instruments are therefore rather directed at standards set by society as levels of acceptable ambient environmental quality (Pearce and Turner, 1990). Pollution control instruments and policies are therefore an iterative search process based on a "satisfying" principle rather than an optimising principle.

environmental management entail prosecution and fines, damage to the firm's reputation and loss of stakeholder confidence. Loss of market access and comparative advantage, government penalties and controls, trade barriers and economic instruments (for example a carbon tax) are further risks accumulated as a result of non-compliance with international and domestic standards.

Public motivation for abatement is more extensive in that it is based on meeting social welfare objectives. Economic incentives for introducing environmental regulation and enforcing compliance with international agreements are to protect domestic markets from trade action in the long-run and encourage competitive behaviour. The potential implications of green trade barriers for the macroeconomy could be reduced balance of payments, a reduction in employment and loss of foreign investors' confidence. Social, environmental and health objectives are additional reasons for introducing environmental regulations and management frameworks.

5.2 Private abatement options

The reduction of pollution and environmental degradation as a result of industrial operations is generally assumed to be a company responsibility. Operations by individual bodies that cause negative externalities for the surrounding environment and society as a whole have become subject to the polluter pays principle (PPP) (UNEP and IISI, 1997). The PPP means that the polluter should bear the expense of carrying out the pollution prevention and control measures decided by public authorities to ensure that the environment reverts to an acceptable state (Pearce and Turner, 1990). A contrary view, that the liability for externalities caused by pollution does not necessarily rest on the polluter, is mentioned in Section 5.3.

Mitigatory procedures that result in a reduction in the level of pollution are generally categorised in terms of:

1. reduction in output;
2. cleaner production (substitute inputs or products, technological adjustment); and
3. end-of-pipe technologies and cleaning up afterwards.

For inflexible methods of production and older technology that require high investment costs associated with "cleaner" technologies, a reduction in output is the only option for reducing pollutant generation. This route is generally not considered economically viable, unless all firms in the global market behave in a similar way, causing prices to increase in general.

Pollution control has traditionally been the approach to a cleaner environment. Control equipment such as scrubbers, bagfilters, and on-site rehabilitation are examples of end-of-pipe mitigation. The continuous application of an integrative environmental strategy to processes and products is the latest development in the forum for cleaner production. This approach to environmental management and mitigation will be discussed shortly. Some argue that it may be less costly to prevent pollution at source than to clean up after it has been produced. Cleaner production may not solve all of the environmental problems at a facility, but will decrease the reliance on end-of-pipe solutions and will create smaller quantities of less toxic waste requiring treatment and disposal. Cleaner production is not only about technology but also about management.

As a guide, the application of cleaner production can be subdivided into the following areas: change of process or manufacturing technology; change of input materials; change to the final product; re-use of materials on-site, preferably within the process; and training.

Implementing cleaner production should be an integrated process that reduces the overall environmental impact. Unlike past efforts that concentrated on media-specific approaches to dealing with pollution, true cleaner production takes into account all media (UNEP and IISI, 1997).

Common examples of end-of-pipe environmental control measures used to remove pollutants from effluents and emissions are briefly outlined here. Waste-treatment plant sludge and effluent generated as a result of lubricants applied during rolling may contain suspended solids, and oil emulsions and acid wastes from the cold rolling and pickling processes. Wastewater treatment is required to remove suspended solids from this sludge and effluent. Wastewater from by-products plants is further treated in biological effluent treatment plants (BETP) to remove cyanides, phenols, thiocyanates and solids prior to discharge. Acid regeneration plants are often installed to neutralise waste acids.

Air pollution control extraction or bagfilter cleaning systems, as well as inert gas blanketing (CO_2 and N_2) are installed in blast furnaces and BOFs to reduce particulate formation and emissions from the cast house. Particulate matter is also removed by dry or wet air pollution control equipment such as electrostatic precipitators (ESPs) or baghouses and wet scrubbers that capture dry particulates. Wetscrubbers are used to treat wastewater plant treatment sludge, which is subsequently disposed of as landfill.

A further examples of cleaner production methods involves recycling effluent arising from the gas cleaning and slag processing operations through the system. Water cooling systems such as those used in an EAF tend to utilise closed-loop water cooling systems, which do not require significant effluent treatment.

Retrieved particulate matter may be recycled as feedstock or as solid waste landfill. Cleaner production technology such as pulverised coal injection, a process which substitutes coal for coke in the blast furnace, cause less pollution than what is associated with coke. Off-site recycling is generally not considered part of cleaner production, although it may bring substantial environmental benefits and result in improved environmental management systems.

Some options for cleaner production will, however, not be viable. Dry quenching for instance has been developed in Europe to eliminate carcinogenic particulate and VOCs associated with water quenching. This technological adjustments require major construction changes and assume high capital costs. Considering the depressed state of the steel industry and the increased regulations for coke making, technological adjustment of this kind is unlikely, and the industry instead forecasts an increase in the amount of coke imported (EPA, 1995).

5.3 Public abatement options

Environmental quality is generally assumed to be a public good. Hence the reason policy-makers are increasingly aligning themselves with the 'polluter pays' principle. A contrary view advanced by Tiebout is that environmental quality is not necessarily a public good. Tiebout argues that environmental quality varies considerably across any spatial continuum. Individuals express their preference for different levels of environmental quality by the amount that they are willing to pay for this commodity. The concept of hedonic pricing is based on this premise of Tiebout. Property prices therefore reflect among other things the environmental quality attached thereto (Baumol and Oates, 1994, p.244).

Pollution control instruments and policies are formulated by government institutions and other public stakeholders to ensure a minimum level of public welfare. The different public approaches that determine the type of pollution control policy interventions are discussed in this section.

There are three general approaches that domestic governing bodies, as well as multilateral organisations, can take to environmental management. These are the *regulatory approach* (direct controls), the *co-regulatory approach* (voluntary compliance), and the *market-based approach* (pricing measures) to environmental management (Heydenrych and Claassen, 1998).

Standards, as a regulatory control, will be discussed in more detail at the end of this section. Standards are still the most dominant form of environmental regulation, and as a result comparisons are regularly drawn between the levels of standards in different countries. Disparities in the level of environmental regulation may have significant trade implications for the countries in question. It is therefore of interest to draw comparisons between international and South African environmental standards in order to discuss the implications of significant differences in standards for trade.

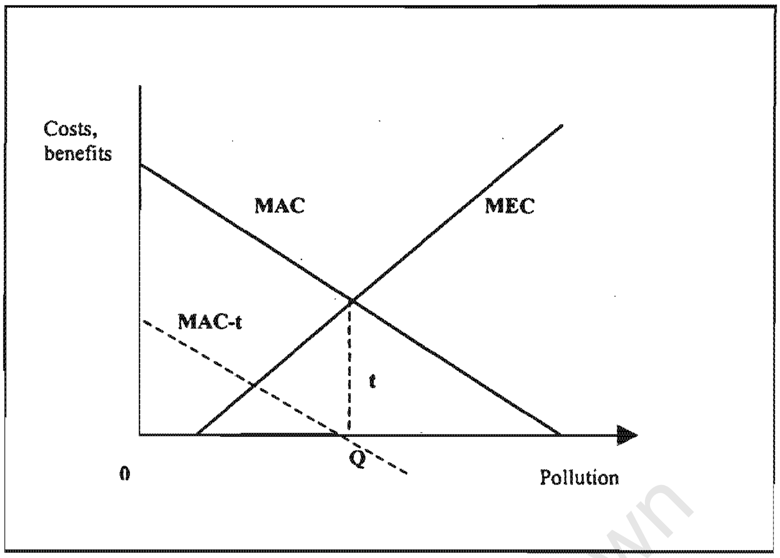
5.3.1 Regulatory approach: taxes, subsidies and standards

The objective of pollution regulation is assumed to be that of finding ways of reaching the socially optimal level of pollution. A need therefore exist for governments to initiate appropriate 'economic instruments'. Many would argue that the *market-based approach* mentioned earlier, is also a type of economic instrument and should be included under the regulatory approach. This is, however, more likely to be a debate around the semantics of abatement, and is ignored for the purposes of this illustration.

(a) Taxes or pollution charges

A tax on the polluter based on the estimated damage (external cost) caused, requires a means of equating marginal abatement cost (MAC) associated with a reduction in pollution and the marginal external cost (MEC) resulting from pollution at the level of optimal pollution (Q). The Pigovian tax (t) is defined as the point where the marginal external cost (MEC) is equal to the level of economic activity that defines the optimum pollution. Figure 12 illustrates the use of taxes to attain this optimal level of pollution.

Figure 12 The use of taxes to attain the optimal level of pollution



It is commonly accepted that such Pigovian taxes serve to internalise the external costs that the polluter imposes on society, by shifting the MNPB of each level of activity to the left. The polluter aims to maximise private net benefits subject to the tax (t), and this occurs at the optimal level of pollution (Q) (Baumol and Oates, 1994). Local taxes manifest as charges or fees. By instituting pollution charges firms are often encouraged to alter the level of pollutants produced by installing pollution abatement equipment (Pearce and Turner, 1990).

(b) Pollution reduction subsidies

It is also possible to encourage firms to install pollution abatement equipment by offering a subsidy on the amount of pollution reduced, i.e. by giving payments to firms to pollute below a certain level. Subsidies can further be applied in partially funding capital costs of pollution control equipment of firms involved in environmental restructuring and cleaner production. GATT makes provision for governments to subsidise up to 20 per cent of firms' initial environmental adjustment costs in adapting to increased regulation (Shaw, 1998).

(c) Standards

The most common approaches to the regulation of industrial releases is either by setting environmental standards or by specifying the level and type of technology that must be installed to meet the legal objectives. Standards are generally set according to some health-related criterion or alternatively in accordance with the capacity of a specific environment to absorb or disperse pollutants.

Standard setting tends to imply the establishment of particular levels of environmental concentration for pollutants (e.g. X milligrams per cubic metre). Standards are set by the government for all industries (in some cases these standards are sector-specific), and it is left to industry to achieve them. Plant permits stipulate the maximum levels of effluent or emissions from a site, and provide guidelines for the best available practices. In practice, these permits use a combination of limits that are defined for the quality of the receiving environment (i.e. *ambient quality*), as well as maximum emission levels from point sources (UNEP, 1996a).

5.3.2 Indirect regulation

Regulating bodies are increasingly becoming reliant on facilitative control instruments such as obligatory public disclosure of emissions data, fiscal incentives, and voluntary agreements, such as environmental improvement plans and ISO 14001 accreditation. Other forms of indirect regulation include environmental compliance, environmental auditing and eco-labelling. Within the global forum multilateral environmental agreements (MEAs) have become a powerful measure for guiding trans-national environmental issues.

There is not scope to discuss all of these approaches to indirect regulation in detail. However, the international trend with respect to environmental management and control is noticeably leaning towards methods such as compliance and environmental agreements to procure cleaner production methods. These methods are also generally preferred by industry due to the flexibility that this allows.

(a) Environmental accreditation through PPMs

As environmental management systems have evolved, a need has arisen to standardise its application. ISO 14000 has been developed by the International Organisation for Standardisation (ISO), as a series of standards providing structured environmental impact management for companies. There are basically two types of standards included in this framework, namely guidance standards and specification standards. All of these except ISO 14001 are guidance standards. ISO 14001 requires that environmental objectives should be consistent with environmental policy and targets should be periodically reviewed to confirm that they are consistent with the overall direction in which the company is moving. Various local iron and steel producers are in the process of obtaining ISO 14001 accreditation (Bethlehem, 1997).

(b) Eco-labelling

Eco-labelling programmes are important environmental policy instruments. The World Trade Organisation (WTO) requires that non-discriminatory practices be followed to protect market access and prevent distortion of competition. Environmental measures that incorporate trade provisions should therefore not discriminate between home-produced goods and imports, or between imports from and exports to different trading partners. Well-designed eco-labelling programmes can be effective instruments of environmental policy. An important starting point for addressing some of those trade concerns is to ensure adequate transparency in their preparation, adoption and application (Shaw 1998).

Although eco-labelling is thought to create market segmentation and have the capacity to create market distortions, continued development of these schemes is encouraged in view of the fact that eco-labelling is an important way of increasing consumer awareness and altering production practices in the market place (Cameron, 1998). A more positive view of eco-labelling practices is that it allows a variety of prices to co-exist through market segmentation, while encouraging cleaner production.

(c) International conventions and multilateral environmental agreements

A general view prevails amongst countries that global problems require global solutions, and that international agreement should take preference to unilateral action where trans-boundary or global environmental problems are concerned. Multilateral Environmental Agreements (MEAs) are favoured as the most tenable solution to international environmental problems. This view has been incorporated as Principle 12 of the Rio Declaration. Of the MEAs already in existence the Basle Convention on hazardous waste, the Convention on International Trade in Endangered Species (CITES), the Montreal Protocol on ozone-depleting substances, and the Kyoto Protocol to the Climate Change Convention are the most significant agreements that deal with trade.

It is important to note that when environmental agreements and even the threat of trade barriers encourage a firm or importing country to change its behaviour the measures taken constitute indirect regulation. When contravention of an MEA result in retaliatory action such as trade embargoes and taxes, these measures are no longer an indirect form of regulation.

In the international context it is possible that countervailing actions may be brought against perpetrators of MEAs by means of tariffs, or in worst-case scenarios trade embargoes. The US-Mexico tuna/dolphin dispute (Pearce, 1993) and the US embargo on shrimp imports from Trinidad and Tobago (Steward, 1998) were examples of this case. For more information about the outcome of these cases, see Chapter 2 (Section 2.3.3) and Chapter 7 (Section 7.1). These cases ensued as a result of differences in the policies regarding process and production methods between trading countries. In both cases the US acted in retaliation against infringement of domestic laws by importing countries. Arguably the actions by the US were unilateral in these cases, and were therefore in contravention of the GATT clause on extra-territoriality. Suffice to say that trade sanctions have been used for environmental purposes, and that such measures have enormous power to influence the behaviour of the affected parties. Another example where international trade measures may be used for environmental purposes is the debate around carbon taxes designed to internalise environmental costs. It has been suggested that international carbon taxes should be instituted to reduce global atmospheric carbon levels in adherence with the Kyoto agreements on greenhouse gases. The European Union proposed such a carbon tax, but the latter has not taken effect (Drake-Brockman and Anderson, 1994).

5.3.3 The market-based approach

The market-based approach is based on the view that individuals and firms are driven by personal utility optimisation and profit maximisation respectively, and that financial incentives may provide more efficient structures for behavioural changes than enforced regulation. Coase illustrated that where voluntary bargains that exhaust the potential gains from trade are struck among the parties to an externality, an efficient outcome will be reached (Baumol and Oates, 1994). Market-based instruments, such as tradable permits, can therefore be used to combine a Coasian approach with regulation. Whereas traditional economic instruments prescribe taxes and subsidies as main regulatory tools, market-based instruments are an extension of basic property rights.

A recent international trend that is being practised by companies in the USA involves trading of the unused allocation of their permit to another plant that has difficulty in meeting the prescribed standards for that industry. As with standards setting, the government allows only certain levels of pollutant emissions, and issues permits for this amount. Pollution permits, however, are tradable within the market. Those firms with minimal emissions (due to cleaner technologies, etc.) may sell their permits to firms that pollute in excess of the limit, and who may be unable to reduce emission without incurring enormous costs (as is often the case with older technology) (Porter and Van der Linde, 1995; Austin, 1999).

Although market-based approaches are practised by some countries, no international implementation of such emissions trading regime has yet occurred. An interesting development will be the institution of international carbon permits in future, to optimise the global consumption of carboniferous materials that contribute to greenhouse warming.

6. A Closer Look at Standards

This chapter presents a closer look at standards. Section 6.1 discusses specific factors determining the level of standards set, giving examples of trade-related conflicts around standard setting. Section 6.2 gives an overview of the externalities and impacts generated during production which are addressed in international fora as well as by national legislatures, referring to plant siting and environmental releases. Environmental releases are subdivided into atmospheric emissions, ambient emissions, effluent and waste disposal. Each subsection describes current international standards and/or regulations or trends, and then focuses on the current status of South African legislation.

6.1 Standard setting

Depending on the location of a plant, the impact of pollution on the recipient environment will alter. Standards for air and water may therefore vary depending on whether emissions or effluent are discharged into an industrial area or a residential area. A distinction in prescribing standards is also made between new and existing plants. In such cases, existing plants with older technologies may be granted more lenient standards or be allowed a period to adapt to the current standards. New plants are generally required to adhere to the latest guidelines and standards (UNEP, 1996a). Governments have a crucial role in determining the environmental standards that must be complied with, and in creating co-ordinated and effective environmental management strategies.

Control mechanisms for industrial releases, whether environmental standards or attitudes toward environmental management, differ greatly between countries. The most significant differences are evident between industrialised and developing countries. Often these differing standards and policies are the results of very dissimilar priorities between countries due to divergent economic and social circumstances (UNEP, 1996a). Various grounds for and against harmonisation of standards have been argued within the literature (Sorsa, 1992; Drake-Brockman and Anderson, 1994; Steward, 1998). Particularly where trans-boundary problems are of concern, the controversial legal question remains whether trade measures should be allowed where environmental standards in the exporting country are lower than the importing country. With the commencement of various multilateral environmental agreements (the Montreal Protocol on Depleting Substances, the Convention on International Trade in Endangered Species, and the Basle

Convention on Trans-boundary Movements of Waste, etc.), the view that global problems require global solutions is becoming more common. Some authors have voiced the opinion that GATT regulation has been biased toward harmonisation where trans-boundary problems are concerned (Canning, 1998).

Environmental groups in favour of harmonisation of standards start from the assumption that trade and investment liberalisation will allow and encourage highly polluting industries to shift location to where environmental regulations are less stringent, potentially undermining environmental standards in wealthier countries. Some environmentalists feel that consensus amongst states with divergent international standards will be achieved only if developed countries compromise by agreeing to accept international standards that are lower than their domestic standards (Steward, 1998; Esty, 1993; Pearce, 1993). They feel that pollution havens may encourage a competitive 'race to the bottom', eroding the level of standards currently prevailing in the developed world. In practice, little evidence has, however, been found to substantiate any of these claims (Drake-Brockman and Anderson, 1994). The majority of findings from studies on industrial migration have shown that very little evidence exists in support of the claim that stringent regulation cause companies to relocate.

The main concern is that as environmental regulations becomes more stringent, firms will uproot and relocate to sites of more relaxed controls. Such relocation of operations will occur at the cost of the domestic labour force of the country with high environmental standards, and at the cost of the environment of the country with slacker environmental controls. Barton (1998) argues that this assumption may be logical given optimal and rational decision-making by firms, but in practice firms behave in ways that are not always rational, and the assumption of free movement across global markets is not always valid. Research into the impact of environmental regulation on global investment has shown that environmental regulations seldom enter into multinationals' decision-making process with regard to locational siting. Appropriate adjustment by firms for environmental regulation typically constitutes up to 1.5 per cent of their total operating cost.

Important factors in decision-making are still traditional factors such as materials, labour and markets. Barton (1998) deduces from the existing studies that environmental regulations have no systematic effects on the siting of plants. Trans-national companies (TNCs) may even ensure that their investments in developing countries meet high standards, in the expectation that growing prosperity will lead to steady rise in public demand for higher environmental quality; if TNC plants did not meet these standards, costly retrofits would be required. The impact of this process on smaller domestically owned industries is, however, less clear (Barton, 1998).

In the steel industry ecological free-riding has to some extent motivated industrialised producers to agitate for harmonisation of environmental approaches. At the same time, European and North American producers have been hit hard by a slump in prices as overproduction ensues. Even as new methods of mass producing steel have come on stream, there has been a slump in demand for manufacturing output in general. European steel companies face competition not only from exports from the high-technology production processes and lower labour costs of the newly industrialised countries, but also from the low labour costs and lax environmental standards of Brazilian pig iron smelters (Lang and Hines, 1993).

The main concern of producers in industrialised countries has been their ability to remain competitive in a context of trade liberalisation, but also within a framework where countries impose different levels of environmental protection or introduce their own labelling requirements. These producers fear that countries with lower environmental standards may have an unfair comparative advantage over them (Brittan, 1998; Steward, 1998). Although even persons representing industry are generally not in favour of discrimination on grounds of PPMs, and fear that dictation of PPMs may inhibit competition and innovation, they seem in favour of including PPMs as appropriate measures within multilateral environmental agreements that strive to harmonise environmental approaches (Canning, 1998).

Those opposed to harmonisation counter that developing countries will find it very difficult to maintain a competitive advantage whilst upholding commitments to trade liberalisation, and in addition will be forced to invest in imported technologies (further skewing their balances of trade). It has also been said that the industrialised countries attained their current state of development at the cost of the rest of the world and of the environment. What is now socially optimal for these countries may not be optimal for developing countries, who face difficulties in adjusting to harmonisation of standards when such technological issues are considered (Jha, 1998).

In the literature covering the trade/environment debate, various authors (Pearce, 1993; Bagwati, 1995; Jha, 1998) argue in favour of differential environmental standards amongst countries. They warn that environmental laws should not be applied extra-territorially, since they may not be appropriate to the geographic and ecological conditions of another country. These authors support the view that differences amongst nations are important reasons for trade, and that differing environmental standards form part of the basis for the liberal theory of comparative advantage. They argue that environmental differences such as absorptive capacity, variations in climate and weather patterns should be viewed as factors in comparative advantage similar to technology-based cost advantage, and governmental policy-induced advantage. Jha (1998) endorses the view that countries need the freedom to decide on resource allocation based on societal needs and a prioritisation of their specific environmental problems.

6.2 Comparison of international and local standards

Identifying significant differences in standards between South Africa and international producers who may in future bring countervailing action against local producers on environmental grounds is of importance to domestic policy-makers. Understanding what the main differences are and whether they are justifiable within a domestic context will prepare policy-makers and producers against potential protectionist attacks. In addition, it allows analysts to model scenarios where these differences in environmental standards are eradicated. This section compares South African environmental standards with those of international iron and steel producers.

6.2.1 Plant siting

Until recently no standards were applied to the siting of plants in South Africa. Although it has subsequently become a prerequisite for new proposals, the siting and infrastructure of older plants often infringe basic considerations that should have been taken into account. When a site is located in proximity to other pollution-intensive works, it is often necessary to impose more stringent environmental standards than the prevailing national standards (UNEP and IISI, 1997).

6.2.2 Environmental releases

Environmental releases are normally regulated by media-specific (air/water/soil) standards under environmental or health laws. The industry is expected to comply with general or sector-specific standards for release to water and to air.

Air pollution at industrial (and in particular, iron and steel) plants is controlled by emission standards. Comparing such standards at national level is not straightforward, as they are described in terms of factors such as the individual unit process, definition of the pollutant, mass flow/gas volume, stack height, pollution control technology, etc., which differ significantly between countries.

(a) Air pollution

Emissions control requirements in developed countries, including most of Europe and Japan, stipulate the use of state-of-the-art technology, often with both emission standards and eventual ambient air quality standards. Stack height prescriptions (formulae relating stack height to dispersion) are also used by some countries.

South African air pollution legislature is addressed partly in the Air Pollution Prevention Act, No. 45 of 1956 (as amended by Amendment Act 17 of 1973). In terms of this Act, any new proposal for a steel plant would be a "scheduled process" in terms of Part II of the Act (Process 30 - Iron and Steel works and Process 34 - Gas and Coke works), and will therefore fall under the direct control of the Chief Air Pollution Officer. In terms of section 9(1)(b) of the Act, a Provisional Registration Certificate for the operation and location of the steel plant has to be obtained from the Chief Air Pollution Officer (CAPO) of the Department of National Health and Population Development (Boegman, 1994). Permits issued by the CAPO may contain specifications (emission limits) as well as recommendations about processes used. Different criteria are used for old and new plants, the distinction being plants that were built before and after 1975.

The Act requires that the "Best Practicable Means" (BPM) be used in the steel plant to reduce emissions. Determination of the BPM involves the balancing of costs and benefits, including the assessment of industrial plant financial viability and environmental assimilative capacities and pollution abatement technological options (Pearce and Turner, 1990). In terms of section 10(2) of the Act, the specifications of BPMs have to be negotiated with the CAPO by each firm in order to obtain a permit. Terms of reference include setting minimum standards in order to ensure a safe environment, and negotiation of cost structure and technology purchases. Odour and visibility are also discussed within this framework (Pearce, 1993).

One of the difficulties with legislation using best practicable means is that there are no general standards for either emissions or ambient conditions. The implementation of BPM is entirely the responsibility of the CAPO. The guidelines for dust and selected other emissions, which imply that BPM are used on average, are compared to standards and guidelines used in other countries in Table 5 (Boegman, 1994).

Table 5 gives an indication of the range of standards adhered to internationally. Particulate emission standards in South Africa compare favourably with some countries, but are significantly higher than those of Germany and the USA. Maximum limits for CO_2, NO_x and SO_x could not be obtained for local limits.

Table 6 Ambient limits and standards

Substance	*Concentration (ηgram/m3)*	
	1 hour	*24 hour*
Sulphur Dioxide:		
SA (corrected for site conditions)	730	365
Germany	400[(1)]	290
USA.	--	365
CANADA	900	300
Finland	500[(1)]	200[(2)]
Italy	--	250[(2)]
Switzerland	100[(3)]	--
Japan	300	120
WHO	750	100-150
Particulate:		
SA	--	300
Germany	--	300
U.S.A.	--	150
Canada	--	120
Japan	200	100
Nitrogen Dioxide:		
SA (total oxides of nitrogen of which 25% is NO_2)	600	300
Germany	--	200
USA (1992)	--	--
WHO Guidelines for Europe (1987)	400	

Notes: 1. Not to be exceeded 95% of the year
2. Not to be exceeded 98% of the year
3. 30 Minute Concentration not to be exceeded 95% of the year.

Source: UNEP (1996a)

As can be seen in Table 6, South African SO_2 and NO_2 limits are generally much higher than those of developed countries. Particulate emissions for older plants are higher than for new plants.

In South Africa, where no local limits for emissions have been set, the permitted 24 hour average ambient limits should not exceed one fiftieth of the Threshold Limit Value (Time Weighted Average) as set by the American Conference of Government Industrial Hygienists (ACGIH) for any individual compound (Confidential source, 1998).

Permits issued to specific plants contain maximum pollution limits and quality specifications for equipment (down-time, etc.). For instance, in situations where a breakdown of air cleaning equipment occurs, compliance is still expected 98 per cent of the time, making the need for standby facilities compulsory. Specifications with respect to monitoring are included in some permits.

Independent monitoring committees have been responsible for the gathering of data on industrial emissions within respective areas. A source inventory (1993 results currently available) is available from the DEAT.

At present no measures exist for penalising companies that do not comply with permits. Yearly meetings are held between the CAPO and big firms, whereby the latter are notified if they do not comply with current technology and best available practices. If prescribed criteria are not met, a two-year period of negotiation follows. If finally they still do not meet specific criteria, their certificate is cancelled, which implies that such firms can then no longer operate (Pearce, 1993).

(b) Effluent standards

Regulatory authorities will also control wastewater or effluent discharges. Both ambient quality and discharge standards are used. In the USA the Clean Water Act (CWA), Safe Drinking Water Act (SWA), and the Toxic Substances Control Act (TSCA) deal with the legislative aspects of effluent discharges. The CWA aims at restoring and maintaining the chemical, physical and biological quality of the surface waters in the United States. In accord with the SWA, the US Environmental Protection Agency (EPA) is in command of establishing regulations to protect human health from contaminants in drinking water. The mandatory role of the EPA involves the development of national drinking water standards and the ensured compliance with these standards. Further, the EPA has been granted authority by the TSCA to create a regulatory framework to collect data on chemicals. The Toxic Release Inventory allows EPA to evaluate, asses, mitigate, and control risks associated with the manufacture, processing, and use of chemicals. TSCA makes provision for a variety of control methods aimed at minimising risks and negative externalities posed by chemicals (Moore, 1998).

In South Africa effluent has been dealt with in two ways:

1. Discharge to the sewer - in which case the water quality is the responsibility of the local municipality. The latter will charge the specific company according to the treatment that the effluent requires (i.e. for heavy metals). The role of the Department

of Water Affairs and Forestry (DWAF) is to see that the quality of water discharged into the sea complies with that stipulated by the permit.

2. Discharge to a water source, i.e. a river - in which case firms need to comply with general and special standards as specified in the Acts (sections 21 and 26 of the Environmental Conservation Act, No. 73 of 1989, and relevant sections of the Water Act, No. 54 of 1956).

In terms of sections 12 and 21 of the Water Act of 1956 and section 20 of the Environmental Conservation Act, No. 73 of 1989, permits are required from the DWAF for the storage of raw materials. Section 12 of the Water Act, No. 54 of 1956 deals with use of water for industrial purposes. The Minister may set conditions upon issuance of any permit, including issuance of permits for previous users. A permit may be revoked by the Minister at any time if the conditions that apply to such a permit are not complied with. A requirement to implement pollution abatement measures proposed in the permit would probably be imposed by the DWAF as a condition of the issue of the permits, if a decision is taken to proceed with a steel plant on a proposed site. Sections 12 and 21 of the Water Act, No. 54 of 1956 and section 20 from the Environmental Conservation Act, No. 73 of 1989 apply to leaching from solid waste dumps and raw material stockpiles, as well as infiltration of storm-water and wastewater (Weaver and Wright, 1994).

South African effluent standards compare favourably with those of other countries, as is evident in Table 7. It is, however, the enforcement of these standards that is a significant problem.

Table 7 Effluent standards for South Africa and selected other countries

	Unit	*South Africa*	*Japan*	*Malaysia*	*Sweden*
pH	pH unit	6-9	5.8-8.6	6-9	
Temp	°Celsius	<30		40-45	
SS	mg/l	10	200	50-100	5-10
Iron	mg/l	0-0.3		1-5	0.5-1
Manganese	mg/l	0-0.05		0.2-1	
Lead	mg/l	0.1	0.1		0.2-0.5
Mercury	mg/l	0-0.02			0.005-0.05

Source: UNEP (1996b)

The new water act dealing with effluent is the National Water Act, No. 36 of 1998, which is based on a Receiving Water Quality Approach (RWQA). In terms of the new Act, discharge into rivers will require environmental impact assessments. Rivers will be classified and standards will be determined by this classification (Einsted, 1998).

South African water policies have been subject to a complex process of transformation, in terms of which the underlying objectives of the new water statutes differ significantly from those under the previous dispensation. One of the fundamental changes in principle is a return to the Roman Law classification of water as "a resource common to everyone". The concept of riparian rights therefore becomes redundant in this context.

Although appropriation of water rights will still be subject to recognition of existing rights, riparian land owners will no longer automatically be entitled to use the water flowing past their land by virtue of their land ownership. Instead they will have to compete with other users for the use of the water. Water will be allocated on the basis of efficiency of use, public interest and equity, with special preference for the development needs of poorer communities (Water Law Review Panel, 1996).

The White Paper on a National Water Policy for South Africa outlines a programme of resource monitoring, assessment and auditing. This includes the ongoing monitoring and investigation of resource use in different sectors, as well as the auditing of sectoral resource use patterns and assessment of whether objectives are being reached. Further auditing areas that need to be covered include compliance with registration and permit conditions, and achievement of objectives for resource protection and management.

(c) Solid waste disposal and site remediation

Land discharge conditions are applied to landfill facilities rather than the source of waste. Nevertheless, these conditions will be reflected in what the facilities will accept from their clients. Toxic slags, for example, must first be stabilised. Liquids are becoming less and less acceptable for land filling (UNEP and IISI, 1997).

Many governments are now requiring by law that companies clean up their sites that have been contaminated by seepage of chemicals and on-site disposals. This is often dealt with under specific "contaminated sites" legislation, or general environmental regulations. Although there has been no agreement or guidelines on "how clean is clean", a number of countries have attempted to prepare guidelines for soil standards expected from successful clean-up operations (UNEP and IISI, 1997).

The Environmental Conservation Act, No. 73 of 1989 requires that for the establishment or operation of any disposal site, a permit has to be issued by the Minister of Water Affairs, and that the issuance of such a permit is subject to such conditions as the Minister may deem fit to impose.

7. Implications of Environmental Regulation for Trade

This chapter presents an overview of possible implications of environmental regulations for trade. Section 7.1 explores possible outcomes of green trade barriers or harmonisation of environmental standards. Input-Output analysis is used in Section 7.1.3 to investigate the overall economic effects of a contraction in demand for exports originating from the basic iron and steel industry. The rest of the chapter discuss further implications of trade-related environmental regulations.

Direct or indirect means of environmental regulation have potential implications for trade. Multilateral Environmental Agreements (MEAs) and conventions, domestic regulation of export destinations, eco-labelling, international standards accreditation, environmental taxes, and consumer preferences are all overlapping trade/environmental issues that could potentially act as barriers to trade.

The sources of environmental damage that hold implicit threats for trade are mainly cheap inputs to production, inefficient production methods that result in resource depletion, excessive pollution and insufficient mitigatory action.

South Africa has a competitive advantage in terms of the cost of raw materials and electricity. For example, electricity costs at ISCOR's Vanderbijl plant are about 7.5 per cent of input costs, compared with the norm of 14-15 per cent. Energy is provided relatively cheaply to local industry for various reasons, one being the result of a failure to internalise negative environmental externalities in the upstream production life-cycle. The iron and steel industry further benefits from cheap and abundant iron ore and coal. This enhances the industry's competitive advantage in alloy and carbon steels, but not in stainless steel, as it has to import nickel. Input costs for carbon steel are about 24 per cent of total cost, compared with overseas input costs of 30 per cent. Input costs for local alloys are 45 per cent of total cost, compared to 52 per cent internationally (Rosenthal, 1998).

Many of the older industrial plants in South Africa utilise technologies that are inefficient in comparison with more recent technologies on the market. Upgrading older plants is, however, expensive, and with the lack of regulation enforcing cleaner production, there is very little incentive for firms to upgrade these plants in the short-term. The inefficient use of raw materials that generate excessive pollution during the production process is a further source of environmental damage, symptomatic of process and production methods which diverge from the international average (Confidential source, 1998).

In addition to this, insufficient investment in appropriate abatement technologies means that cost structures for local industries may be well below international standards (Confidential source, 1998). The implication is that cheap input cost structures may serve as implicit subsidies and consequently be construed as providing an unfair comparative advantage in trade, rendering countries vulnerable to the trade measures outlined above. It should be stressed that this argument is not well substantiated by empirical evidence of legal action taken against low-cost producers. There are, however, numerous examples of anti-dumping and countervailing action that has been brought against local producers in cases where those industries have in the past been subsidised or partly state-owned (Financial Times, 1999).

The impression this author obtained from conversations with various managing personnel within the iron and steel industry is that a logical progression from these dumping cases would be international targeting of differentials in environmental investment between countries. The incentive for implementation of ISO14001 is to a large extent based on an attempt to pre-empt such international action (Confidential source, 1998). It is, however, far more difficult to measure the extent of any "eco-dumping" than of standard economic dumping. This is amongst other things due to the fact that traditional dumping claims can be measured where exporting countries are selling below the private cost of production, whereas in the case of "eco-dumping" the claim results from allegedly inadequate environmental standards of the exporting country (Drake-Brockman and Anderson, 1994).

Some environmental issues, such as respiratory diseases caused by local emissions, have distinctly domestic implications (such as health costs, degradation of the environment and water pollution). Other issues may have local environmental impacts, but also have additional distinct trans-boundary effects, such as climate change due to green house gas emissions. In the longer-term it is especially these trans-boundary issues that becomes prone to MEAs. South Africa is a major emitter of CO_2 emissions, and therefore contributes significantly to the global greenhouse effect. The Intergovernmental Panel on Climate Change (IPCC) has identified the production and consumption of energy from fossil fuels as the most important human activity contributing to increasing greenhouse gasses (Worrel, 1994).

A future moratorium on carbon dioxide emitting processes or similar MEAs would put South African industries that are highly dependent on cheap sources of energy in a very vulnerable position. Reforms as a result of the Montreal Protocol have had significant effects on industries that have had to adjust their factors of production or install expensive equipment on plants to transform ozone-forming substances (Confidential source, 1998). The possible outcomes of international environmental/trade measures for the sector are discussed in more detail in Section 7.1 below.

The environmental trade linkage can be extrapolated even further. Firms in industrialised countries with high environmental standards and cost of compliance are concerned by the lack of global harmonisation with regards to standards (Canning, 1998). Countries that do not impose environmental standards equivalent to those in developed countries may have lower relative costs, and hence gain an unjustified comparative advantage based on cost and pricing structures that do not reflect the costs of environmental externalities of production. In the event that countervailing action is taken to adjust for these differences in pricing, local industry may suffer severe damage (Jha, 1998).

The legal and economic issues arising from the United States embargo on shrimp imports serve as insightful examples of the potential complexities of environmentally-motivated trade measures. In 1973 the US government passed an act in order to implement its obligations under the Convention on International Trade in endangered Species (CITES). In 1989 this act was amended to prohibit the US from importing shrimp from any country which lacked a domestic turtle protection programme that was comparable to the programme in existence in the US. The main aim of this amendment was to reduce the killing of turtles caught in shrimp trawl nets. All commercial shrimp trawl vessels that haul in gear by using mechanical means were henceforth required to install turtle excluder devices in their nets. The law required that a list of suitable trading partners that met with these criteria be identified. It further stipulated that embargoes be placed on shrimp imports or related products from countries that did not comply with these requirements within two years of the commencement of the Act. Subsequently, imports of shrimp from the Caribbean states of Trinidad and Tobago, French Guiana and Suriname were embargoed. The embargoes imposed on Trinidad and Tobago were lifted once the government issued regulations in compliance with the US requirements. The interpretation of this Act has since been legally challenged, with the result that over 30 states had embargoes placed on their exports of shrimp to the USA.

This case has fuelled the discussions about competitiveness between states where differing environmental standards prevail, and also addresses the legality of extra-territorial application of domestic law for environmental purposes. It is a clear example of US trade measures reducing the competitiveness of its trading partners. The question of whether the action was unilateral or whether it qualified for GATT exceptions, although highly contentious, becomes irrelevant in the face of the potential economic losses incurred by affected parties. Previously, GATT rules have not allowed for trade measures against products unless the environmentally harmful effects occur within the jurisdiction of the country imposing the ban.

The well-known tuna/dolphin debate affirmed the GATT position on this issue when the panel decided that US action against Mexico did not qualify under the GATT exceptions, and that the hazardous effects in question were related to the process and production methods. At the time the panel's ruling on the tuna/dolphin dispute brought some closure to the vastly different interpretations regarding the GATT exceptions. However, the US *versus* Trinidad and Tobago shrimp case is now being investigated by the WTO Dispute Settlement Panel, and could lead to new interpretations of the GATT rules (the so-called 'greening' of the GATT).

In a comprehensive article about this case, Steward (1998) notes a growing support for the need to change in the GATT rules on process and production methods. Those in favour of such changes argue that trade measures based on differing process and production methods should be accepted, given that environmental effects caused by production processes are often more severe than those caused by the product (Brown-Weiss, 1992). The growing recognition of the ecological interdependence of the world, reflected by international agreements such as the Rio Declaration and Agenda 21, is indicative of increasing pressure on the sovereignty of countries where issues of global responsibility is concerned Steward (1998).

At this stage it is unclear whether trade measures taken in order to enforce domestic or international goals will be legally binding under the GATT in future. There remains sufficient uncertainty with regard to the possible outcome of these disputes and their implications for South African industrial development to warrant a systematic evaluation of such trade measures with a view to characterising their intended and unintended effects (Cameron, 1998).

7.1 Scenarios

In this section some impacts that environmental regulation or environmental-related trade policies may have on the steel sector are discussed. In most cases these scenarios will be over-simplified, as steel exports occur in a dynamic market with inter-temporal factors affecting the economy. In view of the lack of available data on pollutant types and quantities by the steel industry, and the lack of general standards for the sector which clearly stipulate maximum levels, etc., it is safe to assume that South African industries are currently lagging behind international producers in environmental performance. Estimated environmental investment as a percentage of operating costs is 2.5-5 per cent for local producers and 8-15 per cent for international producers (Bethlehem 1998; Confidential source, 1998).

Only two scenarios will be considered here, namely that of green trade barriers in the form of countervailing or anti-dumping duties, and that of harmonisation of standards or global environmental taxes. Alternative responses to such measures will be identified and possible outcomes explored.

7.1.1 Green trade barriers

In this first scenario a potential situation is considered where South Africa may be held accountable for dumping steel on international markets. If a call for countervailing measures are based on an unfair comparative advantage enjoyed by local producers as a result of lower mandatory investment in environmental control equipment and management options, such claims would have to be investigated by the WTO review panel. In Sections 2.3 and 4.2.1 the US-Mexico tuna/dolphin dispute and the embargo on shrimp imports from Trinidad and Tobago were used as examples to illustrate cases where environmentally motivated trade measures had significant economic implications for affected parties. As is mentioned in Section 2.3.3, the GATT ruling with regards to PPMs is unclear and would for purposes of this argument need to be clarified. If countervailing action becomes warranted within this context, green trade barriers of this nature may none the less hold significant consequences for local producers and for the economy at large.

It is not clear how the level of anti-dumping or countervailing duties is determined. In the case of implicit subsidies as a result of different levels of environmental investment between countries, the difference between the local level of environmental investment and the optimal level of investment would have to be established. As this is an extremely complex procedure, the most likely estimate of such a duty would be the difference between the international and local level of investment. For trade purposes it may even be simplest to equate the anti-dumping-duties or tariffs to the price differential between countries. This tariff can be expressed as:

$$((1 - SAp/INTp)*INTp).$$

where SAp = South African price

and INTp = International price

The total price at which South African steel would be selling will then be:

$$[SAp + (1-SAp/INtp)*INTp]$$, which equals INTp.

Unlike domestic taxes, the actual tariff paid by international consumers is clearly not re-invested in the macroeconomy. Due to the fact that the South African product is no longer provided below international prices, it is bound to lose a significant proportion of the market. This loss of competitive advantage may result in a reduction in trade and also in the removal of certain products from the international market. The magnitude of the reduction of trade due to an increase in price is determined by the price elasticity of demand for steel internationally. Unless this is estimated accurately, it is not possible to deduce by what percentage the export market for the South African product will be reduced. The sensitivity of the South African economy to reduction in trade can however be tested over a specified interval to account for this uncertainty.

In response to the threat of green trade barriers local producers may choose to increase investment in environmental equipment and cleaner technologies. A major problem that many developing countries face is that specialised equipment of this nature is rarely locally obtainable and has to be purchased internationally. Balance of payment constraints can therefore limit the accessibility of such equipment and technology severely. This outflow of capital is an additional implication of regulation for the local economy. The proportion of equipment purchased from international producers can be estimated by using the capital-import ratio. The increase in capital expenditure would most likely be determined by the difference in local and international expenditure on environmental equipment. Environmental investment levels for the industry as a whole are about 5 per cent of operating budget, compared with an international average of about 15 per cent (Bethlehem 1998):

$$[(1-SAexp/INT.exp)INTexp + SAexp = INTexp]$$

where SAexp = South African producer's average expenditure on environmental technologies; and

INTexp = International producer's average expenditure on environmental technologies

The outcome of such increased investment due to green trade barriers for the economy is likely to be an initial contraction. Firms that are unable to compete internationally under a regime of green trade barriers will close down, whereas the more competitive firms will have to adjust input cost structures to remain profitable in the long-run.

7.1.2 Harmonisation

The second scenario considered here is an international move towards harmonisation of standards. Bigger players with significant economic power are in a position to encourage developing countries to become signatories to relevant multilateral environmental agreements that demand the harmonisation of standards, stipulate best available technologies, or prescribe a reduction in carbon emissions. Within the context of globalisation and trade liberalisation, smaller countries and producers may have very little alternative but to align their domestic regulation with world standards. Strong criticisms have been raised about the process through which multilateral agreements evolve. MEAs are generally negotiated through complex and detailed agreements made by a small number of strong contracting parties (CPs), and these agreements can be almost impossible for other CPs to change or alter. For example, CPs do not have an automatic right to take part in GATT negotiations and participation. As indicated in an article by an international environmental NGO (Friends of the Earth, 1993), many countries are obliged to make significant concessions, for example through compliance with structural adjustment programmes, before they can even participate in international trade negotiations.

Another obstacle to transparency in multilateral agreements is the lack of circulation of information to all CPs involved unless clear commitments to structural reform and trade liberalisation have been made by the latter (Friends of the Earth, 1993). For smaller countries that are unable as a result of domestic priorities (environmental or socio-economic) to abide by such conventions, green trade barriers and even sanctions become a real threat.

The possible implications of MEAs that specify the harmonisation of standards and responses that local producers or regulatory bodies may have to such measures can be separated in terms of non-compliance with MEAs and adjustment of local standards in alignment with international standards.

In the former case, green trade barriers that are imposed due to non-compliance with MEAs would be determined to reflect the external cost on the environment due to production. The tariff is applied outside the domestic boundary, and therefore does not impact on the domestic economy other than causing an increase in local prices on the international market, which is bound to result is a loss of market share. The impact on the economy and the steel industry due to a reduction is calculated as before.

The alternate response to harmonisation of standards would be to increase domestic regulations/standards in compliance with MEAs. The outcomes of a local increase in environmental standards can be discussed in terms of reduced output, charges/taxes for non-compliance and increased environmental investment.

In order to comprehend the required adjustment in current legislation, the relation between quantity of pollution generated per quantity steel produced for every plant has to be determined. This would then have to be adjusted to the optimal levels of pollution. Standards normally differ according to plant size, production method, the nature of the receiving environment, etc. Determining the optimal level of pollution is a complex and costly task. Once again it is more likely that local standards will be required to align with the estimated international standards.

Decreasing emissions by a prescribed level may have various outcomes. It can be assumed that production in the short-term would be inflexible. A reduction in emissions in the short-term can therefore only be realised by a reduction in output or by freezing some other form of input costs if possible.

Alternatively, firms may choose to maintain their level of output, but pay a penalty fee for non-compliance. Such a fee can be determined in various ways, but should be approximately equivalent to the value of emission per ton of pollutant (cost of emission), and thus requires an estimation of costs of environmental damage associated with each pollutant.

The response of a firm to such a penalty fee may be two-fold, depending on the price elasticity of demand for its product. If the latter is inelastic the producer is free to increase prices to reflect the increase in input costs. Internalising the costs of environmental externalities is thus borne by the consumer. If the price elasticity of demand for this product is high, on the other hand, increased pricing would lead consumers to shift to other products. The macro-economic implications of such an increase in the demand for substitute goods may not necessarily be negative, but rather implies economic redistribution between sectors. It would, however, cause a reduction within the industry in question, which would probably translate into job loss and economic losses within that sector.

As a competitor in the international market the steel industry is merely a price-taker. An increase in costs of production due to domestic charges therefore has to be internalised if a firm is to remain competitive. Increased costs of production may, however, also damage the comparative advantage of a firm and lead to the closing down of less competitive firms. It is especially the older firms requiring high-cost adjustments that are unlikely to withstand such charges due to non-compliance. On the whole there is always a trade-off between adjusting pollutant levels to prescribed standards *versus* paying a penalty for non-compliance. There is a level of penalty above which it is cheaper to adjust production processes than to pay the penalty.

In the longer-term production can be expected to be more flexible, allowing the producers to invest in environmental equipment and cleaner production methods. Once again, the associated increase in production costs has to be internalised due to the price-taking nature of the steel industry on the international market. Examples of long-term adjustments would be installing additional technology, obtaining ISO 14001 accreditation, pursuing just-in-time production, and implementing other flexible production methods. The importance of exploring efficient and least expensive methods of adjustment cannot be over-emphasised.

7.1.3 Input-output analyses of projected reductions in exports

Specific outcomes associated with reductions in trade as a result of green trade barriers or increased standards are presented here. The results obtained from elementary input-output analysis are used to project changes in overall economic output, income and employment effects resulting from reductions in trade. For a detailed overview of the data and methodology used, the Appendix should be consulted. Detailed results are also presented in the Appendix, and serve as background to the summarised results presented here.

Input-output analysis was performed on an aggregated version of the 1995 Social Accounting Matrices to illustrate the total (direct, indirect and induced) effects of a contraction in net trade. The transactions table was used to calculate a technical coefficient or direct coefficient matrix. From this table the first-round income and output effects of changes in the final demand for any product were obtained.

The inverse Leontief matrix was then calculated for a model that excludes households from the intermediate sectors and also for a model that is open with respect to households. Closing the model with respect to households allowed the inclusion of consumption expenditure inside the technically interrelated table. Table 8 summarises the main finding from the first stage of input-output analyses for the basic iron and steel industry.

Table 8	**Basic iron and steel input-output data**			
Sector	*Output (Rm)*	*Output coefficient*	*Fraction*	*Leontief inverse output coefficient*
Basic iron and steel	774.55	0.04184	0.04175	1.05189

An exogenous increase in the final demand of the basic iron and steel sector by R1 million will result in an increase in the output of that sector by R1.05487 million. This total is made up of R1.0 million initial increase in output, R0.042 million first-round effect (deduced from the direct coefficient matrix), and an amount of R0.01287 million called the industrial support effect.

Multipliers were then calculated from the Leontief inverse matrix including households, and from the Leontief inverse matrix that excludes households. The closed model multipliers are all significantly larger that those calculated for the open model, with total output and income multipliers almost double their simple multiplier equivalents. Table 9 summarises the results from the output multiplier calculations.

Table 9	**Output multipliers for the basic iron and steel industry**			
Sector	*First-round effect*	*Simple output multiplier*	*Truncated output multiplier*	*Total output multiplier*
Basic iron and steel	0.4175	1.852	2.587	3.178

The initial output effect or first-round effect on the economy is defined to be simply the initial rand's worth of a specific sector's output that is needed to satisfy the additional final demand. The initial effect of an increase of one rand in final demand for goods delivered by the basic iron and steel sector is 0.4175. The simple output multiplier for basic iron and steel is 1.852. The total output multiplier for the iron and steel industry is 3.878, whereas the truncated total output multiplier for this industry is 2.587.

The income multipliers for open and closed models are listed below. The simple, truncated and total output multipliers were calculated for each of the industries in the intermediate sector.

Table 10	**Income multipliers for the basic iron and steel industry**			
Sector	*Initial income effect*	*Simple household income multiplier*	*Truncated total income multiplier*	*Total income multiplier*
Basic iron and steel	0.2203	0.4168	0.5843	0.5919

The initial income effect also known as the labour-output ratio in value terms is by definition equal to the ratio of wages and salaries to output for a specific sector. The initial income effect per one rand's worth of sectoral output is 0.2203 for the basic iron and steel industry. This is equal to the household coefficient for basic iron and steel from the direct coefficient matrix.

For the model that is open with respect to households the simple output multiplier for the iron and steel industry is 0.4168. This indicates that R1 million of final demand for the output of the basic iron and steel industry becomes R0.417 million of new household income, when all direct and indirect effects are taken into account, via the Leontief inverse. For the model that is closed with respect to households the total household income multiplier is 0.5919. This figure includes the direct, indirect and induced effects of income generated.

The employment figures for 1994 (CSS, 1996) were included in the transactions table in order to calculate employment multipliers for the basic iron and steel industry. Table 11 presents the simple multiplier and truncated total employment multiplier for this industry. Employment effects calculated in this study are based on 1995 employment figures. The basic iron and steel industry has since seen drastic shedding of labour (up to 30 per cent). This will have considerable effects on the physical labour output ratio, and will therefore also reduce the employment multipliers that were calculated for this industry.

Table 11	**Employment multipliers for the basic iron and steel industry**		
Sector	*Labour-output ratio*	*Simple employment multiplier*	*Truncated employment multiplier*
Basic iron and steel	4.9300	8.6920	14.2496

The simple employment multiplier for basic iron and steel is 8.69, indicating the units of employment per R1 million of output in this industry. An increase in R1 million of final demand for basic iron and steel will result in 8.6 extra labour units. Only the truncated total multiplier was calculated for the model that is closed with respect to households, obtaining a value of 14.25.

The results obtained from the multiplier analysis were used to make static projections of the impacts that reductions in export demand for goods delivered by the basic iron and steel industry would have for the economy at large. The motivation for these projections was to explore the possible outcomes of trade reductions that may result from adjustments to green trade barriers or harmonisation of environmental standards within the basic iron and steel industry.

A range of 5-20 per cent reductions of exports for the basic iron and steel industries and by extension the change in final demand for that industry was calculated. The projected changes in final demand were multiplied by the multipliers described previously. The output, income and employment effects were calculated for different scenarios.

In Column 1 of Table 12 the original external total value (R10 485.54 million) and the associated final demand (R10 621.46 million) for goods produced by the basic iron and steel industry are shown. Projections were made to show the change in demand for exported goods in this industry and the associated change in FD for goods produced by the basic iron and steel industry. A range of reductions in export demand of 5-20 per cent was tested. Column 2 gives the original and external totals. The difference between the original and projected values is shown in Column 3. Original and projected final demand values are presented in Column 4.

Table 12 Projected changes in final demand for goods delivered by the basic iron and steel industry

Projected change in exports	*External total (Rm, 1995)*	*Difference between original EXT.TOT and projected EXT.TOT (Rm, 1995)*	*New final demand (Rm1995)*
Original	10 485.540	-	10 621.460
Projected 5% change	9 961.263	524.277	10 097.180
10% change	9 436.986	1 048.554	9 572.902
15% change	8 912.709	1 572.831	9 048.625
20% change	8 497.165	1 988.375	8 633.081

The results from Table 12 were used to calculate the multiplier effects associated with projected changes in exports and therefore also final demand for the basic iron and steel industry. The original final demand of R10 621 million for basic iron and steel was reduced by a minimum of R524 million (5 per cent reduction in exports) to a maximum of

R1 988 million (20 per cent reduction in exports) in order to estimate the total (direct, indirect and induced) effects on output, income and employment shown in Table 13.

Table 13 Output, income and employment effects of reductions in exports for goods produced by the basic iron and steel industry

Reduction in exports	*Difference between original and projected final demand (Rm)*	*Difference * simple output multiplier (Rm)*	*Difference * simple income multiplier (Rm)*	*Difference * simple employm. multiplier (number)*	*Difference * truncated total output multiplier (Rm)*	*Difference * truncated total income multiplier (Rm)*	*Difference * truncated total employm. multiplier (number)*	*Difference * total output multiplier (Rm)*	*Difference * total income multiplier (Rm)*
5%	524.28	970.90	218.51	4557.02	1356.18	306.37	7470.73	1666.50	310.32
10%	1048.55	1941.80	437.02	9114.04	2712.37	612.75	14941.45	3333.01	620.64
15%	1572.83	2912.70	655.54	13671.06	4068.55	919.12	22412.18	4999.51	930.96
20%	1988.38	3682.24	828.73	17282.97	5143.47	1161.99	28333.50	6320.39	1176.92

The results obtained from these projections indicate the following: for an open model (excluding households), reducing exports by 5 per cent will result in a reduction in total economic output of R970.9 million. Decreasing exports by 20 per cent reduces the overall economic output by R3 682.24. million. Similarly, the open model income effect of such reductions in exports will result in losses in income of R218.51 million to R828.73 million. The losses in employment range from 4 557 to 17 283 persons for the entire economy. These losses in output, income and employment increases significantly when the truncated and total multipliers with respect to a closed model are used to make these projections. The total output multiplier effect of a similar range of reduction in export leads to a reduction in total output of R1 666.5 million to R6 320.39 million.

It should be acknowledged that the scenario presented here may be oversimplified, but it was decided to limit this exercise to variables that could realistically be included in such a forecast. Other possible scenarios were discussed within the text, but were not analysed within this input-output framework due to certain limitations of input-output analysis, as well as lack of data on the variables that are being dealt with.

Specific shortcomings of input-output analysis are without doubt the fixed coefficient assumptions, and the proportionality assumptions. The steel industry, and specifically integrated steel production, is known to exhibit significant economies of scale. Changes in output would therefore fail to incorporate the effects of increasing returns to scale.

The fixed coefficient assumption has dual implications for analysis of the basic iron and steel industry's behaviour to changes in final demand. Firstly, if the relative prices of factors of production change during the period covered by the projection, it is possible that input patterns, and hence some technical coefficients, will be changed. Although this will happen only if some inputs can be substituted for others, these changes in technical coefficients as a result of substitutions effects are not picked up by input-output analysis. Secondly, fixed capital purchases which may occur when industries are forced to adjust to environmental regulation (domestic or international), commonly involve new technologies with a higher level of efficiency and altered production function from the older technologies. Such acquisitions would therefore also involve alterations to the technological coefficients.

More extensive modelling using the input-output analyses is possible, but this would require readjustment of the technical coefficient matrix. The simple scenarios developed here, however gives an indication of the overall economic effects that can be expected if exports contracted.

7.2 Further implications of pollution control measures

7.2.1 The impact of environmental regulation on competitiveness within a sector

Given that compliance with pollution control measures entails acquiring new technologies and embarking on integrated pollution management schemes, it is evident that the initial investments and additional running costs of complying with regulation will cause firms to be less competitive in the short-run.

Environmental regulations naturally lead to positive outcomes for the environment, but the understanding that firms and industry can benefit from regulation is a more recent development. Porter and Van der Linde (Porter and Van der Linde, 1995) describe this as a "win-win" scenario, where regulations lead to innovation and adaptation in order to deal with the cost implications of the regulations. Better management practices, more efficient production and introduction of new technologies are further positive spin-offs from regulations. Examples of German industries' response to regulations relating to emissions has shown that the production methods of the more pollution-intensive industries were subjected to critical assessment, and these sectors were forced to invest in "cleaner" technology at a much earlier stage than other industries. In this way these firms have adapted to the higher cost of internalising environmental externalities, and have gained a competitive advantage over other industries in the global market (Porter and Van der Linde, 1995). There may not necessarily be a causal relationship between environmental investment and competitiveness, but it would seem that they are not exclusive, and the one often complements the other in the longer-term.

In contradiction to this argument, Palmer *et al.* (1995) have painted a somewhat different picture, suggesting that the outcome of tighter regulation may actually be more representative of a zero-sum game within which some firms will gain at the expense of others. Palmer *et al.* (1995) in fact voice the concerns that many developing countries have with respect to harmonisation of standards. According to this second argument, some firms may be unable to remain competitive in a framework of severe regulatory control and may thus be forced to exit the market. Those firms that are able to innovate and increase productive efficiency will remain competitive and gain from increased access to the market (Palmer *et al.*, 1995).

Global players with a large market share and significant influence in technological development and production methods may find it easier to stay ahead under a frame of continual adjustment of environmental technologies. Smaller players such as South Africa have to purchase new technologies from foreign destinations, and may find it more cumbersome to remain competitive and stay abreast of developments.

The impact that trade-related environmental measures may have on competitiveness and share in the market will not be equally felt by all developing countries. The lack of infra-structural and monitoring facilities, limited technology choices, limited access to environmentally-friendly raw materials, insufficient information and the extent to which export-oriented industries have become influenced by environmental standards, all determine the degree to which environmental measures impact on economies (Jha, 1998).

A recent study in the US has shown that consumer awareness is affecting market rating and that companies can indeed profit from operating "clean and green". Studies like this have been possible as a result of enforced public disclosure of environmental emissions and discharge. Both authorities and consumers now have access to information regarding the nature and quantities of pollutants discharged by various industries and plants. Markets are reasonably efficient at pricing business environmental practices in terms of market risks. Research also shows that firms may increase their environmental performance out of concern for their reputations and due to shareholder pressure if they are lagging behind the environmental performance of their competitors. The relationship between the cause and effect however needs further investigation (Austin, 1999).

7.2.2 The effect of environmental regulation on employment

There is no direct reason why adhering to environmental regulation should result in job losses for the steel industry. However, manufacturing everywhere is becoming capital-intensive rather than labour-intensive. This is not an attempt to cut back on labour, but because of technological reasons to improve competitiveness and quality. Technology has to be improved to remain competitive. Without technology improvement industry will experience de-industrialisation that will have drastic implications on labour in the long-term. Improvements in economic conditions and training will affect growth prospects for the industry as a whole, but, following world-wide trends, the steel industry and manufacturing in general are unlikely to create many new jobs in future (Chatzistergou, 1998).

Environmental regulation in as much as it causes a reduction in trade or force firms to reduce production expenditures may indirectly result in job shedding. The relationship between regulation and employment is, however, difficult to establish, as it would be firm-specific and require access to a host of variables that are constantly changing. It is nevertheless possible to obtain an estimate of the impact of trade reduction on employment using simple input-output analysis. Employment multipliers for the basic iron and steel industry were estimated in Section 7.1.3.

It should be noted here that South African commitment to redistribution and job creation may well be different from international policy and priorities. These domestic priorities should also be taken into account when environmental regulations for the local industries are formulated.

7.2.3 Synergies developing between national trade strategy and regional or international trade strategies

South African industry is in a process of substantial restructuring in order to take up the challenges posed by its integration in the global economy. Considerable adjustments to productive structures are aimed at enhancing price competitiveness in the global marketplace through productivity improvements and increased efficiencies (IDC, 1998a).

International surveys conducted over the last four years have ranked South Africa amongst the three or four least competitive of the major trading nations. Preliminary industry cluster studies in the iron and steel downstream industry, further determined that various domestic industries have survived merely due to protection and subsidies. For South Africa to overcome the market distortions and gain international comparative advantage, dramatic change in international and competition policy is required (DTI, 1997). The supply-side approach envisioned for successful future development of the industrial sector requires, amongst other factors, technological enhancement, productivity improvement and industrial development financing.

The integrated competition policy that has been proposed amongst government's national objectives specifically emphasises the integration of industrial strategy, trade liberalisation and competition policy with an active approach to economic empowerment. The aim of competition policy is to support free trade by phasing out government intervention such as subsidies, trade barriers or state ownership and monopolisation in private sector enterprise.

The objective of sustainable competitive manufacturing is to encourage reform of the economic activities of firms, governments and labour to activate long-term economic and employment growth. The extent to which the government support will succeed in entrenching policies and practices that will sustain competitive development, will determine the feasibility of any long-term manufacturing growth. The responsibility that this holds for government not only entails a pursuit of international competitiveness, but also requires a commitment to training, to innovation of products and processes, to best-practice work organisation, to the economic empowerment of historically disadvantaged communities, and to environmental responsibility (DTI, 1995).

Through the Uruguay Round extension of the General Agreement on Tariffs and Trade (GATT) and the creation of the World Trade Organisation (WTO), the international community has revealed a commitment to international trade liberalisation in theory. Prior to 1994 South-Africa's international isolation hindered the successful implementation of an outward-oriented growth policy. The free-trade school of thought that prevails globally has also inspired significant trade reforms (liberalisation) in South Africa. Steps have been taken to align South African export incentives with WTO acceptability. The rules that apply to countries in pursuit of industrial development have become a lot more stringent since the formation of the World Trade Organisation (WTO), limiting the degree to which governments can provide industrial development assistance (DTI, 1995). Tariffs and export subsidies that have previously served to protect local industries have been lifted or are in the process of being phased out. The move towards liberalised trade is aimed at increasing the efficiency of national industries by exposure to international markets, and is further the result of international trading requirements, requiring WTO members to abolish protective measures (DTI, 1997).

Current policy is structured around a supply-side approach, which seeks international competitiveness as its main goal. Firms are encouraged to invest in products and processes that are internationally competitive. Efforts to attain sustainable competitive manufacturing involve increasing general productivity and investing in enhanced capabilities of the factors of production (DTI, 1995).

There is at present still a 5 per cent tariff on all imports internationally, which is in the process of being phased out. The South African government has created profit incentives (in terms of raw steel purchases) for secondary producers, whereas primary producers receive no form of incentive (DTI 1997). Steel production and exports remained at relatively steady levels before, during, and after the South African general export incentive scheme, which has now been phased out. Regardless of any incentives, the industry is not growing.

Anti-dumping legislation remains an outstanding matter with regard to trade policy, and the Department of Trade and Industry (DTI) is currently upgrading its institutional capacity to deal with such cases. South African producers have been accused by international competitors of dumping on international markets in recent years. Historical subsidies (such as start-up capital) and low input cost structures are given as reasons for an unfair comparative advantage gained by South Africa, enabling local producers to market steel internationally at lower than average prices. Whether these claims are legitimate will have to be investigated, and the issue for dumping with regard to process and production methods will have to be further clarified within the international trade forum. It is, however, necessary for local producers to consider negative externalities associated with "cheap" energy inputs (Van Horen, 1997) as well as unsustainable production methods that may in future become prone to green trade barriers. Examples of conflict in international trade and environmental debates caused by negative social and environmental externalities were discussed in Chapter 1.

Protectionism within the international trading forum, though waning, is still common-place, and many fear that the current wave of countervailing and anti-dumping legal suits is motivated by protectionist agendas. The legal procedures involved can drag on for years causing the industries involved irreparable damage, irrespective of whether the original charge was substantiated.

7.2.4 The driving force for environmental adjustment in the market - where are environmental pressures likely to come from?

It can be expected that international market pressure will grow in the near future, given growing environmental awareness amongst the global market and increasingly stringent competitive trade measures. Recent studies have shown that the steel industry is experiencing increasing pressure from international and local sources (Bethlehem, 1998). Although the WTO's stance on PPMs has not been resolved, this issue may in future cause trade pressure through countervailing measures and bans. The general feeling from the majority of stakeholders is that such unilateral measures should be avoided, and that more flexible and creative options such as voluntary agreements, accreditation, eco-labelling, etc., should be sought to align differences in environmental standards (UNEP and IISI, 1997). Internationally, legislation is coercing the steel industry into cleaner production and more efficient production processes. Concurrently, competition from substitute materials is forcing the steel industry to invest in cost-saving and quality enhancing technologies. Simplified and continuous manufacturing technologies that reduce the capital costs and inventories and make provision for more efficient operation of smaller mills seem to be the way forward for those companies that will succeed in this industry in the long-run (EPA, 1995).

Local iron and steel industries do see trade and environmental linkages as a potential threat to the industry in the longer-term. The South African Iron and Steel Institute (SAISI) has been instructed by its members to investigate these matters. A Committee on Environmental Affairs has been established in order to resolve queries surrounding trade/environmental issues. Although there is at present minimal evidence of trade-related environmental action (and *vice versa*) taken against the industry, some companies suspect that measures such as ISO 14001 accreditation will in future become a requirement for international markets. The extensive environmental restructuring and implementation of ISO 14001 at Columbus Stainless has been said to be a strategic move on behalf of the company to pre-empt international pressures, while incorporating more efficient and "cleaner" production methods are also increasing the global competitiveness of this firm (Confidential source, 1998). Some companies have reported problems with German wrapping and labelling requirements for imported goods (Nel, 1999). In other industries such as pulp and paper considerable adjustments has been made to conform with the expectations stipulated in the Montreal protocol (Confidential source, 1998). In general, industry is very cautious to express opinions on this issue due to the unclear implications that this will have for policy decisions and the possible abuse of information by competitors. Responses varied from emphatic denials that the steel industry has or will experience any problems with regards to trade-related environmental pressure, to clear indications that management is highly aware of the conflicts in the trade/environmental arena and its implications for industry in the future.

Domestic complaints from peripheral communities, with regard to environmental problems, are becoming an increasing problem to the steel industry. Local communities are bringing forth legal action as a result of air emissions (Haasbroek, 1998). Government regulation is placing more emphasis on environmental profiles due to the presence of chemicals and heavy metals in plant effluent. Particulate and sulphur emissions are additional concerns to public officials (Bethlehem, 1998).

Various international reports have been published of US adoption of strict environmental standards to exclude competitors that cannot meet stringent standards. Similarly, environmental standards in the packaging and manufacturing industries in Germany have been used to exclude competitors. It is therefore not unlikely that such measures will be introduced in the iron and steel industry, which is already rife with legal action against dumping (Financial Times, 1999).

7.2.5 Sectoral responses to domestic and international environmental regulation

As a result of a lack of clear standards or specifications, as well as insufficient monitoring and control, there is little incentive for industry to upgrade production methods and invest in cleaner technologies. Local representatives of one of the major steel companies concluded that the environmental performance of most South African steel plants is lagging far behind that of international producers, with the exception of some local mills (Bethlehem, 1998). The general range of estimates for environmental investment internationally and locally as a percentage of total operating cost is 2.5-5 per cent and 8-15 per cent respectively. These estimates are based on information obtained from conversations with construction and production engineers. Insufficient estimates were, however, obtained to calculate reasonable uncertainties.

New plants generally employ more sophisticated and less-polluting technologies, and are therefore more in line with international standards. Older plants are, however, lagging behind in international standards as they are very expensive to upgrade and environmental investments thus involve costly retrofits. Various companies in the steel industry have nonetheless made significant investments into end-of-pipe technologies and are further in the process of obtaining environmental accreditation in the form of ISO 14001 (Bethlehem 1998; Confidential source, 1998).

At present ISCOR finds itself with very severe financial problems due to the slump in global steel prices. The urgent need to conform to international cost structures in order to remain competitive has been recognised internally, and major efforts are being undertaken to adjust. According to a recent financial report, ISCOR's Pretoria works has scaled down, saving R170 million per annum, with cost reductions at the Newcastle

Castle plant estimated at R430 million. In addition to this, the Vereeniging works will cut down on R80 million over the next two years, while the Vanderbijl park works are looking at a R1 000 million curtailment over the next four years. In total these measures represent a cost saving of R1 700 million or 13 per cent on total estimated steel-related cost. These savings should enhance competitiveness significantly, and move ISCOR down its cost curve (Vermeulen, 1998). Although this cost adjustment is not a result if environmental regulation, it can be expected that these changes will enable the steel industry to adapt more effectively to environmental regulation in the long-run. Due to the financial problems that ISCOR is currently experiencing, direct environmental investment has almost come to a halt (Confidential source, 1998).

7.2.6 The main players in ensuring that trade and environmental issues are taken into consideration domestically or internationally

The 'polluter pays' principle is systematically winning ground, holding industry accountable for pollution generated during production. The potential threat of conventions or trade agreements that may give rise to green trade barriers are further providing an economic incentive for industry to take into consideration domestic and international trends in environmental regulation.

The role of government is, however, crucial in setting clear standards for industry and in monitoring and controlling compliance by firms. Government and NGOs also have an important role in developing indirect approaches to regulation and providing incentive-driven structured models to the environment. Such models encourage companies to act in such a way as to exploit cost savings (Barton, 1998).

Regulations are context-specific and need to be arrived at by a process of compromise with those agents involved in the regulatory procedure: the implementers, the monitors, the enforcers, and the subjects to the regulations. Without consensus and acceptance of what regulation seek to achieve and how these objectives can be realised, the regulations become costs rather than benefits.

Regulation should protect those who pursue them without the threat of losing market share or global competitiveness while longer-term environmental strategies are implemented. The state regulatory authorities and the business community must both feel that they are working towards long-term environmental goals that will feed back to successful business activities. Strengthening the relationship between both these parties is a cornerstone in achieving longer term security for firms engaged in implementation of environmental regulation. In a recent compilation of essays on trade and the environment, Barton (1998) puts forth the notion that domestic governments should work within multilateral circles in order to create global support networks for firms involved in environmental restructuring.

7.2.7 The extent to which trade and sustainability issues have been addressed in terms of policy, regulations and management policy

South African environmental legislation is in a process of transformation, and the international views on environmental management are also being incorporated into the South African conservation system. Where previously pollution prevention formed the basis of the government's conservation strategy, there has been a shift to integrated pollution control that attempts to balance the need for economic growth and environmental protection. The process is, however, slow and a significant shortcoming may be the lack of a portfolio in government committed to sustainable development.

At present South Africa still lacks an effective waste management strategy. There is not an effective and co-ordinated system or body in place for regulating and controlling pollution caused by waste generation and disposal. Waste management policies have mainly dealt with waste disposal in the past, but neglected to promote or enforce adequate monitoring of waste and pollution levels. These policies further fell short of providing structures for the incorporation of information on the nature and volume of wastes being produced. Waste minimisation at source, as well as domestic and trans-boundary movement and transportation of waste has not been addressed and remains virtually uncontrolled at present (Cloete, 1996).

No general specifications, minimum standards or fines for non-compliance that are transparent have been entrenched in industry practices or within government. General standards for ambient pollution levels have generally been below current international standards. There is a need for access to information on waste emissions, pollution levels and the general state of the environment in order for informative research to be executed and subsequently for informed policy decisions to be made. The lack of data, emissions inventories, and compulsory revealing of quantities of emissions is a severe handicap to adequate environmental management. As Goldblatt (1997) points out, "any management system of the complexity of an integrated pollution control system must be based on one that is reliable, consistent, easily retrievable and usable".

7.2.8 Key policy issues and avenues for intervention

Industries and governments have traditionally practised environmental control on a media-specific basis to resolve air, water, and waste disposal problems. A limitation of this approach has been its ineffectiveness in addressing the entire spectrum of environmental damage resulting from industrial development. The reduction of one of these pollutant releases, by practising media-specific pollution targeting may not be considered appropriate if this merely shifts the release from one process stage to another, or the impact from one environmental compartment to another.

On account of this, there has been a general shift towards Integrated Pollution Control (IPC) and subsequently total environmental risk management. The concept of accounting for all impacts simultaneously and addressing the priority areas in a systematic way has now become universally accepted. A second principle, equally important, has been that of preventative rather than remedial action.

Current media-based regulation therefore needs to be transformed to integrated environmental management systems. A formal environmental management system provides a decision-making structure and action programme to support continuous improvements in environmental performance. The Integrated Environmental Management (IEM) approach attempts to combine all three of these philosophies in order to create the most optimal policy structures and programmes for effective implementation. In this way, regulation is used as a framework within which provision is made for the implementation of co-regulatory and market-based instruments.

An effective IEM require a frame-work for effective environmental management (standards, values, norms and criteria), decision support instruments, management instruments, monitoring instruments, market based instruments, information and communication instruments and crises response instruments.

It is however necessary to add that effective compliance and enforcement measures are the only means whereby environmental legislation or any IEM can succeed. Institutional procedures such as environmental permitting and monitoring are equally important additional measures to environmental standards (UNEP, 1996a). With standards in place, monitoring *agencies* have to be created to oversee compliance and to execute some form of punishment if standards are not complied with. Unless monitoring agencies has the power to punish perpetrators, there is no incentive for polluters to keep emissions below the prescribed level other that some form of social conscience.

The success of any IEM or other environmental strategy is conditional on the continual assessment of its effectiveness. Indicators which can be meaningfully compared over time and which allow the assessment of company performance in terms of the environmental policy and objectives, should be selected. The following list summarises the type of environmental performance indicators that have to be developed: tons of raw material consumed, energy consumption per ton of steel, number of incidents, such as spills, quantity of pollutants released to the environment, financial investment in environmental protection, elimination of toxic substances from products, percentage of time that internal and external set limits are complied with, cost per ton of product, and annual environmental costs (including operative as well as capital costs) (UNEP and IISI, 1997).

Local environmental regulation may in future be supplemented by alternative approaches to regulation other than the traditional command and control pollution standards. Incentive-driven approaches need to be considered in conjunction with regulation-driven approaches to the environment. The emerging European and US environmental management models is generally incentive-driven (giving companies tax breaks for environmental investments) which elicits a greater response and higher projected returns. Similar methods may be considered for implementation in local management options (Palmer *et al.*, 1995).

A final policy issue that presents a problem for environmentally-based analysis is the lack of data on actual levels of pollution within South Africa. Goldblatt (1997) provides detailed examples of the extent and type of problems encountered in the effort to obtain environmental data from industry of government for research purposes. A US industrial census has provided valuable data for research. The public disclosure of emissions data is now a standard procedure for all US companies (Austin, 1999). There is a similar need for detailed environmental data in industrial records in other countries (especially the developing world) if progress is to be made with our comprehension of sectoral and national impacts of environmental regulation and management. Releasing information about environmental performance not only aids monitoring, but increases consumer awareness and encourages companies to strive toward greater efficiency.

8. Conclusion

There is in principle no reason why the objectives of trade and sustainable development should be mutually exclusive, and as Brack (1998) suggests, an inherent compatibility is in fact suggested by the theory of comparative advantage. Trade allows for specialisation in the production of goods and services in which countries are relatively most efficient. The optimisation of production by countries within a context of restricted inputs, the removal of distortionary subsidies and pricing policies, and improvement of efficiency of resource allocation are advantages of trade that can hold benefits for the environment. Higher growth rates associated with trade help generate the resources needed for investment in environmental protection and cleaner technology (Brack, 1998).

Trade does, however, hold various negative implications if environmental regulations or management strategies are not in place. The latest WTO Secretariat report emphasised that globalisation and growth reinforce the need for sound environmental policies at a national and international level. Negative social externalities associated with trade and growth include resource depletion and increased pollution, which again have implications for public welfare. In most cases, environmental degradation occurs because producers and consumers are not required to account for the cost induced by their polluting activities.

This dissertation presented an overview of the major trade and environmental issues on the agenda of the iron and steel industry in South Africa at present. Areas on which the dissertation focussed included the industry's economic importance, the major production processes, environmental performance within the industry and the abatement options now available. A comparison was drawn between local and international environmental regulation and guidelines for industry.

In exploring these issues prior to discussing the main conflicts between trade and the environment, it was shown that neither addressing the international trade question nor formulating a local industrial or regulatory response, is a straightforward process. The production process for iron and steel manufacturing is highly integrated and specialised, with different externalities arising at its various stages. It is therefore necessary to include the entire production life cycle in order to assess the appropriate abatement options or policies. Another factor that emerges is the data intensity of a study like this. Severe data gaps regarding the actual levels of pollution and costs of environmental externalities that arise, prevent us from making inferences about the outcomes of pollution reduction policies.

In Chapter 7, the advantages and disadvantages of trade for sustainability, economic growth and the environment were highlighted. The objectives of industrial policy for industry were discussed in terms of both the trade and environmental agendas, but also with respect to issues where trade and environmental policies have a direct bearing on each other.

Aspects of international trade-environmental conflict that have not been clarified under the GATT or the WTO's Committee on Trade and the Environment were also discussed. In particular it was noted that trade measures which have significant implications for exporting countries in the third world can target the international differences between products, as well as between process and production methods (PPMs) due to differing environmental standards.

Internationally environmental measures with potential trade implications are used to address related *products*. According to GATT Articles I and II, consumption externalities generated by imported products should be treated the same as externalities caused by consumption of domestic products. As a result international markets are becoming increasingly discerning of the products that they import. The cost for exporting countries associated with upgrading their product to a level acceptable to the importing country can be significant, but these costs are seldom comparable to the economic losses incurred with total sanctioning of the product.

Actual cases where differences in *process and production methods* between countries were used as a basis for trade discrimination have been scarce, with the tuna/dolphin and shrimp/turtle disputes the only cases that have been tried by the WTO's dispute panel. In both cases the drawn-out settlements resulting from these legal suits have been very expensive and nearly destroyed the industries of the accused parties. Local producers have not experienced direct trade-related threats due to differences in domestic and international standards or due to insufficient levels of environmental investments for *like process and production methods*. Areas that have been affected by international pressures include eco-labelling, packaging, and increasing international consumer awareness of environmental quality.

The cost of compliance with environmental measures is likely to increase due to higher future standards and recycling requirements. It is unlikely that the conflict between trade and the environment will lessen given the increasing commitment to global environmental imperatives. The number of signatories to multilateral agreements aiming to ensure compliance with global environmental initiatives such as those against global warming and ozone depletion is increasing and international trade is becoming more competitive. As a result he differences in environmental approaches and standards between trading countries are increasingly sought and exploited in times of slumps in the market. Internationally, the question remains whether pressure from increased trade liberalisation will encourage protectionist abuse of multilateral environmental agreements. The launching of protectionist attacks against GATT and the WTO on environmental grounds is becoming more likely as producers incur financial burdens because of increased regulation.

The developments underway in the latest Round of WTO negotiations in Seattle have indicated that the consensus is likely to steer clear of WTO influence over labour and environmental laws. Most participants do not want to see the WTO use countervailing duties to enforce environmental or trade rules. It is unlikely that any form of countervailing duties will become GATT-legal in the foreseeable future. Both environmental groups and free traders are calling for multilateral solutions to international trade and environmental conflicts and are criticising unilateral and bilateral action. However, two areas where trade-environmental pressures may be felt by developing countries in future are MEAs such as the Kyoto Protocol, and with regard to buyer specifications.

The impact that green trade barriers or carbon taxes may have for local industry was briefly discussed in Section 7.1. The economic implications of potential reductions in trade were examined by means of input-output analysis. The possibility that economic incentives exist for local environmental regulation, to conform to international standards, policies and management options, needs to be investigated more rigorously. The practicality of comprehensive modelling is limited by the shortcomings in current data. The type of information that is required to model scenarios such as the economic outcomes of green trade barriers and standards harmonisation on industry, includes the identification of differences in the extent and cost of meeting local and international abatement levels. Such information is a potential basis of cost advantages over rival firms and hence difficult to obtain. Relationships between actual loss in market share due to trade barriers and actual reduction in exports, based on the price elasticity of demand for steel on international markets, also have to be examined in detail.

South Africa's position with respect to issues such as green trade barriers, harmonisation of environmental standards and the imposition of carbon taxes are difficult to assess, given the uncertainty of global trade/environmental dispute handling and the approach that will be taken in MEAs in future. The behaviour of the South African iron and steel sector and other metals processing industries is increasingly being influenced by that of their competitors and by international market pressures. In South Africa, no specific countervailing action against international dumping has so far been taken on environmental grounds. This may in part be the result of conflict that still exists within the WTO with regard to extra-territoriality and process and production methods. Local industries are, however, aware of the potential for international action based on environmental differences in process and production methods. The move towards ISO14001 is cited by various individuals in industry as an attempt to pre-empt such action (Confidential source, 1998). Market-driven changes in industry are mainly product-related.

It has been clear from this study that differences in technical and environmental performance exist between local and foreign industries. It was also shown that differences exist between the level of local and international guidelines and industry pollution control standards. Whether these differences are legitimate and in our interest in the longer run need to be assessed in future research. It is not clear how such differences address South Africa's longer-term priorities for sustainable resource use, social welfare and environmental protection.

Differences in environmental quality across countries, as well as differences in awareness of environmental problems, differences in the structure of policies, and costs of implementation, all contribute to the complexity of the trade-environmental debate. International efforts to co-ordinate environmental policies may help, but many differences in the level of environmental action taken by countries will remain (Sorsa, 1992). It is unlikely and undesirable that all environmental standards be forced into harmony across countries. But at the same time, it is necessary that multilateral objectives are sought and suitable environmental policies formulated. With these in place, trade will have positive outcomes for welfare, which follows into positive outcomes for the environment.

Within the context of globalisation South African industry and government is in a process of continual reform. Government reform in terms of trade liberalisation has required a South African move toward outward orientation and increased competitiveness. Import substitution and export subsidies are in the process of being phased out completely. Economic reform is a slow and painful process, and in the short-term, it can happen at the expense of other social priorities. There have already been major job losses in the iron and steel industry, with ISCOR shedding more than 30 per cent of its workforce over the last few years.

As a price-taker in the international steel market, South Africa needs to be aware of the consequences that future environmentally motivated trade action may hold for the industry and the economy. Unless the responses of trade to environmental regulation and *vice versa* can be assessed more accurately, the ability of current regulation to meet environmental objectives will remain speculative, and the future trend for development of a regulatory framework with regard to trade and the environment will remain unclear.

Regarding participation by South Africa and other developing countries in MEAs and WTO negotiations, there is a need for the developing countries in the South to formulate a cogent and assertive strategy for future negotiations. Much of the South's argument against multilateral trade agreements in the past has been based on lack of representation in agreements formulated by primarily the northern countries. At the recent, Seattle Round it became evident that the South would not simply accept rules formulated by industrialised countries of the North. The general sentiment is that the world needs multilateral trade rules, but that these rules must incorporate the needs of developing countries. The South however needs to formulate its own environmental agenda more clearly and perhaps form trading blocks with other Southern countries to promote the case of developing countries.

One of the issues on the South's agenda may for instance be that multinationals need to commit to a "global corporate citizenship" in the form of concessions to labour, human rights and the environment. Another recommendation in addressing equity issues may be for developing countries to engage more actively with industrialised countries in assisting with joint projects that benefits sustainable development and cleaner production in the South. It is necessary to create incentives for local companies to reduce pollution. By sharing international knowledge on how to improve efficiency and increase productivity, win-win situations will ensue for North and South alike.

ISCOR, for example, is currently involved in a joint study with Hoogovens to increase its energy efficiency and implement savings. One of the main objectives of the study, which is partially funded by the Dutch government, is to establish the current CO_2 emission level of ISCOR and to investigate the possibilities to reduce emissions at all four ISCOR production sites. The joint programme involves auditing sessions, as well as, on-going presentations on energy management and good housekeeping (ISCOR 1999).

Specific improvements in local governance would include more open and transparent communication between industry, government and the public concerning trade-related environmental conflicts and priorities. There prevails a level of ignorance about the agendas and stances of local opposing groups, with little scope for constructive co-operation. Increasing stakeholder participation would also help to inform local ministries and prevent their entry into international agreements that could be hard for local industries to meet.

The current low prices in the steel market create a harsh atmosphere for environmental reform. Irrespective of the longer-term benefits, that accompany cleaner production and waste minimisation, there may not be the opportunity for local producers to embark on extensive environmental programmes in the near future (Confidential source, 1998). The significant changes that have occurred within the Iron and Steel Industry should not be overlooked. Saldanha Steel is representative of the latest international technology, with its

COREX and MIDREX plants. Columbus Stainless is one of two stainless steel manufacturers worldwide to have been awarded the ISO14001 Environmental Management System rating. Significant investments in environmental equipment were also made at Columbus during its Expansion Project in 1992 (Columbus Stainless, 1998).

In South Africa the policy tools that have been used include traditional regulation in the form of pollution control standards latterly supplemented with integrated environmental management (IEM) and environmental impact assessments (EIAs). A further dimension to local environmental management is provided by suasion instruments such as voluntary agreements and specifically ISO 14001 performance ratings.

Determining the effectiveness of ISO14001 in contributing to mitigation is a complex task, as this management system is more of a tool for risk assessment of environmental impacts caused by production. It therefore does not necessarily guarantee that any action will be taken to affect a change in the given level of environmental pollution. The moves towards integrated environmental management, cleaner production and ISO 14001 accreditation within the Basic Iron and Steel industry is of future value to the industry, but unless regulation becomes more specific and transparent the impacts of increased compliance with international environmental approaches or regulation are unclear.

In South Africa, the lack of proper enforcement of regulation and punishment in case of transgression of environmental regulation is a major weakness of our current environmental strategy. The formulation of regulations and implementation of strategies, monitoring and updating regulation are important portfolios for business as well as for regulating bodies. Increasingly important in mobilising change where access to information is concerned, however, are other suasion instruments (e.g. voluntary disclosure of environmental information) and well as increased stakeholder participation in corporate environmental governance.

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Appendix: Input-Output Analysis

A.1 Introduction

The 1995 social accounting matrix (SAM) for South Africa is used here to analyse some of the basic economic interactions with regard to the basic iron and steel industry. The model is extended to explore the economic impacts of changes in final demand and specifically for trade goods in the sector.

In Section A.2 the origin and some of the basic assumptions of the SAM are discussed. Section A.3 covers methodological aspects of this study, while section A.4 gives an overview of the results. In the final section of this appendix the findings of this exercise are briefly discussed.

A.2 Background

For the purposes of this study it is assumed that the reader is familiar with the theory of input-output analysis and social accounting matrices. If this is not the case, Chiang (1984, pp.115-123); Miernyk, 1969; Millar and Blair, 1985; and Van Seventer, 1985 are suggested as references. This section will, however, discuss some of the main advantages and shortcomings associated with input-output analysis.

Input-output (I-O) analysis is recognised as the only method capable of tracing interrelationships between different industries in the economy. The I-O methodology is an ideal tool for translating the effects of changing patterns in final demand and technology to the total output requirements of a specific industry, and conversely to see what is the impact of that industry on the rest of the economy (Roukens de Lange, 1985).

Input-output tables describe the structure of an economy by presenting the interactions between the various components (i.e. sectors or sub-sectors) of the economy. These linear inter-industrial production functions are inserted into a system of general equilibrium equations. With this information the level of production in each of the industries necessary to satisfy a given level of final demand can be determined. It is further possible to trace the reaction triggered off by any exogenous change in final demand (FD) using these tables (Van Seventer, 1985). An increase in final demand for the products of an industry within the processing sector, for example, will lead to both direct and indirect increases in the output of all industries in the processing sector.

It is, however, necessary to consider some of the assumptions underpinning input-output modelling in order to understand the limitations and nature of the results associated with this analytical tool. The three major assumptions adopted by I-O modellers as a rule are:

- the homogeneity assumption - only one homogeneous commodity is produced by each industry, unless more than one good is produced in fixed proportion to one another;
- the proportionality assumption - the production in an industry is subject to constant returns to scale; and
- the fixed coefficient assumption - each industry uses a fixed input ration or factor combination (Chiang, 1984).

Input-output tables and SAMs present a quantitative, comparative static overview of the economy. They therefore suffer limitations in terms of linearity, in that they do not take into account dynamic changes over time. Unless the necessary adjustment is made, the model further assumes fixed coefficients for respective production functions. As a result, substitution possibilities in consumption, production, imports and exports are ignored.

A.3 Methodology

Section A.3 outlines the methods used to calculate standard input-output results such as the direct and indirect coefficient matrices and multipliers for output, income and employment. The method used to make projections of changes in economic output resulting from changes in final demand for a specific industry is also covered here.

A.3.1 Transactions table

This study uses the 1995 Social Accounting Matrix (SAM) that was developed by the Development Bank of South Africa (DBSA). The data sources for this SAM are the South African Reserve Bank (SARB) Quarterly Bulletin and unpublished data, the Central Statistical Services (CSS) (unpublished data), and the CSS October Household Survey (Van der Merwe, 1997).

The population censuses allow for the identification of a full input-output spectrum of 104 sectors. The structure of the transaction table has been derived from censuses of production activities. Production functions for all production activities, combining intermediate and primary inputs, are derived accordingly. The structure of the production functions contained in the 1995 SAM are, however, derived from 1987 census data and may therefore have undergone significant changes in the interim.

(a) Aggregation

The transactions table was aggregated to include only major sectors within the economy. The model contains a total of 16 intermediate sectors. The manufacturing sector was, however, disaggregated to isolate the input-output structure of the basic iron and steel industry. The methods used for aggregation of sectors within the SAM are described in Millar and Blair (1985, p.175). For more detail on the sub-sectors contained in these aggregated sectors, the 1993 input-output tables should be consulted (CSS, 1993).

(b) Basic economic information

A summary of basic economic information obtained from the transactions table is presented in the result section of this Appendix. Amongst other things, this table includes the basic iron and steel industry's contribution to gross domestic product (GDP).

Various ways exist for the calculation of GDP. The value-added approach requires that wages and salaries and gross operating surplus (GOS), capital expenditure and imports within that industry are summed (Van Seventer, 1985). By definition, the output of an industry is equal to the input of that industry. This enables us to calculate the contribution that each sector makes to GDP.

A.3.2 Direct coefficient matrix

From the transactions table, a table of technical coefficients or direct coefficients can be developed. Technical coefficients are calculated for processing sectors only, and are expressed in monetary terms. The technical coefficients represent the proportionate inputs required to produce one rand of output of a given industry (Miernyk, 1969). The table of direct coefficients also shows the "first-round" effects of a change in the output of one industry on the industries from which it purchases inputs. These are the direct purchases that will be made by a given industry from all other industries within the processing sector.

To produce the direct coefficient matrix, all entries in the processing sector of the transactions table are divided by the adjusted gross output for that industry. In this way, the production functions are described more formally and the results can be used to calculate the multipliers later (Van Seventer, 1985).

A.3.3 Inverse Leontief matrix

In order to calculate further inter- industry effects resulting from exogenous exchanges in final demand, the direct coefficient matrix has to be "inverted". An integral part of input-output analysis is the construction of this table, which shows the direct and indirect effects of changes in final demand. It shows the total expansion of output in all industries as a result of the delivery of one rand's worth of output outside the processing sector by each industry.

The matrix that is inverted to obtain a table of direct and indirect coefficients is called the Leontief input-output matrix. It is defined as the matrix $(I-A)$ where I represent the identity matrix and A represent the direct coefficient matrix. The use of this notation becomes clearer when expressed in terms of an equation designed to find the final demand required per unit of output for each sector:

$$(I-A)x = d$$

where x and d are the variable vector (output) and the final demand vector respectively.

As long as the matrix $(I-A)$ is non-singular, a unique solution for the equation can be found by inverting $(I-A)$:

$$\bar{x} = (I-A)^{-1}d$$

The table of Leontief inverse coefficients shows the total requirements, direct and indirect, per rand of delivery to final demand, outside the processing sector. This table is a general solution to the input-output system. It illustrates the principle of economic interdependence.

A.3.4 Open and closed models

The model that has been dealt with until now, $(I-A)x = d$, depends on the existence of an exogenous sector that has no relation to the technologically interrelated productive sectors. As an extension of this analysis the model has also been closed with respect to household and the Leontief inverse matrix has been calculated for a closed model.

Households earn incomes in payment for their labour inputs to production processes, and, as consumers, they spend their income in well-patterned ways. Although households tend to purchase goods for "final consumption", the amount of their purchases is related to their income, which depends on the output of the sectors. Moreover, consumption expenditure constitutes possibly the largest single element of final demand. It is therefor possible to shift the household sector from the final demand column and place it inside the technically interrelated table, that is make it one of the " endogenous" sectors. This is known as closing the model with respect to households (Millar, 1985).

When calculating the Leontief inverse one has the option to choose whether or not to include households represented by the row of wages and salaries and the column of private consumption expenditure in the inverted matrix (Van Seventer, 1985). By including households the assumption is made that their inclusion results in an extra chain reaction.

A.3.5 Multipliers

Calculation of multipliers is based on the concept that a relatively small change in aggregate expenditure can lead to a large change in national income. Multipliers are therefore used for measuring the total impact upon employment, income and output resulting from a given change in investment. The approximate total addition to national income, which would result from a given injection of "new" income, would be the multiplier times this income increment. The international trade regime is a case in point: if import restrictions on certain products are increased, it becomes important to understand how changes in the pattern of international trade will affect specific industries.

Three of the most frequently used types of multipliers are those that estimate the effects of the exogenous changes on:

- outputs of the sectors of the economy;
- income earned by households because of new outputs; and
- employment that is expected to be generated as a result of the new outputs.

The notion of multipliers rests upon the difference between the initial effect of an exogenous (final demand) change and the total effects of that change. The total effects can be defined in either of two ways:

- as the direct and indirect effects (which means that they would be found via elements in the Leontief inverse of a model that is open with respect to households) - *simple multipliers*; or
- as direct, indirect, and induced effects (which means that they would be found via elements of the Leontief inverse of a model that is closed with respect to households) *total multipliers* (Millar, 1985).

(a) Output multipliers

The output multiplier represents the effect on the output of the total economy (total value of production in all sectors of the economy) of a unit increase in final demand for an industry represented by any specific column.

For the **simple output multiplier**, this total production is the **direct and indirect output effect**, obtained from a model in which **households are exogenous**. The initial effect is read from the **total** of the column of interest in the Direct Coefficient matrix. The simple output multiplier for basic iron and steel is the sum of the relevant column of the Leontief inverse (without households):

$$O_j = \sum_{i=1}^{n} \alpha_{ij}$$

where (gamma)$_{ij}$ is the Leontief input coefficient and

O_j is the simple output multiplier

The total output multiplier is obtained by summing the relevant column in the Leontief inverse with households included.

Total output multiplier:

$$\overline{O}_j = \sum_{i=1}^{n+1} \overline{\alpha}_{ij}$$

The truncated output multiplier is basically the same as the total output multiplier. It relies however only on summing from 1 to n and not to n+1 (the row representing household coefficients).

(b) Income multipliers

Income multipliers reveal that different amounts of income are generated by different sectors of the economy even if we assume that each sector expands its output by the same amount (Miernyk, 1969). These multipliers therefore attempt to translate the impacts of final-demand spending changes into changes in income received by households, rather than translating the final-demand changes into total value of sectoral output.

Income multipliers, like output multipliers can be calculated for models that are open or closed with respect to households. The simple multiplier (open model) takes only the direct and indirect changes in income resulting from an increase of one rand in the output of all the industries in the processing sector into account.

The total multiplier (closed model) is a more realistic measure which takes into account the direct and indirect effects indicated by the input-output model plus the *induced* changes in income resulting from increased consumer spending.

In order to calculate the simple income household multiplier it is necessary to convert each element in a particular column of $(I-A)^{-1}$, which measures the value of direct plus indirect output effects, into rands worth of household income via household coefficients from the direct coefficient matrix. The latter indicates household income received per rand's worth of sectoral output.

The initial effect of the income multiplier is by definition equal to the ratio of wages and salaries over output for a specific sector. It is therefore read from the direct coefficient matrix. The direct plus indirect effects for sector j would be in terms of rand's worth of new household income, and the initial effect is in terms of one rand's worth of final demand, and hence output, for sector j. The expression for the simple input multiplier is as follows:

$$H_j = \sum_{i=1}^{n} a_{n+1,i}\alpha_{ij}$$

where a_{n+1} is the direct input coefficient for households (W&S);
$(\text{gamma})_{ij}$ is the Leontief coefficient; and
H_j is the simple household multiplier.

The total household income multiplier is measured by weighting the elements of the closed model of the inverted Leontief matrix in a similar manner. The total effects include the direct, indirect and induced effects of income generated.

$$\overline{H}_j = \sum_{i=1}^{n+1} a_{n+1,i}\overline{\alpha}_{ij}$$

Which is the same as:

$$\overline{H}_j = \overline{\alpha}_{n+1,j}$$

(c) Employment multipliers

Employment multipliers are used to estimate the relationships between the value of output of a sector and employment in that sector (in physical terms). In order to calculate these multipliers, the original transactions table had to be augmented with the employment numbers for different industries for 1995.

The initial effect of the employment multiplier is calculated as the ratio of employees in a specific industry to total output of that industry. This is also known as the physical labour input coefficient ($W_{n+1,i}$):

$$W_{n+1,i} = E_i / X_i$$

Where X_i = Output in sector i

E_i = Number of employees on sector i

$W_{n+1,i}$ = Employees per rand's worth of output

The employment effects or household employment multipliers are similar to income effects and household income multipliers, but the physical labour-input coefficients ($W_{n+1,j}$) are used instead of the monetary labour input coefficients (a_{n+1}). That is the elements W_r are used instead of the elements H_r. The full multiplier effects are calculated as the output multiplier times the physical labour input coefficient. As before, this multiplier can be calculated for a model that is either open or closed with respect to households.

The simple employment effect or simple household employment multiplier for sector j, the measure analogous to the simple output multiplier (H.J.) is:

$$E_j = \sum_{i=1}^{n+1} w_{n+1,i}\alpha_{ij}$$

where $W_{n+1,i}$ = Employees per rand's worth of output and

E_j represents jobs created per rand of new sectoral output.

The total employment effect or total employment household multiplier is calculated as follows:

$$\overline{E}_j = \sum_{i=1}^{n+1} w_{n+1,i}\overline{\alpha}_{ij}$$

If only the total employment effect on the original n sectors (not including the household sector) are of interest, the truncated form of the total employment multiplier is used (Millar, 1985).

A.3.6 Scenarios

Input–output analysis can be used as a forecasting tool to the extent that changes in final demand for a specific industry can be translated into total output, income and employment effects for the entire economy. Although a consistent forecast cannot guarantee any predicted outcome, projections for individual industries and sectors will add up to a total projection (e.g. GDP) if the structural relations of the economy do not change significantly over the projection period.

The results obtained from the multiplier analyses were used to make static projections of the impacts that reductions in exports of primary iron and steel would have for the economy as a whole. This was done in view of potential effects that may result from adjustments to green trade barriers, or industrial adjustments to enforce international regulation. It should be acknowledged that the scenario presented here may be oversimplified, but it was decided to limit this exercise to variables that could realistically be included into such a forecast.

A range of 5-20 per cent reductions of exports for the basic iron and steel industries and by extension the change in final demand for that industry was calculated. The projected changes in final demand were multiplied by the multipliers described previously. The output, income and employment effects were calculated for different scenarios.

A.4 Results

A.4.1 Transactions table

The rows and columns from the transactions table pertaining to the basic iron and steel industry and also to the gross inputs and outputs for respective industries are shown in Table I.

Table I Extract from the transactions table

Sector	*Iron and steel inputs*	*Total inputs*	*Sector*	*Iron and steel outputs*	*Total outputs*
TOT AGR	2.99	39952.71	TOT_AGR	67.58	39887.65
TOT MIN	2166.55	60177.16	TOT MIN	120.80	60071.61
TOT CONSUM	0.00	67126.54	TOT_CONSUM	0.00	67007.92
TOT TEXTILE	167.51	20482.14	TOT_TEXTILE	10.24	20440.45
PULP&PAPER	27.78	35599.35	PULP&PAPER	44.82	35545.67
CHEM&PLASTICS	565.83	71301.61	CHEM&PLASTICS	84.36	71176.25
MINERAL_PROD	10.51	9384.83	MIN_PROD	96.32	9366.78
IRON&STEEL	774.55	18549.97	IRON&STEEL	774.55	18513.83
MET_PROD&EQUIP	725.26	55168.25	MET_PROD&EQUIP	4711.33	55075.30
TRANSP_EQUIP	0.00	27934.48	TRANSP_EQUIP	1041.68	27883.85
OTHER_MANUFACT	0.00	5268.94	OTHER_MANUFACT	48.75	5260.50
WATER&ELEC	1701.82	36306.55	WATER&ELEC	160.83	36242.62
CONSTRUCT	0.00	41817.70	CONSTRUCT	610.63	41742.11
WHOLESALE AND TRADE	458.89	118339.19	61,620,621,622	43.30	118129.79
OTHER_SERVICES	717.07	70350.44	OTH_SERV	104.34	70229.87
SERVICES	1585.17	139842.54	SERVICES	8.98	139595.55
TOT_INDUS	8903.93	817602.39	INTM_TOT	7928.51	816169.75
CAPITAL (GOS)	3771.00	203981.99	GOS	0.00	205416.00
TOTAL_OC(W&S)	4079.06	256257.27	TOT_W&S	0.00	256257.27
TOTAL_HH	0.00	357880.06	TOTAL_HH	2.69	357881.31
GOV_TOT	78.10	137133.21	GOV_CONS	27.40	137134.85
TOT_CAP	0.00	81038.00	TOT_CAPI	105.83	81036.17
EXTERNAL_TOT	1681.74	109781.99	EXTERNAL_TOT	10485.54	109782.25
VALUE_ADDED	9609.90	1146072.52	FINAL_DEMAND	10621.46	1147505.16
TOT_INPUT	18513.83	1963674.91	TOT_OUTPUT	18549.97	1963674.91

Columns 1 and 2 are identical to the columns in the transactions table, with Column 1 showing raw material and factor inputs requirements for basic iron and steel production from other industries. The TOTAL_INDUS value of R8 903 million is the sum of all the intermediate inputs required for the production of goods delivered by the basic iron and steel industry. The TOTAL_INPUT value of R18 513.83 million is the sum of intermediate inputs and value added for this industry.

The last two columns in Table I are transposed versions of the rows in the transactions table. The second last row represents output of the basic iron and steel industry into the intermediate sectors and towards final demand. The last column is the total output of each sector in the transactions table and coincide roughly with the row of gross economic inputs.

(a) Basic economic information

It can be seen that the intermediate input requirement for mining to maintain the production process of basic iron and steel is R2 166.55 million. Similarly, the basic iron and steel industry supplies R10 485.54 million to the export market while receiving R1 681.74 million from imports.

Value-added for the basic iron and steel industry equals the sum of total wages and salaries and gross operating surplus, government transfers and imports within this industry. According to the value-added approach, the GDP contribution by the basic iron and steel industry is R9 609 million, which is 0.0084 per cent of total GDP (R1 146 billion). GDP estimates are useful in themselves, but do not take into account any backward linkages within the economy.

Another table presenting the final demand for a specific industry may be broken down into a more detailed structure that can be compared to the economy as a whole.

Table II Final demand for the iron and steel industry

Item	*Value for iron and steel (Rm, 1995)*	*Value for total economy (Rm, 1995)*
Total final demand (FD)	10621.456	1147505.161
Total output (X)	18549.966	1963674.911

Table III Elements of final demand

Item	*Value for iron and steel*	*Value for total economy*
FD/X	0.573	0.584
EX/X	0.565	0.056
-M/X	0.091	0.056
EX/FD	0.987	0.097
-M/FD	0.158	0.096

In Tables II and III final demand and output for the basic iron and steel industry, as well as final demands and output for the entire economy are compared. Specific ratios such as final demand to output and exports to output are also shown. It is important to note that 98 per cent of final demand is contributed by exports, whereas imports constitute only 15 per cent.

A.4.2 Direct coefficient matrix

The technical coefficient matrix or direct coefficient matrix is shown in Table IV.

Table IV Direct coefficient matrix

	Tot_Agr	Tot Min	Tot_ Consum	Tot_ Textile	Pulp & Paper	Chem & Plastics	Min_Prod	Iron & Steel	Met_Prod & Equip	Transp_ Equip	Other_ Manufact	Water & Elec	Construct	Whole sale Trade	Oth_Serv	Services
Tot agr	0.060989	0.000462	0.251468	0.004912	0.036910	0.003844	0.000695	0.000162	0.000801	0.000405	0.000909	0.000530	0.000099	0.000146	0.006334	0.001359
Tot min	0.002825	0.002894	0.001386	0.000678	0.004284	0.116782	0.058176	0.117023	0.018435	0.002086	0.133835	0.061537	0.017867	0.000006	0.001897	0.001975
Tot consum	0.103645	0.000378	0.171778	0.024552	0.003842	0.005538	0.000331	0.000000	0.000000	0.000369	0.000044	0.002099	0.000000	0.002158	0.049312	0.002828
Tot textile	0.004981	0.004013	0.002634	0.222969	0.022134	0.005445	0.006632	0.009048	0.005318	0.009482	0.035056	0.000353	0.005656	0.003210	0.006123	0.002105
Pulp&paper	0.012188	0.006537	0.036642	0.016472	0.187070	0.014298	0.022821	0.001500	0.007575	0.006205	0.025602	0.000666	0.020434	0.034736	0.012601	0.026766
Chem&plastics	0.110571	0.056206	0.032499	0.065787	0.051260	0.151051	0.040546	0.030563	0.048165	0.024225	0.053419	0.015436	0.044817	0.030360	0.057585	0.026159
Mineral_prod	0.004738	0.002040	0.008924	0.000264	0.002175	0.008026	0.071142	0.000568	0.008951	0.004823	0.001753	0.003446	0.093948	0.000472	0.005816	0.002654
Iron and Steel	0.001694	0.003029	0.000000	0.000501	0.001261	0.001185	0.010283	0.041836	0.085543	0.037358	0.009267	0.004438	0.014629	0.000367	0.001486	0.000064
Met_prod&equip	0.010534	0.077076	0.032469	0.008721	0.018044	0.019014	0.018176	0.039174	0.130010	0.045446	0.086304	0.018546	0.082393	0.004475	0.012068	0.011649
Transp_equip	0.010600	0.016104	0.000000	0.000044	0.000000	0.000008	0.000000	0.000000	0.000114	0.200397	0.000000	0.001904	0.000000	0.003802	0.011196	0.007874
Other_manufact	0.000001	0.000334	0.000049	0.002223	0.000201	0.000100	0.000023	0.000000	0.000712	0.000021	0.012176	0.000348	0.000000	0.000389	0.001120	0.002824
Water&elec	0.011938	0.063848	0.012416	0.012101	0.022522	0.027155	0.040012	0.091922	0.026401	0.009161	0.005667	0.252157	0.007212	0.012512	0.036384	0.020674
Construct	0.006066	0.004644	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.029355	0.142517	0.013924	0.008152	0.012841
Wholesale&Trade	0.071809	0.030133	0.036781	0.036906	0.051149	0.030763	0.032814	0.024786	0.041478	0.071148	0.043564	0.018672	0.043278	0.088162	0.053555	0.039020
Other_services	0.027000	0.021879	0.028201	0.010297	0.017595	0.036286	0.031380	0.038732	0.024971	0.011600	0.016059	0.030464	0.027931	0.067767	0.060606	0.056479
Services	0.024106	0.076128	0.063206	0.054350	0.083801	0.056821	0.055271	0.085621	0.073365	0.081033	0.070687	0.031808	0.076685	0.140061	0.084972	0.192087
Tot_Input (exl hh)	0.463684	0.365705	0.678454	0.460777	0.502247	0.476316	0.388302	0.480934	0.471841	0.503760	0.494341	0.471758	0.577465	0.402544	0.409207	0.407360

The basic iron and steel industry supplies 4.18 per cent to itself, while 11.7 per cent is supplied by the mining industry and 9.2 per cent is supplied by water and electricity. Total intermediate inputs (excluding wages and salaries) is 48 per cent for this industry and 22 per cent is paid in wages and salaries.

The first-round effects can also be deduced by the direct coefficient matrix. If it is assumed that the production structure represented by the direct coefficient do not change over time it also follows that when basic iron and steel output is reduced by R1 million the intermediate demand for mining will decrease by R0.11 million. This is called the first-round effect on mining of a change in output of the basic iron and steel industry. Similarly, the first-round effect of reducing output of metal products and equipment by R1 million suggests a drop in demand for goods produced by the basic iron and steel industry of R0.0855 million.

A.4.3 Inverse Leontief matrix

In order to calculate further inter-industry effects resulting from exogenous exchanges in final demand, the Leontief matrix has been inverted. This matrix is called the Leontief inverse matrix, and is shown in Tables V (open model) and VI (closed model). The Leontief inverse shows the total expansion of output in all industries as a result of the delivery of one rand's worth of output outside the processing sector by each industry.

Table V Leontief inverse matrix excluding households

Sector	Tot_Agr	Tot_Min	Tot_ Consum	Tot_ Textile	Pulp & Paper	Chem& Plastics	Min_ Prod	Iron and Steel	Met_Prod & Equip	Transp_ Equip	Other_ Manufact	Water & Elec	Construct	Wholesale & Trade	Other_ Serv	Services
Tot Agr	1.10655	0.00393	0.34114	0.02131	0.05529	0.01115	0.00521	0.00398	0.00474	0.00413	0.00619	0.00442	0.00538	0.00707	0.02844	0.00799
Tot Min	0.02868	1.02476	0.02412	0.01953	0.02378	0.14928	0.08016	0.14382	0.05077	0.02179	0.15671	0.09391	0.04945	0.01250	0.02112	0.01535
Tot Consum	0.14460	0.00570	1.25716	0.04486	0.01861	0.01498	0.00643	0.00697	0.00614	0.00589	0.00703	0.00865	0.00711	0.01175	0.07079	0.01192
Tot Textile	0.01195	0.00892	0.01199	1.29073	0.03859	0.01218	0.01302	0.01600	0.01237	0.01930	0.05109	0.00382	0.01469	0.00895	0.01241	0.00733
Pulp & Paper	0.03688	0.01993	0.07693	0.03928	1.24605	0.03290	0.04098	0.01527	0.02371	0.02459	0.04732	0.01150	0.04780	0.06018	0.03306	0.04999
Chem& Plastics	0.17067	0.09005	0.12025	0.12019	0.10428	1.20929	0.07577	0.07020	0.09078	0.06185	0.10240	0.04821	0.09875	0.06435	0.09831	0.05916
Mineral_Prod	0.01130	0.00667	0.01788	0.00361	0.00653	0.01337	1.07970	0.00498	0.01420	0.00968	0.00620	0.01202	0.12223	0.00553	0.01152	0.00794
Iron & Steel	0.00655	0.01426	0.00776	0.00370	0.00611	0.00722	0.01621	1.05189	0.10547	0.05656	0.02236	0.01220	0.03156	0.00346	0.00618	0.00421
Met_ Prod & Equip	0.03236	0.10190	0.06451	0.02464	0.03813	0.04736	0.03863	0.07075	1.16773	0.07771	0.12459	0.04734	0.12812	0.01856	0.03034	0.02782
Transp_ Equip	0.01774	0.02328	0.00834	0.00296	0.00425	0.00593	0.00415	0.00623	0.00415	1.25418	0.00595	0.00721	0.00433	0.00944	0.01828	0.01476
Other_ Manufact	0.00051	0.00096	0.00079	0.00340	0.00100	0.00075	0.00058	0.00078	0.00147	0.00076	1.01315	0.00092	0.00080	0.00128	0.00183	0.00387
Water&Elec	0.04060	0.10497	0.04970	0.03737	0.05665	0.06981	0.07959	0.15697	0.07227	0.04009	0.04284	1.35838	0.04574	0.03742	0.07013	0.04878
Construct	0.01332	0.01266	0.00916	0.00498	0.00711	0.00697	0.00651	0.01026	0.00692	0.00657	0.00645	0.04981	1.17283	0.02400	0.01694	0.02303
Wholesale and Trade	0.11505	0.05763	0.10475	0.07302	0.09537	0.06439	0.06053	0.05673	0.07606	0.12025	0.08015	0.04760	0.08866	1.12356	0.08823	0.07195
Other_ Services	0.06194	0.04829	0.07649	0.03725	0.05145	0.06893	0.05814	0.07178	0.05899	0.04497	0.04800	0.06161	0.06869	0.10212	1.09300	0.09019
Services	0.09922	0.14017	0.16589	0.12733	0.17444	0.13332	0.11858	0.16529	0.15672	0.17818	0.15564	0.09466	0.17783	0.22644	0.16037	1.28162
Total	1.897940	1.664076	2.336858	1.854150	1.927633	1.847834	1.684171	1.851885	1.852491	1.926502	1.876059	1.862257	2.063974	1.716607	1.760931	1.725893

Table VI Leontief inverse matrix including households

	Tot_Agr	Tot Min	Tot_ Consum	Tot_ Textile	Pulp & Paper	Chem & Plastics	Min_ Prod	Iron & Steel	Met_Prod & Equip	Transp_E quip	Other_ Manufact	Water & Elec	Construct	Wholesale & trade	Oth_Serv	Services	PCE
Tot Agr	1.1386	0.0527	0.3801	0.0718	0.1007	0.0470	0.0554	0.0500	0.0554	0.0442	0.0469	0.0381	0.0623	0.0646	0.0797	0.0535	0.1103
Tot Min	0.0392	1.0407	0.0369	0.0361	0.0387	0.1610	0.0966	0.1589	0.0674	0.0349	0.1701	0.1049	0.0681	0.0314	0.0379	0.0303	0.0362
Tot Consum	0.2072	0.1010	1.3334	0.1436	0.1075	0.0851	0.1045	0.0969	0.1053	0.0842	0.0866	0.0745	0.1185	0.1243	0.1710	0.1010	0.2158
Tot Textile	0.0270	0.0318	0.0303	1.3145	0.0600	0.0290	0.0366	0.0376	0.0362	0.0381	0.0702	0.0197	0.0415	0.0360	0.0365	0.0287	0.0519
Pulp&Paper	0.0588	0.0532	0.1036	0.0738	1.2771	0.0574	0.0752	0.0467	0.0583	0.0519	0.0751	0.0345	0.0867	0.0995	0.0680	0.0811	0.0754
Chem&Plastics	0.2158	0.1587	0.1751	0.1913	0.1682	1.2597	0.1464	0.1349	0.1621	0.1182	0.1597	0.0956	0.1789	0.1453	0.1704	0.1233	0.1553
Mineral_Prod	0.0145	0.0116	0.0218	0.0087	0.0111	0.0170	1.0848	0.0096	0.0193	0.0137	0.0103	0.0154	0.1280	0.0114	0.0167	0.0126	0.0112
Iron&Steel	0.0088	0.0177	0.0105	0.0073	0.0093	0.0097	0.0197	1.0551	0.1090	0.0594	0.0252	0.0146	0.0356	0.0075	0.0098	0.0074	0.0078
Met_Prod &Equip	0.0471	0.1244	0.0825	0.0479	0.0591	0.0639	0.0617	0.0920	1.1911	0.0962	0.1433	0.0629	0.1544	0.0451	0.0539	0.0488	0.0509
Transp_Equip	0.0280	0.0390	0.0209	0.0192	0.0189	0.0174	0.0203	0.0210	0.0205	1.2671	0.0190	0.0180	0.0227	0.0279	0.0348	0.0294	0.0355
Other_Manufact	0.0014	0.0024	0.0019	0.0049	0.0023	0.0018	0.0021	0.0021	0.0030	0.0019	1.0143	0.0019	0.0025	0.0030	0.0033	0.0052	0.0032
Water&Elec	0.0642	0.1409	0.0785	0.0746	0.0902	0.0962	0.1166	0.1909	0.1097	0.0696	0.0728	1.3832	0.0878	0.0799	0.1079	0.0824	0.0814
Construct	0.0182	0.0201	0.0151	0.0127	0.0141	0.0125	0.0142	0.0173	0.0147	0.0127	0.0127	0.0550	1.1816	0.0328	0.0248	0.0300	0.0169
Wholesale & Trade	0.2167	0.2124	0.2285	0.2333	0.2396	0.1782	0.2198	0.2027	0.2370	0.2473	0.2093	0.1545	0.2695	1.3062	0.2508	0.2165	0.3502
Other_Services	0.1117	0.1240	0.1370	0.1157	0.1220	0.1246	0.1360	0.1432	0.1377	0.1071	0.1112	0.1139	0.1572	0.1914	1.1725	0.1609	0.1713
Services	0.2125	0.3126	0.3038	0.3059	0.3352	0.2600	0.2960	0.3279	0.3360	0.3197	0.2995	0.2138	0.3793	0.4299	0.3415	1.4427	0.3901
Total_Oc	0.4123	0.6275	0.5020	0.6501	0.5851	0.4613	0.6458	0.5919	0.6526	0.5153	0.5238	0.4337	0.7334	0.7405	0.6593	0.5863	1.4201
Trunc Tot.	2.4099	2.4432	2.9601	2.6613	2.6541	2.4206	2.4860	2.5868	2.6627	2.5663	2.5263	2.4006	2.9745	2.6360	2.5795	2.4538	1.7632
Total	2.8222	3.0707	3.4621	3.3114	3.2392	2.8819	3.1318	3.1787	3.3153	3.0816	3.0501	2.8343	3.7079	3.3765	3.2389	3.0401	3.1833

From Tables V and VI it can be seen that an exogenous increase in the final demand of the basic iron and steel sector by R1 million will result in an increase in the output of that sector by R1.05487 million. This total is made up of R1 million initial increase in output, R0.042 million first-round effect (deduced from the direct coefficient matrix) and an amount of R0.01287 million called the industrial support effect. The same can be done for column totals. They represent the effect on the output of the total economy of a unit increase in final demand for the industry represented by the column; this is known as the output multiplier. An exogenous increase in the final demand of the basic iron and steel sector by R1 million will result in an increase in the output of the total economy of R1.851 million. For the closed model, including households, this value is R3.4609 million. The multipliers will be discussed in further detail below.

A.4.4 Multipliers

Output, income and employment multipliers were calculated as described in Section A.3. Simple multipliers were calculated from the inverse Leontief where households were not included in the intermediate transactions and total multipliers were calculated from the closed model including households.

(a) Output multipliers

Table VII summarises the results from the output multiplier calculations. The simple, truncated and total output multipliers were calculated for each of the industries in the intermediate sector and are presented in Table VIII.

Table VII Output multiplier data

Sector	*Simple output multiplier*	*Truncated total output multiplier*	*Total output multiplier*
TOT_AGR	1.898	2.410	2.822
TOT MIN	1.664	2.443	3.071
TOT_CONSUM	2.337	2.960	3.462
TOT_TEXTILE	1.854	2.661	3.311
PULP&PAPER	1.928	2.654	3.239
CHEM&PLASTICS	1.848	2.421	2.882
MIN_PROD	1.684	2.486	3.132
Iron and Steel	1.852	2.587	3.179
MET_PROD&EQUIP	1.852	2.663	3.315
TRANSP_EQUIP	1.927	2.566	3.082
OTHER_MANUFACT	1.876	2.526	3.050
WATER&ELEC	1.862	2.401	2.834
CONSTRUCT	2.064	2.974	3.708
Wholesale and Trade	1.717	2.636	3.377
OTH_SERV	1.761	2.580	3.239
SERVICES	1.726	2.454	3.040
HH		1.763	3.183

Table VIII Output multipliers

Sector	*Open model*	*Closed model*	
	Simple output multiplier	*Truncated output multiplier*	*Total output multiplier*
Basic iron and steel	1.852	2.587	3.178

The initial output effect or first-round effect on the economy is defined to be simply the initial rands worth of a specific sector's output that is needed to satisfy the additional final demand. The initial effect of an increase of one rand in final demand for basic iron and steel is 0.4375. The simple output multiplier for basic iron and steel is the 1.852. The total output multiplier for an increase of one rand in total final demand for the basic iron and steel industry is 3.878, whereas the truncated total output multiplier for this industry is 2.587.

(b) Income multipliers

The data used to calculate the income multipliers for the basic iron and steel industry are presented in Table IX. The multipliers were calculated for models that are open and closed with respect to households.

Table IX Income multiplier calculations

Income multipliers	*H_r (from direct coefficient matrix)*	*Iron and steel (column from inverse matrix without households)*	*Product*	*Iron and steel (column from inverse matrix with households)*	*Product*
TOT_AGR	0.1133	0.00398	0.0005	0.04995	0.0057
TOT MIN	0.2948	0.14382	0.0424	0.15890	0.0468
TOT_CONSUM	0.1111	0.00697	0.0008	0.09689	0.0108
TOT_TEXTILE	0.2618	0.01600	0.0042	0.03761	0.0098
PULP&PAPER	0.2080	0.01527	0.0032	0.04667	0.0097
CHEM&PLASTICS	0.1352	0.07020	0.0095	0.13492	0.0182
MIN_PROD	0.2914	0.00498	0.0015	0.00964	0.0028
Iron and Steel	0.2203	1.05189	0.2318	1.05513	0.2325
MET_PROD&EQUIP	0.2586	0.07075	0.0183	0.09195	0.0238
TRANSP_EQUIP	0.1568	0.00623	0.0010	0.02102	0.0033
OTHER_MANUFACT	0.1556	0.00078	0.0001	0.00213	0.0003
WATER&ELEC	0.1299	0.15697	0.0204	0.19089	0.0248
CONSTRUCT	0.2532	0.01026	0.0026	0.01731	0.0044
61,620,621,622	0.3448	0.05673	0.0196	0.20268	0.0699
OTH_SERV	0.2977	0.07178	0.0214	0.14318	0.0426
SERVICES	0.2408	0.16529	0.0398	0.32789	0.0790
HH				0.59190	0.0075

The household coefficients from the direct coefficient matrix shown in Column 2 are multiplied with the basic iron and steel input coefficient from the inverted Leontief matrix. The income multipliers for open and closed models are shown in Table X.

Table X Income multipliers

Sector	*Initial income effect*	*Simple household income multiplier*	*Truncated total income multiplier*	*Total income multiplier*
Basic iron and steel	0.2203	0.4168	0.5843	0.5919

The initial income effect is also known as the labour-output ratio in value terms. This ratio is by definition equal to the ratio of wages and salaries to output for a specific sector. The initial income effect per R1 of sectoral output is 0.2203 for the basic iron and steel industry. This is equal to the household coefficient for basic iron and steel from the direct coefficient matrix.

For the model that is open with respect to households the simple output multiplier for the iron and steel industry is 0.4168. This indicates that an additional R1 of final demand for the output of this sector when all the direct and indirect effects are converted into rand estimates of income, would generate R0.42 of new household income. This also means that R1 million of final demand for the output of the basic iron and steel industry becomes R0.417 million of new household income, when all direct and indirect effects are taken into account, via the Leontief inverse.

For the model that is closed with respect to households the total household income multiplier is 0.5919. This figure includes the direct, indirect and induced effects of income generated.

(c) Employment multipliers

The employment figures for 1994 (CSS, 1996) were included in the transactions table in order to calculate employment multipliers for the basic iron and steel industry. Table XI presents the data that was used to calculate these employment multipliers.

Table XI	**Data used to calculate employment multipliers**				
Employment multiplier	*W_{n+1} (employment in sector/output multiplier)*	*Inverse from iron and steel without households*	*Product*	*Inverse from iron and steel including households*	*Product*
TOT_AGR	33.9610	0.0040	0.1350	0.0500	1.3165
TOT MIN	12.7068	0.1438	1.8275	0.1589	1.6231
TOT_CONSUM	3.3638	0.0070	0.0234	0.0969	0.3073
TOT_TEXTILE	12.7346	0.0160	0.2037	0.0376	0.4182
PULP&PAPER	4.9964	0.0153	0.0763	0.0467	0.2204
CHEM&PLASTICS	2.3027	0.0702	0.1617	0.1349	0.3321
MIN_PROD	11.2981	0.0050	0.0563	0.0096	0.0808
3710	4.9300	1.0519	5.1858	1.0551	3.4676
MET_PROD&EQUIP	2.2878	0.0707	0.1619	0.0920	0.5402
TRANSP_EQUIP	8.9765	0.0062	0.0560	0.0210	0.0644
OTHER_MANUFACT	5.1706	0.0008	0.0040	0.0021	0.0277
WATER&ELEC	1.5686	0.1570	0.2462	0.1909	0.2105
CONSTRUCT	9.7647	0.0103	0.1002	0.0173	0.1519
WHOLESALE & TRADE	5.7614	0.0567	0.3268	0.2027	1.3323
OTH_SERV	8.4330	0.0718	0.6053	0.1432	0.5721
SERVICES	8.4769	0.1653	1.4011	0.3279	3.5845
HH				0.5919	

The simple multiplier and total truncated employment multipliers for this industry are shown in Table XII.

Table XII	**Employment multipliers**		
Sector	*Labour-output ratio*	*Simple employment multiplier*	*Truncated employment multiplier*
Basic iron and steel	4.9300	8.6920	14.2496

Employment multipliers have been calculated for a model that is open with respect to households. This simple employment multiplier for basic iron and steel is 8.69, indicating the employment per million rands of output in this industry. An increase of R1 million in final demand for basic iron and steel will therefore result in 8.6 extra labour units. Only the truncated total multiplier was calculated for the model that is closed with respect to households. The value obtained for this multiplier was 14.25.

A.4.5 Scenarios

In Column 1 of Table XIII the original external total value (R10 485.54 million) and the associated final demand (R10 621.46 million) for basic iron and steel are shown. Projections are then made to show the change in external demand for exported goods in this industry and the associated change in final demand for goods produced by the basic iron and steel industry. A range of reductions in export demand of 5-20 per cent is tested. Column 2 gives the original and external totals. The difference between the original and projected values is shown in Column 3. Original and projected final demand values are presented in Column 4.

The results from Table XIII were used to calculated the multiplier effects associated with projected changes in exports and therefore also final demand for the basic iron and steel industry.

Table XIII Projected changes in final demand for goods delivered by the basic iron and steel industry

Projected change in exports	*External total*	*Difference between original EXT.TOT and projected EXT.TOT*	*New final demand*
Original	10485.54		10621.46
Projected 5% change	9961.263	524.277	10097.18
10% change	9436.986	1048.554	9572.902
15% change	8912.709	1572.831	9048.625
20% change	8497.165	1988.375	8633.081

The original final demand of R10 621 million for basic iron and steel was reduced by a minimum of R524 million (5 per cent reduction in exports) to a maximum of R1 988 million (20 per cent reduction in exports) in order to estimate the total (direct, indirect and induced) effects on output, income and employment.

The simple output multiplier, truncated total output multiplier and total output multiplier effects for each scenario are shown in Table XV. The methodology used and definitions of each multiplier are discussed in Section A.3.6.

Table XV Output, income and employment effects of reductions in exports for goods produced by the basic iron and steel industry

Reduction in exports	*Difference between original and projected final demand (Rm)*	*Difference * simple output multiplier (Rm)*	*Difference * simple income multiplier (Rm)*	*Difference * simple employm. multiplier (number)*	*Difference * truncated total output multiplier (Rm)*	*Difference * truncated total income multiplier (Rm)*	*Difference * truncated total employm. multiplier (number)*	*Difference * total output multiplier (Rm)*	*Difference * total income multiplier (Rm)*
5%	524.28	970.90	218.51	4557.02	1356.18	306.37	7470.73	1666.50	310.32
10%	1048.55	1941.80	437.02	9114.04	2712.37	612.75	14941.45	3333.01	620.64
15%	1572.83	2912.70	655.54	13671.06	4068.55	919.12	22412.18	4999.51	930.96
20%	1988.38	3682.24	828.73	17282.97	5143.47	1161.99	28333.5	6320.39	1176.92

The results obtained from these projections indicated the following: for an open model (excluding households), reducing exports by 5 per cent will result in a reduction in total economic output of R970.90 million. Decreasing exports by 20 per cent reduces the overall economic output by R3 682.24 million. Similarly, the open model income effect of such reductions in exports will result in losses in income of R218.51 million to R828.73 million. The loss in employment ranges from 4 557 to 17 283 persons for the entire economy. These losses in output, income and employment increase significantly when the truncated and total multipliers with respect to a closed model are used to make these projections.

The total output multiplier effect of a similar range of reduction in export leads to a reduction in total output of R1 666.50 million to R6 320.39 million.

A.5 Conclusions

Input-output analysis has been used here to illustrate the total (direct, indirect and induced) effects of a contraction in net trade. The 1995 SAM had to be aggregated. The transaction table was used to calculate a technical coefficient or direct coefficient matrix. From this table the first-round income and output effects of changes in the final demand for any product could be read.

The inverse Leontief matrix was calculated for a model that exclude households from the intermediate sectors and also for a model that is open with respect to households. The entries in this table could were used to describe the total expansion in all industries as a result of the delivery of one rand's worth of outputs outside the processing sector by each industry.

Closing the model with respect to households allowed the inclusion of consumption expenditure inside the technically interrelated table. Multipliers could therefore be calculated from the Leontief inverse matrix including households and one excluding households. The closed model multipliers were all significantly larger that those calculated for the open model, with total output and income multipliers almost double their simple multiplier equivalents.

The results from the output, income and employment multiplier calculations were used to postulate scenarios in which export demand for goods delivered by the basic iron and steel industry contracted by 5-20 per cent in total. The total economic effects of such changes were calculated for each scenario. The motivation for these projections was to explore the possible outcomes of trade reductions that may result from green trade barriers or harmonisation of environmental standards within the basic iron and steel industry. Other possible scenarios were discussed within the text, but were not analysed within this input-output framework due to certain limitations of I-O analysis and lack of data on the relevant variables.

Employment effects calculated in this study are based on 1995 employment figures. The basic iron and steel industry has since seen drastic shedding of labour (up to 30 per cent). This will have considerable effects on the physical labour output ratio and will therefore also reduce the employment multipliers that were calculated for this industry.

Specific shortcomings of input-output analysis are without doubt the fixed coefficient assumptions, and the proportionality assumptions. The steel industry, and integrated steel production in particular, is known for exhibiting significant economies of scale. Changes in output would therefore fail to incorporate these possibilities.

I-O assumes "fixed" technical coefficients, whereas over a sufficiently long period of time new technological developments are bound to affect input patterns. Thus there is a need to adapt the analysis to a dynamic model. The fixed coefficient assumption has dual implications for analysis of the basic iron and steel industry's behaviour to changes in final demand. Firstly, if the relative prices of factors of production change during the period covered by the projection, it is possible that input patterns, and hence some technical coefficients, will be changed. Although this will happen only if some inputs can be substituted for others, these changes in technical coefficients as a result of substitutions effects are not picked up by input-output analysis. Secondly, fixed capital purchases which may occur when industries are forced to adjust to environmental regulation (domestic or international), commonly involve new technologies with a higher level of efficiency and altered production function from the older technologies in production function. Such acquisitions would therefore also involve alterations to the technological coefficients.