Trade Liberalization and its Environmental Impact in South Africa: An Empirical Analysis

ABSTRACT

Over the past decade, South Africa's trade has been liberalized gradually. This increasing trade liberalization coupled with the laxity of South Africa's environmental laws creates, theoretically, the perfect condition for the existence of a pollution haven effect. The pollution haven effect occurs when trade liberalization, coupled with lax environmental regulations, results in increasing economic activity in pollution intensive industries. This effect is mostly said to happen in developing countries. Using industry level data for forty-five manufacturing industries, this paper looks at output and export trends and attempts to find evidence that trade liberalization is associated with a shift in production and exportation towards pollution intensive goods. This study finds weak evidence for the pollution haven hypothesis when looking at output trends but stronger evidence is found when export trends are observed.

1. INTRODUCTION

South Africa, like most countries in Africa, is a developing economy. Similar to many other developing economies, South Africa has undergone an ongoing trade liberalization process over the last few decades with significant trade liberalization occurring in the 1990's (Fedderke and Vaze, 2001). According to trade theory, a country benefits most when it exports the goods in which it has a comparative advantage (Krugman and Obstfeld, 2009). Developing countries like South Africa tend to have comparative advantage in resource-based industries. These resource-based industries tend to be highly pollution intensive (OECD, 2011). Therefore, as trade is liberalized, South Africa becomes susceptible to what is known as the pollution haven effect.

The pollution haven hypothesis theorizes that as trade liberalization occurs, the developing countries, having less stringent environmental regulations than the developed countries, coupled with a comparative advantage in the production of pollution intensive output will end up producing more pollution intensive output the more trade is liberalized. This effect has been studied previously in various developing economies. Some literature has found evidence of the pollution haven effect, such as Gamper-Rabindran and Jha (2002); while others have found no evidence to support the pollution haven hypothesis (Dietzenbacher and Mukhopadhyay, 2007).

Bosshard (2008) outlines in his paper how the invasion of many developing economies in Africa by China has created fear among environmental specialists, claiming that this will result in severe environmental degradation, an effect whose beginnings are already being felt. Many of the Chinese industries that have relocated to Africa are in the "environmentally sensitive" industries such as mining, oil and gas exploration and timber. This has resulted in environmental abuse such as what was seen during an oil exploration project that was carried out at Loango National Park in Gabon (Bosshard, 2008).

Grossman and Krueger (1991) looked at the effect of the North American Free Trade Agreement (NAFTA) from the Mexican context. They concluded that even though there were negative effects to the liberalization of trade through the implementation of NAFTA; these were far outweighed by the positive effect that the agreement would have in terms of pollution. Grossman and Krueger (1991) anticipated that the resultant economic growth would result in a decrease in pollution, the opposite of what the pollution haven hypothesis predicted.

Gamper-Rabindran and Jha (2002) also carried out a study on the environmental effect of India's once off trade liberalization program. They found that there was indeed evidence of the pollution haven effect in India.

Their sentiments were not shared by Dietzenbacher and Mukhopadhyay (2007), who using input-output analysis, examined the case of India and concluded that the country benefits from trade through a decrease in pollution.

Currently no study exists to determine whether the pollution haven hypothesis holds true in the South African case. This study contributes by looking for evidence of trade liberalization being associated with a shift in production towards pollution intensive industries as is theorized by the pollution haven hypothesis.

In addition to the pollution haven hypothesis, there is reason to suspect that trade liberalization in South Africa would be associated with a shift in output towards more pollution intensive products since the country is a natural resource exporter (Hausmann and Klinger, 2008) and therefore its comparative advantage lies in resource-based industries that tend to be pollution intensive in nature. It is however important to note that it would be difficult to separate the effect of comparative advantage and the pollution haven effect when analyzing the shift in production towards pollution intensive industries. Nevertheless, this paper will attempt to determine whether for the South African case, there is evidence of a pollution haven effect.

2. LITERATURE REVIEW

As mentioned previously, the key premise of the pollution haven hypothesis is that developing countries will specialize in pollution intensive output due to the laxity of their environmental regulations while developed countries will specialize in the production of less pollution intensive output for the same reason. Cole (2003) argued that the specialization of developing countries in pollution intensive output will lead to a situation where the North relies on the South for the provision of pollution intensive output, while the North will specialize in the production of environmentally clean output. Literature has various views on the pollution haven hypothesis, with some finding evidence for its existence, others finding no evidence and others choosing to elaborate on why it is hard to find the evidence necessary to prove that this hypothesis holds true as is elaborated below.

Copeland and Taylor (1994) found that it is possible for the pollution haven effect to exist due to the nature of environmental quality when classified in terms of a good. They further stated that environmental quality has been observed by many researchers to be a normal good. Therefore due to the differing distribution of income, less developed countries will tend to have less stringent environmental regulations in comparison to developed countries, resulting in the pollution haven effect.

Grossman and Krueger (1991) looked at the pollution haven hypothesis and further broke it down into three different effects; the scale effect, the technique effect and the composition effect.

The scale effect is the increase in pollution that could be generated by economic growth resulting from increased market access. The technique effect refers to the change in production technology used as a result of trade liberalization; and the composition effect refers to the change in the composition of an economy's output that may occur as trade is liberalized. This is mainly because a country will specialize in output where it enjoys a comparative advantage (Krugman and Obstfeld, 2009).

Copeland and Taylor (1994), with specific emphasis on these three effects, looked at environmental regulation as an endogenous variable to the production of output, rather than an exogenous policy that affects the production process with the aim of showing that it is income inequality that is behind the pollution haven effect. Their findings showed that countries with lower income would tend to produce pollution intensive output. This implied therefore, that if a country experienced increasing gains to trade (high income), it would produce less pollution intensive output due to factors such as employing better production technologies. They hence discovered that the pollution haven effect only occurs before an economy achieves a higher income, a fact that Grossman and Krueger (1991) augured with.

Cole and Elliot (2005) further examined the pollution haven effect by looking at the outward flow of Foreign Direct Investment (FDI) from the United States of America (USA) to less developed countries. They attempted to relate this to laxity of environmental regulations in the developing countries to which FDI outflow was directed. Rather than examine whether or not the pollution haven hypothesis is a reality, Cole and Elliot carried out an empirical discussion on what reasons could be behind the lack of evidence to support the pollution haven hypothesis. Their main conclusion was that the lack of evidence to support the pollution haven hypothesis

was caused by many researchers excluding factor endowments from their analyses of the pollution haven hypothesis. They argued that factor endowments and laxity of environmental regulations were both important for the identification of potential pollution havens. Therefore countries that would have significant pollution haven effects would be those with high levels of capital endowment coupled with lax environmental regulations (countries such as Brazil and Mexico) (Cole and Elliot, 2005). Given South Africa's high level of capital endowment, especially as relates to resource-based industries, one would expect significant pollution haven effects to exist according to the findings of Cole and Elliot (2005).

Ederington *et al* (2005), similar to Cole and Elliot (2005), looked at why the effect of environmental regulations on the structure of trade may be difficult to observe. They attributed this to a number of factors. Firstly, the fact that some industries are geographically immobile and therefore migrating to areas with less stringent environmental regulations is not an option for these industries. Secondly, except for those industries that are highly regulated, pollution costs are a small fraction of total costs and therefore would not be sufficient to warrant a migration. Lastly, most of a developed nation's trade comes from another developed nation which might have even more stringent environmental regulations.

Unlike what is stated by the pollution haven hypothesis, some researchers have found that trade liberalization, may in some instances, reduce pollution emissions. This is because, due to high levels of competition, countries are forced to allocate resources efficiently and to minimize waste. Through this, cleaner production methods are discovered and used, and pollution is minimized (Cole, 2003).

Some researchers have also argued that if indeed environmental quality is a normal good, then increasing gains from trade resulting from trade liberalization should not have a negative effect on the environment; but rather, these gains should result in a higher demand by politicians for higher environmental quality and hence more stringent environmental regulations (Copeland and Taylor, 1994).

Davis (1997) outlines a common argument against the pollution haven hypothesis in his review of the book *Trading Up* by David Vogel. The pollution haven effect is said to result because in developing countries, the cost of pollution is higher than in developed countries. Davis (1997) mentions that if polluting firms were relocating from developed to developing countries solely

because of the cheaper cost of pollution in developing countries; then this migration should have been observed a while ago when stringent environmental policies were implemented in the developed world. However, Davis (1997) states, there is no evidence of such a migration then and even less evidence of such a migration now.

Davis (1997) further argues that the main decision that causes firms to relocate is not the difference in pollution costs but rather the difference in resource endowments. Therefore firms move to developing countries to take advantage of their natural and other resource endowments. This implies, according to Davis (1997) that as trade is liberalized, firms in developed economies will have better access to such endowments and will therefore not have to migrate to the developing countries. This will have an effect on pollution that is the reverse of that predicted by the pollution haven hypothesis. Firms will shift back to their own countries and the pollution effect they were having on the developing country will be nullified.

Eskeland and Harrison (2003) also found no evidence to support the pollution haven hypothesis. They examined whether it was true that multi-nationals were migrating to developing countries to take advantage of the lax environmental regulations and could not find evidence strong enough to support this claim. They did however find weak evidence that most of the migrating multi-national firms were from pollution intensive industries. Surprisingly though, they discovered that the indigenous firms had far higher pollution emissions than those of the migrating multi-nationals who were more efficient in energy use and used cleaner energy hence they had lower pollution emissions.

In this paper, industry level data from forty-five of South Africa's Manufacturing industries is used to carry out an analysis to determine whether there is evidence of a pollution haven effect in South Africa. By doing so this paper will contribute to the existing body of literature on the pollution haven hypothesis such as the work of Gamper-Rabindran and Jha (2002) who looked at industry level data in India to determine whether there was evidence to support the existence of the pollution haven effect in India.

3. TRADE POLICY IN SOUTH AFRICA

As previously mentioned, South Africa has undergone significant trade liberalization over the past decade. This has involved various trade policy reforms such as the removal of quantitative restrictions (Kaplinsky and Morris, 1999) and import surcharge reduction (Roberts, 2000).

In the early 1990's South Africa introduced the General Export Incentive Scheme (GEIS) with the aim of assisting exporters in offsetting the price disadvantage they were faced with in international markets. The scheme was implemented through a system of tax-free grants (Cassim *et al*, 2004) coupled with the removal of both surcharges and the outstanding quantitative restrictions (Edwards, 2005).

South Africa signed the Marrakech Agreement under the General Agreement of Tariffs and Trade (GATT) in 1994 (Roberts, 2000) as a measure for import liberalization. This was then implemented under the World Trade Organization (WTO). The agreement involved a simplification of the South African tariff structure and an abolishment of all polices that contravened WTO conventions such as local content requirements (Roberts, 2000). With the signing of the Marrakech Agreement, South Africa agreed to phase out the GEIS over a three-year period beginning in April 1995 (Cassim *et al*, 2004). This marked the start of a speedy liberalization process for South Africa (Lewis, 2001).

In the same year, South Africa embarked on a five-year tariff reform program as an offer to the WTO (Cassim *et al*, 2004). The aim of this program was to reduce both the dispersion of tariff rates and the average effective rates of protection (Kaplinsky and Morris, 1999) by decreasing the average tariff level by approximately a third. This was to be done over a five year period with the highest reductions occurring in the first year of the program. The program also was to involve the reduction in tariff lines from over 10,000 to 6,000 and the conversion of quantitative and formal duties to ad valorum taxes (Roberts, 2000). Some sectors, such as the automobile, clothing and textile sectors, were granted eight years to attain the levels mentioned in the WTO offer as opposed to the five that the rest of the economy was given (Cassim *et al*, 2004). The early adoption of this program was a sign that the South African government was serious about trade reforms (Lewis, 2001).

Through this agreement, some imported goods had a massive reduction in import duties with consumption goods being reduced from 34% to 17%, intermediate goods from 8% to 4% and

capital goods from 11% to 5%. The GATT import duty levels for these goods were 26%, 4% and 15% respectively (Cassim *et al*, 2004). Hence South Africa was undergoing a considerable amount of trade liberalization under the reform program.

Also included in the 1995 reform were support programs such as the local content program for the motor vehicle industry as well as restructuring supply side measures and subsidies (Roberts, 2005).

In its efforts to liberalize trade, South Africa later signed a number of free trade area agreements. In 2000, South Africa entered the EU-SA Free Trade Area (FTA) Agreement. Under this agreement, South Africa was supposed to liberalize the tariffs on 95% of the European Union (EU) imports from South Africa. This was supposed to be carried out over a three-year period and by 2010, all of EU's imports from South Africa were to be liberalized with the exception of agricultural exports, and wines and spirits (Cassim *et al*, 2004).

South Africa was also involved in the South African Development Co-operation (SADC) Trade Protocol which was concluded in August 1996. Under this protocol, total trade liberalization was expected to be achieved in 2012. This protocol mainly concerned South Africa liberalizing exports from other SADC countries faster than the other SADC countries did for South African exports (Cassim *et al*, 2004).

It would therefore generally seem that South Africa has undergone sufficient trade liberalization and therefore the examination of whether the pollution haven effect exists in South Africa is logical. It is however important to note that there are many who believe that South Africa still has room for further trade liberalization, as mentioned by Edwards (2005) and Fedderke and Vaze (2001). This is evidenced by the fact that since 1996 there has been minimal progress in rationalization (Lewis, 2001). This can also be seen when the South African tariff structure is compared with that of other Southern African economies such as Malawi and Zambia. These economies have tariff schedules that are "much more streamlined, with fewer 0 rates and tariff bands, lower maximum rates and mean positive rates not markedly different than in South Africa" (Lewis, 2001).

4. ENVIRONMENTAL POLICY IN SOUTH AFRICA

Before the 1990's, South Africa had a number of environmental laws and policies in place, some of which still exist to date; for example, The Atmospheric Pollution Prevention Act of 1965 that dealt with air pollution, The Water Act of 1956 that dealt with water conservation, and The Environmental Conservation Act of 1982 that dealt with environmental management as a whole.

Over the past decade, South Africa has implemented a number of environmentally related policies and changes. One of the non-policy changes has been the addition of nine provincial departments of environment where previously there existed only the Department of Environmental Affairs (DEA) that was responsible for the whole nation (Whyte, 1995:15). This addition of provincial departments has been followed by a number of new policies.

The South African Constitution outlines that every human being is entitled to a sustainable environment (Attfield *et al*, 2004). Under the constitution therefore, South Africa aims at having an environment that is well conserved. This is further seen in the ANC's policy document *Ready to Govern,* where the ANC outlines that "it will establish a legislative and administrative system to ensure effective environmental management" (ANC, 2011). The government has tried to attain these goals of environmental conservation in a variety of ways.

Post-Apartheid, the South African government's main goals included poverty reduction. Under this, the protection of the environment, especially as it regards to water, was key. In 1994, the government introduced the White Paper on Water Supply and Sanitation. This was later made a publication in 1997. This paper recognized that the path to sustainable water resources involved ensuring that the environment and the ecosystem were protected (Allan, 2003).

Later, the National Water Act of 1998 followed (Stein, 2004). Under this Act, pollution was controlled through a procedure of license issue. Licenses were issued and allocation schedules implemented by the Department of Water Affairs. Before a new work could be approved under this act, the Minister had to receive an Environmental Impact Assessment (Allan, 2003). The government was responsible for ensuring that water was "protected, used, developed, conserved, managed and controlled in a sustainable and equitable manner for the benefit of all persons" (Perret, 2002).

In the same year, the government introduced the 1998 White Energy Paper. One of the document's major objectives was the management of the impact of energy-related issues on the environment (Winkler, 2005). This paper aimed at promoting the use of renewable energy which would reduce air pollution and also have a positive impact on the emission of greenhouse gases. Unfortunately, despite the introduction of this paper, the government does not seem to have any strategies in place to implement renewable energy (Sebitosi, 2008) therefore leaving the South African environment to suffer the consequences of non-renewable energy, the biggest of which is increased air pollution.

Again in 1998, the government passed the National Environmental Management Act, an act similar to the Environmental Conservation Act of 1982. This act, unlike a number of others, dealt with all the fields of environmental concern i.e. pollution control and waste management, and land-use planning and development (Glazewski, 2000).

South Africa was also one of the first countries to implement a tobacco control policy in 1993 (The Tobacco Products Control Act, Act 83 of 1993). This was followed by the Amendment Act (Act 12 of 1999). The Amendment Act was quite comprehensive and included a ban on smoking in public space (Chopra *et al*, 2009). This can be seen as a commitment by South Africa to ensure the preservation of air quality.

In the same year, South Africa signed the UN Framework Convention on Climate Change (the FCCC) which it ratified later in 1997 (Glazewski, 2000). This Convention was with regard to the emission of greenhouse gases and its purpose was to stabilize the emission of these gases at a level that would have minimal harm to the environment.

Many of the environmental policies introduced in South Africa have been unsuccessfully implemented, as mentioned by Sebitosi (2008). Also, some of the policies have major gaps, such as the ANC's *Ready to govern,* which though very succinct about the party's commitment to environmental protection, does not make any mention of plans to implement clean technologies, or a "proactive green trade policy" (Whyte, 1995:15).

Given the laxity with which most of the environmental policies in South Africa are implemented, there is reason to believe that a pollution haven effect could exist as trade is liberalized.

5. DATA AND METHODOLOGY

Conceptual Framework

The effect that trade liberalization has on a country is dependent on the country's comparative advantage which is in turn also influenced by country differences in factor endowments, environmental policy and technology among others (Gamper-Rabindran and Jha, 2002).

The factor endowment theory simply put states that when a country opens itself up to trade, it will make an output specialization decision according to its factor endowments (Leamer, 1995). As previously mentioned, South Africa is a natural resource exporter and its comparative advantage lies in resource-based industries. Therefore, as trade is liberalized one would expect to observe a structural shift towards resource-based industries such as chemical and metal extraction industries.

However, resource-based industries are the ones that tend to be pollution intensive and are the ones most susceptible to the pollution haven effect as was observed by Bosshard (2008). Therefore under the pollution haven hypothesis one would expect to observe a shift in output produced towards pollution intensive industries which also happen to be resource-based. It is highly likely that such a trend will be observed given the laxity with which South African environmental policy is enforced.

Given this background, this paper shall examine two hypotheses;

1. Is trade liberalization in South Africa associated with an increase in output from pollution intensive industries?
2. Is trade liberalization in South Africa associated with an increase in exports from pollution intensive industries?

This paper has chosen to look at exports as well so as to exclude output that is produced specifically for domestic consumption as this is unlikely to be affected by the pollution haven effect in this context.

Theoretical Framework and Methodology

To test these hypotheses this paper shall use methods similar to Gamper-Rabindran and Jha (2002). For the first hypothesis real output is observed over the period 1990 to 2002 using a simple Cobb-Douglas Production function. In this function capital (K) and labor (L) are taken as

proxies for capital and labor productivity. Pollution-intensity is also included as a proxy for pollution generated by a particular industry and tariffs as a measure of trade liberalization.

Pollution can be regarded as either a cost or an input to the production process. Due to the lax nature of environmental laws in South Africa, the abatement costs associated with pollution in South Africa are minimal in comparison to those of developed countries. It is therefore more logical to take pollution as an input in the production process, a method used by Gamper-Rabindran and Jha (2002).

The Cobb Douglas Production Functions used and the associated cost function is of the form

$$Y=f(K, L, P)$$

Where Y is output, K is capital stock, L is labor, and P is amount of pollution released during the production process. The costs associated with this production function are, r which is the cost of capital, w which is the wage rate and c which is the cost of pollution. Capital, labor and pollution produced are inputs to the production process. Pollution is regarded as an input as motivated previously; c/r and c/w would be lower for developing countries than corresponding ratios for developed countries under no trade. With trade liberalization, developing countries would specialize in pollution intensive industries and export pollution intensive goods, turning into pollution havens.

The regression model used to analyze the impact of trade liberalization on production is;

$$\ln(Y_{it}) = \beta_1 \ln(K_{it}) + \beta_2 \ln(L_{it}) + \beta_3 \ln(T_{it}) + \beta_4 (P^* \ln(T_{it})) + \mu_i + t_t$$

where Y is real output per industry i for time period t, K is capital stock per industry i for time period t, L is number of employees per industry i for time period t, P is the pollution intensity variable, T is the tariff per industry i for time period t, μ is industry fixed effects and t is time fixed effects. This paper is interested in the interaction term between pollution intensity and tariffs. If the pollution haven effect exists in South Africa and trade liberalization is associated with an increase in the output of pollution intensive industries, it is expected that β_4 will not equal 0 and will be negative. The regression model is run both with and without the capital stock and employee variables on the right hand side.

For the second hypothesis exports are observed over the same period (1990 – 2002). A model similar to the one used by Grossman and Kruger (1991) and Gamper-Rabindran and Jha (2002)

is estimated. Exports are estimated as a function of pollution intensity (P) and tariffs (T) as a measure of trade liberalization.

The regression model used is

$$\ln(X_{it}) = \beta_3 \ln(T_{it}) + \beta_4 (P^* \ln(T_{it})) + \mu_i + t_t$$

Where X is exports per industry i for time period t, P is the pollution intensity variable, T is the tariff per industry i for time period t, μ is industry fixed effects and t is time fixed effects. This paper is interested in the interaction term between pollution intensity and tariffs. If the pollution haven effect exists in South Africa and trade liberalization is associated with an increase in the exports of pollution intensive industries, it is expected that β_4 will not equal 0 and will be negative.

Fixed effects for both time and industry are added in both the output and export regressions. This is done so as to remove any effects that could be observed on output or exports that are industry specific or that are specific to a particular year.

Data Used

The data used were obtained from Lawrence Edwards of the School of Economics, University of Cape Town and the Industrial Pollution Projection System by Hettige *et al* (1994). Appendix A provides a list of all variables used and their data sources.

SIC (Standard Industrial Classification) industry level data for forty-five Manufacturing Industries was used. Revenue for Electricity was also used as a proxy for fuel prices.

Due to insufficient pollution data on South African industries, the pollution intensity index used is derived from the air, water and land pollution measures given by the Industrial Pollution Projection System which is based on United States (US) industries. This is similar to what other papers have done when faced with a similar data constraint such as Gamper-Rabindran and Jha (2002). These measures were given under the Four digit ISIC (International Standard Industrial Classification) code and therefore the industries had to be matched to the SIC code used in South Africa. After the matching, through principal component analysis, the air, land and water pollution measures were then merged into a single factor that was used as a proxy for the pollution intensity of an industry. Appendix B gives the correlations of the key variables in both the output and export regressions and Appendix D gives the pollution intensities of all the

industries used. The industries used comprise of resource-based industries (such as basic iron and steel, and coke oven and petroleum products) and non-resource based industries. Resource-based industries have an average pollution score of .504 compared to -.288 for non-resource based industries. Resource-based industries are therefore more pollution intensive than their non-resource based counterparts.

Graphical Analysis

The graph in Figure 1 shows the trends observed in average real output over the period 1990 – 2002. Average real output is graphed by pollution intensity of the industries as determined by the pollution intensity variable in the regressions (low pollution intensive industries, medium pollution intensive industries and high pollution intensive industries). The graph shows that there has been an increase in output produced in high pollution intensive industries over the period 1990 - 2002. The trend in output growth in high pollution intensive industries illustrates a growth rate that is higher than both the low and medium pollution intensive industries especially from 1993 onwards.

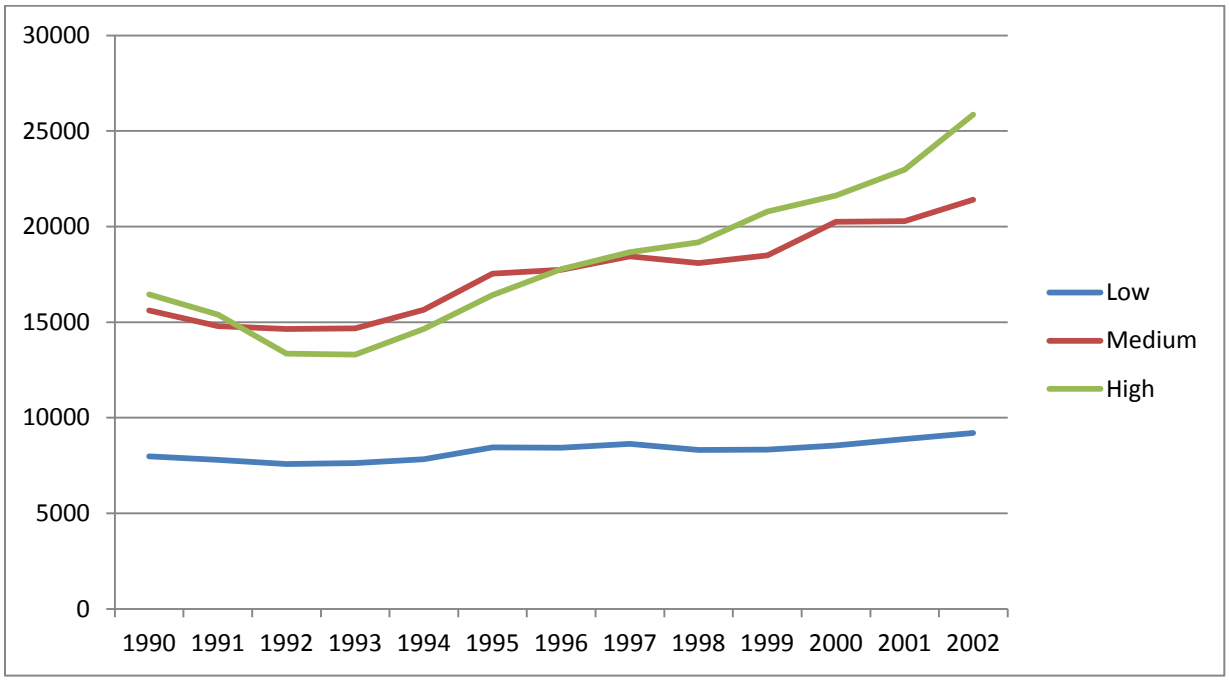

Figure 1: *Graph of real output in 2000 prices from 1990 to 2002 according to pollution intensity of industries*

The growth of output in high pollution intensive industries is in line with the pollution haven hypothesis as there is increasing output in these industries in a period of increasing trade liberalization.

A concern for isolating a pollution haven effect is that since South Africa's comparative advantage lies in resource-based industries, it would be expected that the low pollution intensive industries would have higher tariffs prior to trade liberalization due to their higher need for protection. Therefore as trade is liberalized, it would be expected that the decrease in tariffs would be greater in the low pollution intensive industries and South Africa would shift its production to the resource-based pollution intensive industries in which it has its comparative advantage. This would mean that it would be difficult to isolate the effect on production of the pollution haven effect from that of the comparative advantage effect.

In the period 1993 – 2002, the decrease in tariffs was 43% in low pollution intensive industries whereas it was 81% in high pollution intensive industries. This can be seen in the graph in Figure 2 which indicates that there is no clear evidence of sharper tariff cuts for low pollution intensive industries compared to high pollution intensive industries. In fact, it indicates that the comparative advantage mechanism over this period, might have worked in the opposite direction. Therefore if a shift towards the pollution intensive industries is observed in association with increased trade liberalization, this would be indicative of a pollution haven effect.

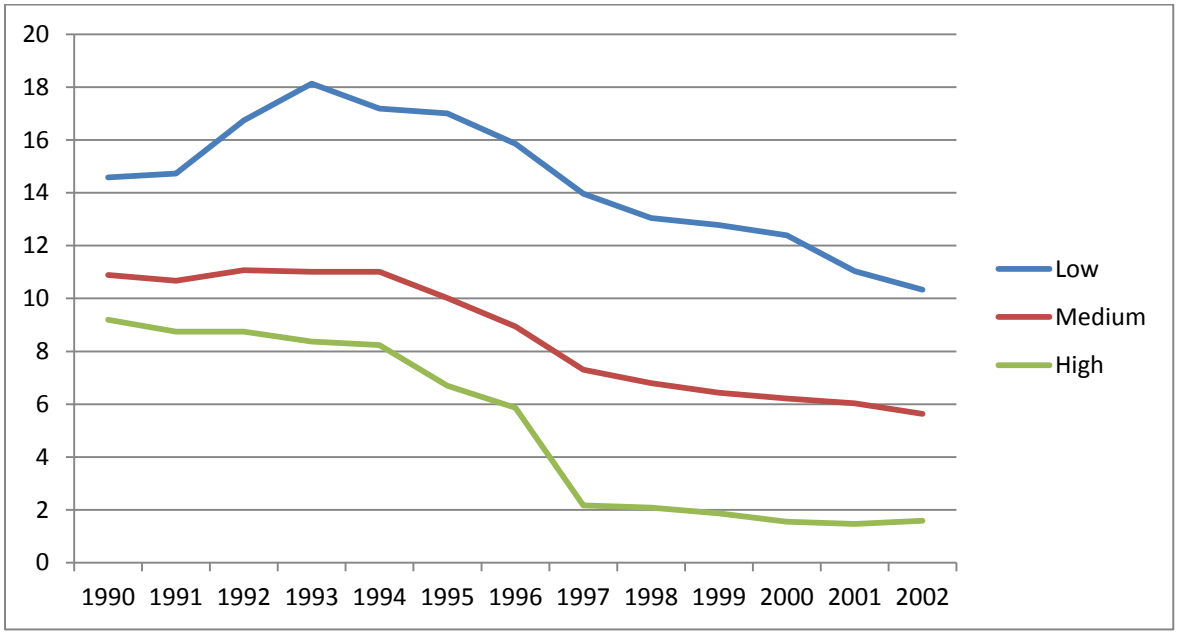

Figure 2: *Graph of tariffs from 1990 to 2002 according to pollution intensity of industries*

The graph in Figure 3 below shows the trend in exports over the period 1990 – 2002 by pollution intensity of industries;

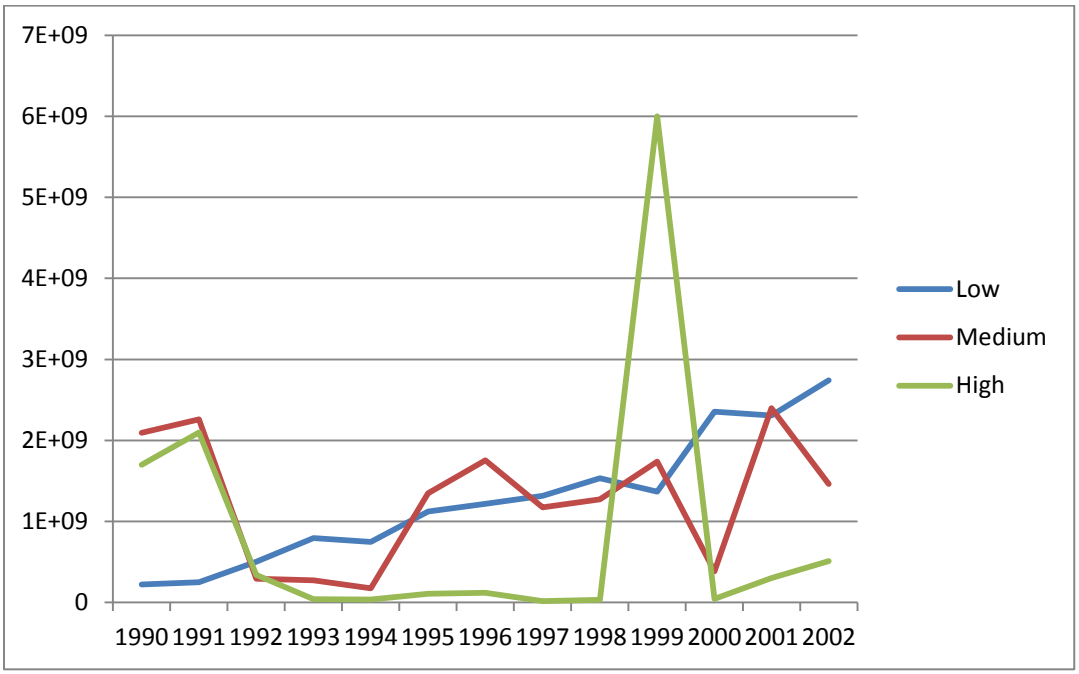

Figure 3: *Graph of exports in 2000 prices from 1990 to 2002 according to pollution intensity of industries*

As can be seen in the graph above, there is a steady increase in the exports from low pollution intensive industries. There is no noticeable trend in the high pollution intensive industries apart from the upward spike that began in 1998, peaked in 1999 and ended in 2000. The 1999 exports observation presents a significant outlier in the exports regression. However even when this year is dropped from the sample, the results of the exports regression remain unchanged in terms of sign and significance of coefficients.

6. REGRESSION RESULTS AND INTERPRETATION

Output Regression

Appendix C shows the descriptive statistics of variables used. Below are the results of the initial output regression;

Table 1: Output Regression with and without capital and labor variables

Dependent Variable: ln (Output)	**Coefficient**	
	(1) (time and industry fixed effects)	**(2) (time and industry fixed effects)**
ln(capital stock)		.0493** (.0236)
ln(number of employees)		.203** (.0349)
ln(tariffs)	.00399 (.0146)	.0128 (.00699)
Pollution*ln(tariffs)	-.0424** (.00717)	-.0438** (.0143)
Number of Observations	572	572
R^2	0.98	0.98

***Significant at the 5% level*

Initially output is regressed without capital and labor variables in (1) and then with both capital and labor variables in (2). In both specifications, as is seen above, there is a negative significant coefficient on the interaction term between pollution intensity and tariffs. The magnitude of the interaction term coefficient is similar in both (1) and (2). Therefore using (2),

$$\frac{\partial ln(Output)}{\partial ln(tariffs)} = .00399 - 0.438(pollution)$$

When the lowest(-.477) and highest (6.003) pollution intensities in the data set are compared, the lowest intensity gives a coefficient of .213 significant at the 10% level while the highest intensity gives a coefficient of -2.625 significant at the 5% level. Therefore a one percent fall in tariff is associated with a .213% fall in output in the low pollution intensive industries, and a 2.625% increase in output in the high pollution intensive industries. The two effects are hence different with the effect on the high pollution intensive industries being greater. This indicates that the

change in output with tariffs is negatively related to pollution. Therefore as tariffs decrease, as was the case in 1990 – 2002, output is expected to increase in industries that are high pollution intensive. This implies that trade liberalization, as indicated by falling tariffs, is associated with a shift in output towards high pollution intensive industries as is hypothesized by the pollution haven hypothesis.

As part of its trade liberalization process, South Africa signed the SADC Trade protocol in 1996 and the Marrakech Agreement under GATT in 1994 as previously mentioned. These two events can be controlled for in this paper's output regression by inserting dummies first for the SADC Trade protocol and then for the Marrakech Agreement under GATT and then interacting these two dummies with pollution intensity. However both variables cannot be included in a single regression at the same time as they are highly correlated (correlation coefficient of 0.90). When including the SADC and GATT interactions, the paper is interested in the combined effect of trade liberalization through tariff decrease and trade liberalization through global integration as is indicated by the SADC Trade Protocol and the Marrakech Agreement under GATT.

Table 2:Output regression with SADC and GATT variables

Dependent Variable: Output	**Coefficient (time and industry fixed effects used in all specifications)**			
	(1)	**(2)**	**(3)**	**(4)**
ln(capital stock)		.0502** (.0236)		.0514** (.0234)
ln(number of employees)		-.206** (.0349)		-.212** (.0348)
ln(tariffs)	.00481 (.0157)	-.0144 (.0143)	.00875 (.551)	.0191 (.0143)
Pollution*ln(tariffs)	-.0403** (.00794)	-.0403 (.00773)	-.0282** (.00952)	-.0263** (.00923)
Pollution*SADC	.00949 (.0157)	.0161 (.0152)		
Pollution*GATT			.0333** (.0148)	.0412** (.0143)
Number of Observations	572	572	572	572
R^2	0.98	0.98	0.98	0.98

***Significant at the 5% level*

Both regressions of SADC and GATT are run initially without the capital and labor variables in (1) and (3), and then with the capital and labor variables in (2) and (4). For both the regressions with the SADC interaction term, a non-significant coefficient is obtained for the SADC interaction. The pollution and tariff interaction however is still negative and significant indicating that tariffs capture most of the effect of trade liberalization on output.

For the GATT interaction term, a positive significant coefficient is obtained for both regressions. This indicates that the effect of the signing of the Marrakech Agreement on the amount of output produced is dependent on the industrial pollution intensity. Specifically, after the agreement was signed, increased production was associated with those industries with high pollution intensity as is identified by the pollution haven hypothesis.

Robustness Check

This paper now examines whether the shift towards pollution intensive production is driven not by tariff changes, but by changes in fuel prices. Fuel prices over the period 1990 – 2002 were falling as indicated by the graph in Figure 4 below. High pollution intensive industries are more susceptible to changes in fuel prices than are low pollution intensive industries and such a drop in fuel prices could have caused the observed production shift.

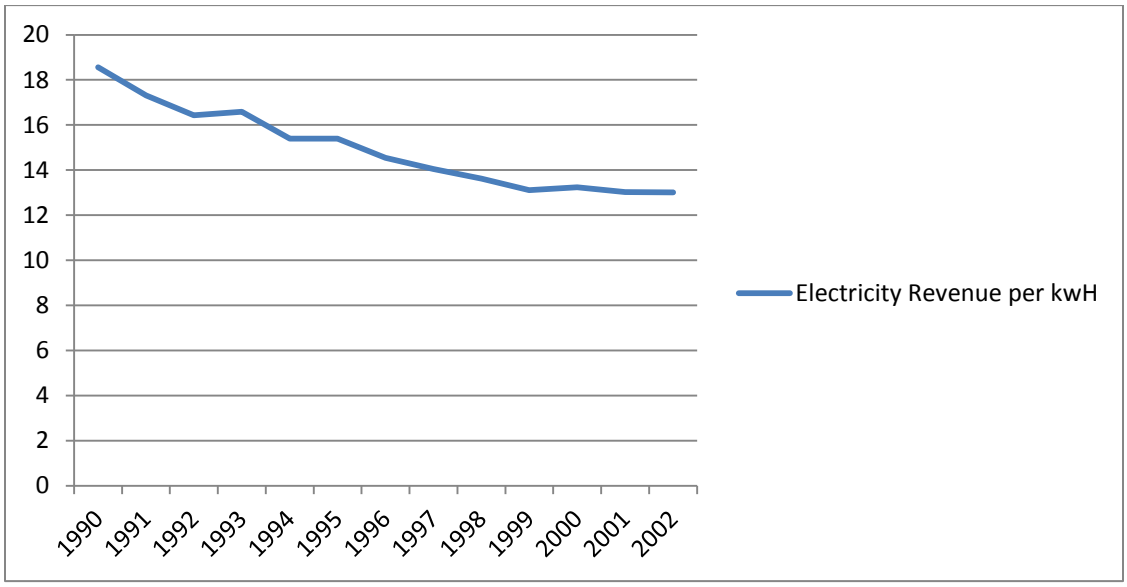

Figure 4: *Graph of electricity revenue in 2000 prices per kwH from 1990 to 2002*

To examine this, a regression of output is run with a control for fuel prices. Electricity revenue per kwH of electricity is used as a proxy for fuel prices in the output regression. It is interacted

with the pollution intensity variable to determine if the effect a change in fuel prices has on the amount of output produced differs by pollution intensity. The regression results obtained are in the table below;

Table 3: Output regression controlling for electricity prices

Dependent Variable: Output	**Coefficient (time and industry fixed effects)**	
	(1)	**(2)**
ln(capital stock)		.0496** (.0231)
ln(number of employees)		.219** (.0343)
ln(tariffs)	.0212 (.0149)	.0329** (.0145)
Pollution*ln(tariffs)	.0139 (.0152)	.0202 (.0147)
ln(electricity revenue)*pollution	-.398** (.0953)	-.454** (.0923)
Number of Observations	572	572
R^2	0.98	0.98

***Significant at the 5% level*

The electricity price regression is run initially without the capital and labor variables in (1) which are then included in (2). Both of the regressions indicate that when electricity price is included in the regression, the significant coefficient initially observed on the pollution and tariff interaction becomes insignificant.

In both regressions, the electricity price interaction displays a negative significant coefficient. This implies that there is a negative association between electricity prices and pollution intensity. Fuel prices have been falling over the period 1990 – 2002 as indicated by the graph in Figure 4 above. There is therefore an association between the decrease in fuel prices and the increased output in pollution intensive industries. This implies that the association observed previously in the output regression that did not include electricity revenues was not due to the effect of a pollution haven, but rather due to a change in fuel prices.

Unfortunately a similar analysis cannot be carried out for the SADC and GATT interaction terms as they are highly correlated with the electricity revenue interaction term (correlation coefficients of 0.88 and 0.77 respectively).

Overall, the evidence seems to suggest that, though over the period of trade liberalization a shift in output was observed towards high pollution intensive industries as consistent with the pollution haven hypothesis; this shift was not driven by a decrease in tariffs but by changes in electricity prices.

Exports Regression

Initially the exports regression is run inclusive of electricity prices to see if trade liberalization is associated with a shift towards the exportation of high pollution intensive goods in the presence of electricity price controls. The results of the initial exports regression are seen in the table below;

Table 4: Exports regression controlling for electricity prices

Dependent Variable: Exports	**Coefficient (time and industry fixed effects)**
ln(tariffs)	-.1005 (.172)
Pollution*ln(tariffs)	-.413** (.165)
ln(electricity revenue)*pollution	3.719** (1.102)
Number of Observations	572
R^2	0.35

***Significant at the 5% level*

The results of the export regression indicate that when electricity price is included in the regression, a negative significant coefficient is observed on the pollution and tariff interaction term and a positive coefficient is observed on the electricity price interaction.

This means that when electricity prices are controlled for, there is evidence that the effect a change in tariffs has on exports is dependent on the pollution intensity of the industry. Therefore;

$$\frac{\partial ln(Exports)}{\partial ln(tariffs)} = -.1005 - 0.413(pollution)$$

When the lowest (-.477) and highest pollution (6.003) intensities in the data set are compared, the lowest intensity gives a coefficient of .097 significant at the 5% level while the highest intensity gives a coefficient of -2.579 also significant at the 5% level. Therefore, a one percent fall in tariff is associated with a .097% fall in exports in the low pollution intensive industries, and a 2.579% increase in exports in the high pollution intensive industries The two effects are therefore different with the effect on the high pollution intensive industries being greater.

This implies that a tariff decrease (a sign of trade liberalization) is associated with an increase in exports from high pollution intensive industries. This result holds in the presence of electricity prices. It is hence possible that the price of fuel (as indicated by electricity revenue) is a key determinant of the export decision.

The electricity price interaction term is then dropped and a new regression is run without it. Instead dummy variables for the signing of the SADC Trade Protocol and the Marrakech Agreement under GATT are used. The results obtained are contained in the table below;

Table 5: Export regression with SADC and GATT variables

Dependent Variable: Exports	**Coefficient (time and industry fixed effects)**	
	(1)	**(2)**
ln(tariffs)	.00631 (.165)	-.0159 (.168)
Pollution*ln(tariffs)	-.0555 (.0897)	-.114 (.109)
Pollution*SADC	-.775** (.177)	
Pollution*GATT		-.533** (.169)
Number of Observations	572	572
R^2	0.36	0.35

***Significant at the 5% level*
**Significant at the 10% level*

Due to the high correlation between the SADC and GATT interaction terms, as mentioned previously, each regression is run separately. For both regressions, both the SADC and GATT interaction terms have negative and significant coefficients. However, the pollution and tariff interaction term though still negative, is now insignificant. This implies that after controlling for the signing of the SADC Trade Protocol and the Marrakech Agreement under GATT, tariffs do not seem to be a good indicator of trade liberalization in the case of exports. The SADC and GATT dummies seem to be better indicators of trade liberalization than tariffs. This is logical as the SADC Trade protocol and the Marrakech Agreement under GATT are more likely to influence the export decision than tariffs.

When tariffs change, they are more likely to influence the import decision and the decision to produce domestically. Tariffs therefore may not be expected to have much of an effect on the export decision and therefore would not capture the pollution haven effect if it existed. Trade Agreements on the other hand, such as the SADC Trade protocol, are most times signed specifically to enable a country to easily export goods. Such trade agreements are therefore more likely to affect the export decision hence these agreements provide for a better analysis of whether trade liberalization is associated with an export shift towards pollution intensive industries.

The negative significant coefficient on both the SADC and GATT interactions indicates that the signing of these two trade agreements was associated with a shift in exports towards high pollution intensive industries. This is in line with the pollution haven hypothesis. Therefore when the SADC and GATT variables are considered, there is evidence for the existence of a pollution haven effect in South Africa.

Overall, it appears that in the case of exports, trade liberalization is associated with an export shift towards industries that are high pollution intensive. This is what is hypothesized by the pollution haven hypothesis and holds true even in the presence of electricity price controls in the export regression.

7. POLICY IMPLICATIONS AND CONCLUSIONS

Over the decade, South African tariffs have been decreasing as is seen in the previous graphs. This paper analyzed the relationship between trade liberalization and the environment. This was done by modeling output and export regressions. With the output regression, there is weak evidence for the existence of a pollution haven effect. The results suggest that the change in electricity prices is more important in explaining the structural shift observed. However, the negative coefficient on the pollution and tariff interaction could be capturing two different effects; the pollution haven effect, and the effect of tariffs falling more in high pollution intensive industries (as shown by the graph in Figure 2) effectively pushing production away from these industries. It would therefore be hard to separate the two effects given the data available.

However, with the export regression conducted in this paper, there is evidence that trade liberalization, as indicated by the signing of the SADC Trade Protocol and the Marrakech Agreement under GATT, was associated with an increase in exports from high pollution intensive industries. The findings are therefore consistent with the pollution haven hypothesis and the work of Cole (2003), Cole and Elliot (2005), and Gamper-Rabindran and Jha (2002) who all indicated that the pollution haven effect could exist in developing countries.

Given the findings on the exports regression, there is therefore a need for South Africa to improve the stringency with which environmental policies are implemented especially as trade is liberalized further. If this is recommendation is not effected, the South African environment might suffer severe environmental degradation.

It was also observed that as fuel prices fall, there is a shift in output towards high pollution intensive industries. Over the past decade, fuel prices have been falling (as indicated by the graph in Figure 4). The South African government must therefore again look at more stringent enforcement of currently existing environmental policies; or creating new environmental policies based on the polluter pays principle, if the South African environment is to be conserved.

The pollution intensity values used in this paper were derived from US estimates. It would therefore be of great interest to use pollution estimates obtained from South Africa and run a similar analysis. It would also be of great interest to look at the output trends over the period 1990 – 2002 and separate the two effects mentioned previously; that caused by the decreasing tariffs, and the other the pollution haven effect, if at all it is existent in the South African output case.

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APPENDICES

Appendix A: Data Sources of variables used

Variable	Source
Real Output	Lawrence Edwards, School of Economics, University of Cape Town
Exports	
Capital Stock	
Number of employees	
Wages	
Tariffs	
Pollution Intensity	International Pollution Projection System (IPPS) data
Electricity Revenue	Energy Price Report (2005), Department of Minerals and Energy, Republic of South Africa

Appendix B: Correlation Coefficients of key variables

	Capital Stock	Number of employees	In(tariffs)	Pollution*tariffs
Capital Stock	1.000			
Number of employees	-.0812	1.000		
In(tariffs)	-.205	0.209	1.000	
Pollution*tariffs	.201	-.0083	-.219	1.000

Appendix C: Descriptive Statistics

	Mean	**Standard Deviation**
Output Regression **Years: 1990-2002**		
Output (measured in R millions)	9550.643	8475.663
Number of employees	31.252	23.875
Capital Stock (measured in R millions)	46.733	110.228
Pollution Intensity	2.37e-09	1
Tariffs	13.569	11.053
Electricity Revenue	14.942	1.766
Export Regression **Years: 1990-2002**		
Exports	1.26e+09	2.21e+09
Capital Stock (measured in R millions)	46.733	110.228
Wages (measured in R millions)	319.115	259.678
Pollution Intensity	2.37e-09	1
Tariffs	13.569	11.053
Electricity Revenue	14.942	1.766

Appendix D: Air, Water and Land Pollution intensities and Pollution Scores by Industry

Description	**Air Pollution**	**Land Pollution**	**Water Pollution**	**Pollution Score**
Meat, fish, fruit, vegetables, oils & fat	71.22	306.81	19.39	-0.4119189
Dairy products	31.03	254.19	22.35	-0.4285817
Grain milling & animal feeds	13.02	14.55	0.86	-0.4768632
Other food products	49.02	201.48	3.49	-0.4428796
Beverages	57.47	76.36	18.39	-0.4419203
Spinning and weaving	350.96	326.21	178.85	-0.19348
Other textiles	1953.39	394.49	12.51	0.2161657
Knitted and crocheted fabrics	139.68	273.27	12.87	-0.3978655
Clothing	352.79	433.36	10.04	-0.3122667
Leather and leather products	2407.46	6346.34	110.01	1.079382
Footwear	472.39	13.96	0.06	-0.3252426
Sawmilling and planing of wood	226.97	71.31	1.09	-0.3996743
Wood and wood products	749.37	69.73	0.07	-0.2274326
Paper and paper products	1883.84	717.35	407.31	0.5337173
Publishing	413.12	55.79	0.02	-0.3404471
Printing and related services	413.12	55.79	0.02	-0.3404471
Coke oven and petroleum products	502.95	1345.63	28.75	-0.1503275
Basic chemicals	5923.99	20577.03	2992.9	6.00338

Appendix D (continued)

Description	Air Pollution	Land Pollution	Water Pollution	Pollution Score
Other chemicals	2255.83	2588.33	108.96	0.6260374
Rubber products	947.47	472.64	1.64	-0.117408
Plastic products	1896.01	561.73	4.63	0.2089341
Glass and glass products	211.54	136.09	17.15	-0.3854062
Non-metallic mineral products	300.7	504.77	15.41	-0.3177305
Basic iron and steel	985.15	5647.07	350.16	0.7191321
Non-ferrous metals	2988.29	7920.98	4.62	1.358807
Structural steel products	289.96	326.82	72.85	-0.2958112
Other fabricated metal products	1226.97	87.3	41.14	-0.0353661
General purpose machinery	472.39	212.51	14.95	-0.2924469
Special purpose machinery	148.61	245.51	2.67	-0.4057833
Household appliances	203.56	117.99	0.04	-0.4032532
Electrical motors, generators and transformers	381.77	188.64	1.97	-0.3351092
Electricity distribution and control apparatus	414.9	858.69	10.33	-0.2459219
Insulated wire and cable	414.9	858.69	10.33	-0.2459219
Accumulators and batteries	414.9	858.69	10.33	-0.2459219
Electric lamps and lighting equipment	414.9	858.69	10.33	-0.2459219
Other electrical equipment	381.77	188.64	1.97	-0.3351092
Television, radio and other electronic equipment	732.25	660.59	6.47	-0.1649016
Medical appliances, measuring and controlling equipment	148.61	245.51	116.07	-0.3178748
Motor vehicles	445.62	201.48	2.21	-0.3123793
Bodies for motor vehicles	445.62	201.48	2.21	-0.3123793
Parts and accessories for motor vehicles	565.63	497.01	6.87	-0.237344
Other transport equipment	806.92	247.98	24.4	-0.1704112
Furniture	996.52	216.68	1.15	-0.1289233
Other manufacturing	448.6	245.76	4.49	-0.3048841