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Pigovian Tax Dynamics and Net Income Earnings in Commercial Timber Plantations in South Africa: A General Algebraic Modeling System Analysis

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ABSTRACT From the 1997 Kyoto Protocol to the 2011 Durban Platform, the global lobby for pollution-free environment policies and regulations is greater than it has ever been. Governments have agreed to forge a global climate deal to curb greenhouse gas emissions and pollution by 2020 to slow climate change and global warming. A carbon tax is being considered among the range of powerful instruments available to these governments as part of the agreed upon global agenda of effective mitigation actions for pollution-free environment. This study aims to address the lack of studies that specify methods for calculations of the impact of Pigovian taxes on the competitiveness of businesses. Using a general algebraic modeling system analysis, the study expresses mathematically a "timber model" whose objective function is to maximize net-income earnings of commercial timber plantations subject to miscellaneous endowment constraints involved in timber production – including a given level of Pigovian tax. Results give one apparent pattern: the net-income earnings is at its peak (maximum level) when timber is in a "tax free" production process. A regime of Pigovian tax dynamics disproportionately impacts on the timber yield, water use, and net-income earnings of commercial plantations. While a regime of tax dynamics appears not to have significantly dampened the level of some timber yield and water use, all net-income earnings tumbled. This appears to have significant policy implications, particularly with respect to the way in which the viability and competitiveness of businesses in South Africa would respond to potential fiscal policy that incorporates Pigovian tax.

I. INTRODUCTION

From the 1997 Kyoto Protocol to the 2011 Durban Platform, the global lobby for pollution-free environment policies and regulations is greater than it has ever been. Governments of countries around the world have agreed to forge a global climate deal to cut and limit greenhouse gas emissions and pollution by 2020 to slow climate change and global warming. A carbon tax is being considered among the range of powerful instruments available to these governments as part of the agreed upon global agenda of effective mitigation actions for a pollution-free environment. The expectation is that, ceteris paribus, the more a country or firm spends on Pigovian tax as a share of its total costs, the more elastic it would be relative to greenhouse emissions or pollution. In South Africa, Pigovian taxes geared to curb greenhouse gas emissions and pollution are being imposed. Government pointed that a carbon tax policy to address the challenges of climate change through facilitating a viable and fair transition to a low-carbon economy is essential to ensure an environmentally sustainable economic development and growth path for South Africa. This would also send signals to investors and consumers of the need to ensure that future investments are more climate resilient (DNT 2013).

The International Water Management Institute (IWMI), which set indicators for determining the water scarcity in the world, compares water withdrawal to its supply. If the total withdrawals are greater than 50 percent of annual water supplies then the country is considered to be water-scarce. In 1990, major water users in South Africa included: agricultural with about 9580 10^6 cubic meter per year (m^3/year), domestic with about 2281 10^6 m^3/year, industrial with about 1448 10^6 m^3/year, lakes and wetlands with about 18519 10^6 m^3/year and others with about 5210 10^6 m^3/year, which adds up to a total water withdrawal of about 18519 10^6 m^3/year (FAO 2013). (www.fao.org/docrep/v8260B/v8260B1j.htm). South Africa in general has about 65% of its landscape located in semi-arid areas where low rainfall is of an order ranging between 500 to 800 millimeters (mm) per annum. In respect of this characteristic, South Africa is an extremely water-scarce country. The lack of important arterial rivers or lakes in South Africa requires extensive water conservation and control measures otherwise the country will suffer from soil erosion and desertification (EIA 2008) (www.eia.doe.gov/emeu/cabs/South_Africa/pdf.pdf). In respect of this characteristic, water is an important natural resource in the country and its use has been under the spotlight for all of the stakeholders concerned. National Water Resource Strategy (NWRS) is the government's agency tasked to introduce efficient water management strategies. To put water to more productive uses, the NWRS enforced charges for water for all possible uses as well as fostered judicious use of water by all of the stakeholders (DWAF, 2004). The agency had to introduce the most beneficial and efficient utilization of water in the country from a social and economic perspective by allocating water in an efficient manner, and meeting water demand so that all users are better off.

Commercial plantations are involved in forest plantations where forests are grown or maintained so that they can be harvested or used for commercial purposes. Their economic activities include tree removal for arable farming, exploitation of the carbon absorption capacity of the forest vegetation, the stream flow reduction (SFR), and evapotranspiration (ET). The ET quantifies the overall evaporative losses from trees species and other stands of commercial plantations, which includes transpiration from both the dry and wet canopies and from forest litter on the soil surface. The SFR quantifies the reduction in the quantity of water from catchments and forest hydrological resources as a result of uptake of water by trees species and other stands of commercial plantation. Their activities also contribute to soil degradation and indirect emissions of nitrous oxide from managed soils. Many are using mono cropping and high levels of agrochemicals either to speed up the growth of tree species – by using fertilizers – or to kill fungi and insects that harm crops, using herbicides, fungicides, or pesticides, some of which, such as Dichloro-Diphenyl-Trichloroethane known as DDT, are banned in other countries (United States, Australia, etc). Commercial plantations have also used intensive irrigation and heavy machinery.

In 1991, South Africa had the biggest cultivated commercial plantations on the African continent with a total area of more than 1.5 million hectares – around 1.32 percent of the total landscape (http://www.fire-uni-freiburg.de/iffn/country/za/za_1.htm)(Sabie 2013). The areas planted with eucalyptus and wattle, and with pine species are totalling an area of 1, 257, 341 hectares (DAFF 2011). There are technical differences in water uptake by eucalyptus and wattle species, which require a rotation length of time frames ranging between 10 to 12 years, while with pine species, the rotation length ranges between 30 to 40 years.

In 1996, the commercial plantations sector was a net exporter to the value of 1.7 billion South African Rand (ZAR) and had a total turnover of around ZAR 13. 1 billion (Burger, 1998: 68-, 69). In 2005, commercial plantations had a capital base of ZAR 30 billion, an annual turnover of ZAR 12 billion and a positive trade balance of ZAR 2 billion per annum. In respect of its profitability and international competitiveness, the commercial plantations sector is being considered a success in the South African economy (Tewari 2001, 2005).

There is a dichotomy and an inextricable link between the economic success of commercial plantations versus the land and water use. Unsustainable practices in commercial plantations coupled with very little monitoring of agrochemical use have led to negative externalities on ecosystems. Activities of commercial plantations not only diminish the quantity of water with an increase in the reduction in stream flow, which diverts water to be released to downstream users, but also alters the quality of water and food since the runoff from plantations contains agrochemicals residues. Questions have been raised about the impacts of agrochemical on the health of agricultural workers and farmers. An estimate done on 20% of the area of South Africa suggests that about 8.1 millionmm hectares of commercial plantations landscape have been severely degraded and about 22.1 millionmm hectares have been moderately degraded (Whyte 1995)(www.idrc.ca/en/ev-82688-201-1-DO_TOPIC.html). The contention is that there are social costs resulting from landfrom land degradation and water pollution and water withdrawal by commercial plantations that are benefiting from an implicit inputs subsidy from society. There is an agreement that society has to be compensated for environmental damages associated with the use of natural resources, the discharge of effluent, and emissions. (www.fao.org/docrep/).

A catchment's management tax and a stream flow reduction tax to curb water pollution, use, and withdrawal in the commercial plantations sector were imposed (Tewari 2003; Jewitt 2002) as economic incentives to shift farmers away from high-input, unsustainable practices toward low-input practices and less use of water (Whyte 1995). However, the regulation which entailed the Pigovian tax did not specify a method for its calculation. Although this is important for the South African government, there is a paucity of studies carried out on how to fill this gap. Hence, there is a paucity of methods of calculation of the impacts of Pigovian taxes on profitability and international competitiveness of businesses in South Africa. Many countries around the world are imposing water taxes to raise revenue for water management projects, reduce waste, and/or to induce water conservation (Jacobson 2003). This study aims to address the lack of studies that specify methods for calculations of the impact of Pigovian taxes on the competitiveness of businesses.

Using a mathematical programming method, the objective of this study is to model the impact of a regime of potential Pigovian taxes in the commercial plantation sector as an addition to the limited literature. The method of estimation that is used in this study provides a high-level language for the compact representation of large and complex models. This high-level language describes an algebraic problem in terms of generality, and most of the statements are reusable without having to change the algebra when new instances of the same or related problems arise.

Tables 1, 2, 3, and 4 present the salient features of four commercial timber plantations in South Africa. Baynesfield, Kia-ora, and Tanhurst, all located in the driest part of the midlands area, and Kwambonambi located in Zululand, all of which are in the KwaZulu-Natal province of South Africa.

Among commercial plantations, Baynesfield produces less harvestable cumulative mass and this stunted production level is probably due to the weather conditions prevailing in this driest part of the midlands of KwaZulu-Natal province in South Africa. The midlands' adverse semi-arid weather conditions, dry area, low and irregular rainfalls, all limit the water-hungry tree species from growing to their full potential, and even when planted in irrigated areas their growth potential is still stunted. For these reasons, conditions at Baynesfield commercial plantations are not conducive for tree species to grow to their full potential. One clear pattern in Tables 1, 2 and 3 is that the cumulative estimated water (ET) values are higher than water (SFR) values.

Table 1: Timber yields and water withdrawal, Baynesfield, South Africa

Tree age (Yrs)	*Harvest-able cumulative mass (Ton/ha)*	*Cumulative estimated ET (mm)*	*Cumulative estimated SFR (mm)*
1	N.A	1090	58
2	7.6	1752	116
3	11.6	2327	174
4	18.2	2937	232
5	22.2	3559	290
6	34.0	4766	348
7	51.6	5629	406
8	64.9	6694	464
9	72.9	7444	522

Source: Adapted from Water Research Commission Report No. 1133/1/2003.

Table 2: Timber yields and water withdrawal, Kia-Ora, South Africa

Tree age (Yrs)	*Harvest-able cumulative mass (Ton/ha)*	*Cumulative estimated ET (mm)*	*Cumulative estimated SFR (mm)*
1	N.A	1192	51
2	8.8	1851	102
3	22.9	2609	153
4	41.4	3294	204
5	61.7	4135	255
6	64.3	4575	306
7	68.9	5310	357
8	75.6	5926	408
9	83.6	6815	459
10	101.8	7931	510
11	115.4	8882	561

Source: Adapted from Water Research Commission Report No. 1133/1/2003.

Weather conditions prevailing in Kwambonambi commercial plantations in Zululand are mostly semi-tropical with high levels of rainfall, which makes Zululand a water-rich area surrounded by mountain chains, hills, and plateaus adjacent to rivers. The major vegetation type of Zululand is mangrove swamp forests coupled with lakes, rivers, lagoons, and river valleys that connect with the Indian Ocean.

Table 3: Timber yields and water withdrawal, Tanhurst, South Africa

Tree age (Yrs)	*Harvest-able cumu-lative mass (Ton/ha)*	*Cumulative estimated ET (mm)*	*Cumulative estimated SFR (mm)*
1	N.A	843	118
2	16.5	1506	236
3	50.9	1968	354
4	68.1	2875	472
5	73.4	3814	590
6	89.5	5071	708
7	100.9	5801	826
8	125.3	7067	944
9	149.1	7760	1062
10	167.5	8851	1180

Source: Adapted from Water Research Commission Report No. 1133/1/2003.

Mangrove swamp forests are influenced by semi-tropical weather conditions which make the environment a wet upland region. It is this wet upland area that is an environment that is very conducive for tree species to grow to their full potential, making Zululand a richly fertile timber-producing area. Hence, Kwambonambi commercial plantations, presented in Table 4, are expected to withdraw more water (ET, SFR) and produce more harvestable cumulative mass than others.

Table 4: Timber yields and water withdrawal, Kwambonambi, South Africa

Tree age (Yrs)	*Harvest-able cumu-lative mass (Ton/ha)*	*Cumulative estimated ET (mm)*	*Cumulative estimated SFR (mm)*
1	3	993	175
2	39.6	2739	350
3	86.9	3824	525
4	130.4	5085	700
5	154.3	6259	875
6	172.1	6811	1050
7	177.7	7344	1225
8	187.7	8082	1400
9	207.2	9070	1575
10	226.4	10431	1750

Source: Adapted from Water Research Commission Report No. 1133/1/2003.

Indeed, one can see that Kwambonambi commercial plantations are more densely wooded than others. Kwambonambi plantation also has the highest values for both water (ET) and water (SFR) justified probably by the good climatic conditions offered by its location in Zululand.

Each production process yields multiple products (timber), uses some inputs with a fixed market price, and uses miscellaneous resources that are available in fixed quantity, such as labour for harvesting, transportation and loading, water, land and fixed capital, as illustrated in the following Table 5.

Table 5: Costs and prices for Tree Stands, South Africa

Particulars	*Midlands area*	*Zululand area*
Total Fixed Capital (ZAR/ha)	2394.74[1]	2578.83
Labour (Harvesting) (ZAR/ha)	29.13	19.72
Miscellaneous costs including Loading and Transportation (ZAR/ton)	52.59	47.40
Average Price of Timber (ZAR/ton)	180.15	188.43

1. In term of constant 1996 prices (1996=100).
Source: Adapted from Water Research Commission Report No. 1133/1/2003.

II. METHODOLOGY

The study expresses mathematically a “timber model” whose objective function is to maximize net-income earnings of commercial timber plantations subject to miscellaneous endowment constraints involved in timber production – including a given level of Pigovian tax – and solves it by general algebraic modeling system (GAMS). Substantial studies point to linear programming as being a powerful problem-solving tool that aids management in making profit-optimization decisions. GAMS output reports, particularly net-income earnings, yield of timber, and quantity of water used help to identify the break-even levels, which in turn enable this study to do a sensitivity analysis of the impact of potential Pigovian tax dynamics on net-income earnings in the commercial plantations sector.

The “timber model” requires indices to depict the product - timber (P), the production processes (j), the fixed prices of inputs purchased (k), and the resources available in fixed quantity (m) (such as landscape). To this end, three types of variables are defined in this study: (1) X_p denotes the total quantity of the p^{th} product sold (can be referred to as sales forecast or variables of available quantities of outputs), (2) Y_j denotes the quantity of the j^{th} production process utilized (can be referred to as production variables). These production variables show the production explicitly in the matrix, and products are sold through another activity, and (3)

Z_k denotes the amount of the k^{th} input purchased (this study incorporate the potential Pigovian tax among these variables).

The objective is to choose the value of X_p that maximizes commercial plantations' net-income earnings or total profits from timber production subject to miscellaneous constraints. The objective function is an expression of the net-income earnings or total profits of commercial timber plantations. This requires parameters for the sales prices of timber (C_p) and miscellaneous inputs purchased Costs (e_k). That is, total revenue from sales of timber minus total costs as suggested by the equation (1).

Other than non-negativity - number of timber produced cannot be less than zero – as suggested by the equation (5), three additional types of constraints are also specified: (1) the quantity sold of each product (timber) is related to the quantity yielded by production (timber-output) as a supply-demand balance. The demand in the form of sales forecast of P^{th} product (timber) is required to be less than or equal to supply (timber-output), which is the amount of timber yielded (produced) across the alternative production processes. Furthermore, since production and sales forecast are endogenous, this is written as sales forecast minus production (timber-output) and is less than or equal to zero. Implicitly in this constraint, the restriction on the value of Y_j shows that timber produced is expected to not exceed sales forecast (the number that can be sold) as suggested by the equation (2); (2) the quantity of inputs purchased (Z_k) is related to the quantity utilized in the production process ($r_{kj}Y_j$) given by the summing up of the total fixed price of inputs used, and equate it to inputs purchased. In this constraint, inputs purchased are additional factors incorporated into the "timber model". Inputs prices are unit variable costs for the timber producer. The price charged for timber ultimately determines the price of inputs entering timber production processes such as a Pigovian tax. The microeconomics theory of derived demand also conveys that prices of inputs should be determined by their contribution to the market value of timber produced, reflected in its market price as suggested by the equation (3); (3) the classical resource availability constraint to insure that the quantity used of each fixed quantity of input does not exceed the resource endowment (the size of timber commercial plantations should not exceed the landscape). This can be likened to a resource-allocation problem and this study needs to gather (a) the amount available of each resource, and (b) the amount of each resource needed by each production process. Specifically, for each combination of resource and production process, the amount of the resource used per unit of timber production has also to be evaluated, that is (c) the contribution per unit of each production process to the generation of net-income earnings of commercial timber plantations. The specification also requires the definition of parameters for the resource endowment (b_m) and resources used in a specific production process as suggested by the equation (4). The amount of resource used depends on which production process is undertaken, the level of this production process, and how heavily this production process needs to use the resource. The resultant composite "timber model" is suggested by the equations (1), (2), (3), (4), and (5) below.

$$Max \sum_{p=1}^{n} C_p X_p - \sum_{k=1}^{n} e_k Z_k \qquad \text{Equation (1)}$$

S. t.

$$X_p - \sum_{j=1}^{n} Yj \leq 0 \text{ for all } p \qquad \text{Equation (2)}$$

$$\sum_{j=1}^{n} r_{kj} Y_j - Z_k < 0 \text{ for all } k \qquad \text{Equation (3)}$$

$$\sum_{j=1}^{n} S_{mj} Y_j < b_m \text{ for all } m \qquad \text{Equation (4)}$$

$$X_p, Y_j, Z_k \geq 0 \text{ for all } p, j, k \qquad \text{Equation (5)}$$

Studies have suggested that the equations (2) and (3) - first two constraints - can be considered as supply-demand balances, and the equation (4) as the resources endowment (Hillier and Hillier 2006; McCarl 2002).

The required data were compiled with information provided by the Institute for Commercial Forestry Research and the Council of Scientific and Industrial Research as well as the Forestry Economics Services and archived by the Water Research Commission Report No. 1133/1/2003 (Tewari 2003). The entire analysis is in term of constant 1996 prices. The four commercial timber plantations selected handle large and complex data that required many revisions to establish an accurate model. Data as presented in Tables 1, 2, 3 and 4 were nonlinear and so needed to be linearized to provide linear yield response functions.

Modeling often turns to environments where models are constantly changing. With GAMS, revisions are accommodated and changes in model specifications can be made simply and safely. This is helpful since this study makes scenarios by varying the value of the Pigovian tax and so a benchmark model can be used without having to rewrite it again and again. The "timber model" as defined above is essential information, as having the objective function, yield balance, input balance and available resource constraints all defined will allow data to be entered conventionally to the GAMS language. The features of this "timber model" also allow readers to understand all the steps of algorithms since the tasks of model development and model documentation are done simultaneously. Documentation is crucial to the usefulness of mathematical models and it is more useful (and most likely to be accurate) if it is embedded within the model itself rather than written up separately. This makes GAMS' output easy to read and use. The solution report from the GAMS's solver is automatically reformatted so that related equations and variables are grouped together and appropriately labeled.

III. RESULTS

GAMS output reports are presented and discussed here under two sections. Regime of Pigovian tax dynamics on water (ET) and their impact on net-income earnings is discussed in section one using the GAMS outputs reported in Table 6, whereas the regime of Pigovian tax dynamics on water (SFR) is discussed in section two using the GAMS outputs reported in Table 7.

In Table 6, where the regime of Pigovian tax dynamics is on water (ET), break-even points are respectively, ZAR 0.11/m^3 for Baynesfield, ZAR 0.16/ m^3 for Kia-ora, and ZAR 0.27/m^3 for Kwambonambi, and ZAR 0.07/m^3 for Tanhurst.

In the following Table 7, where the regime of Pigovian tax dynamics is on water (SFR), break-even points are respectively, ZAR 1.60/m^3 for Baynesfield, ZAR 1.20/m^3 for Kia-ora, ZAR 1.90/m^3 for Kwambonambi, and ZAR 1.00/m^3 for Tanhurst.

Table 6: Regime of Pigovian tax dynamics, water (ET) value, timber yield, net-income for four commercial timber plantations, South Africa

Commercial plantations	*Pigovian tax (ZAR/ m^3)*	*Timber yield*	*Level of water chosen*	*Net-income level (ZAR)*
Baynesfield	0.00	115.40	88820	8964.08
	0.01	115.40	88820	8075.88
	0.10	115.40	88820	82.08
	0.11	0.00		
	0.00	0.00		
Kia-ora	0.00	167.50	88510	14092.29
	0.01	167.50	88510	13207.19
	0.10	167.50	88510	5241.29
	0.15	167.50	88510	815.79
	0.16	0.00	0.00	0.00
Kwambonambi	0.00	226.40	1.0431 E+5	24885.80
	0.01	226.40	1.0431 E+5	23842.65
	0.18	207.20	90700	6230.60
	0.26	172.10	68110	590.02
	0.27	0.00	0.00	0.00
Tanhurst	0.00	72.90	74440	4780.81
	0.01	72.90	74440	4036.41
	0.06	72.90	74440	314.41
	0.07	0.00	0.00	0.00

Source: Author's computation using GAMS as a solver.

Table 7: Regime of Pigovian tax dynamics, water (SFR) value, timber yield, net-income earnings for four commercial timber plantations, South Africa

Commercial plantations	*Pigovian tax (ZAR/ m^3)*	*Timber yield*	*Level of water chosen*	*Net-income level (ZAR)*
Baynesfield	0.00	115.40	5610	8964.08
	0.01	115.40	5610	8907.98
	1.59	115.40	5610	44.18
	1.60	0.00	0.00	0.00
Kia-ora	0.00	167.50	11800	14092.29
	0.01	167.50	11800	13974.29
	1.19	167.50	11800	50.29
	1.20	0.00	0.00	0.00
Kwambonambi	0.00	226.40	17500	24885.74
	0.01	226.40	17500	24710.75
	0.95	172.10	10500	83323.60
	1.30	154.30	8750	4764.30
	1.70	130.40	7000	1340.00
	1.90	0.00	0.00	0.00
Tanhurst	0.00	72.90	5220	4780.81
	0.01	72.90	5220	4728.61
	0.90	72.90	5220	82.80
	1.00	0.00	0.00	0.00

Source: Author's computation using GAMS as a solver.

IV. DISCUSSION

The results give one apparent pattern: the net-income earnings is at its peak (maximum level) when timber is in a "tax free" production process. The implementation of the regime of Pigovian tax dynamics disproportionately impacts on the timber yield, water use, and net-income earnings of commercial plantations. While the regime of tax dynamics appears not to have significantly dampened the level of some timber yield and water used, all net-income earnings tumbled. As shown by the trend in both Tables 8 and 9, the regime of Pigovian tax dynamics on water (SFR) at which commercial plantations break-even are all above the ZAR 1 mark. The regime of Pigovian tax dynamics on water (ET) at which they break-even are all less than the ZAR 1 mark. Out of all of the commercial plantations, Kwambonambi is generating the highest net-income earnings for both Pigovian tax on water (ET) and (SFR) than the others, especially Baynesfield plantations, which is constrained by its location in the midlands of Kwazulu-Natal that is identified as the driest area of the province and has the lowest level of rainfall. This was expected, as Kwambonambi is favoured by weather conditions at its location in Zululand. These results are in line with other studies. The commercial plantations sector has been regulated since 1970s because of years of complaints by downstream population blaming reduced stream flow on the upstream. In 2002, the water charges ranged from 0.3 cents to 1 cent per cubic meter translating to about ZAR2 to ZAR6 per hectare per year (Jacobs 2003).

The results indicate that some commercial plantations face significant financial risk since subjected to a lump sum Pigovian tax, they might generate losses. The implementation of a Pigovian tax in the commercial plantation sector need to be effectively managed and a differential Pigovian tax has to be explored. Should the South African government wish to pursue environmentally motivated Pigovian taxation as a policy objective, a substantially higher rate of Pigovian tax should be imposed on water (SFR) than on water (ET). This appears to have significant policy implications, particularly with respect to the way in which the viability and international competitiveness of commercial plantations in South Africa would respond to a potential fiscal policy that incorporates a Pigovian tax.

V. CONCLUSION

The reduction of stream flow induced by commercial plantations diverts water that would have been released to downstream users and the quality of this water is compromised since the runoff contains agrochemicals. When compared to business-as-usual forecasts in the commercial timber plantations sector, under ceteris paribus condition, a regime of Pigovian tax dynamics is expected to cause a decrease in the levels of water use as inputs in the production processes become costlier, a decrease in the yields, and net-income earnings will plummet until they become nil. Thus, the commercial plantations sector would minimize the water pollution, greenhouse emission and the uptake of water. That is what governments around the world are striving to achieve. Premised upon the empirical results, Sstakeholders in commercial plantations, for example, in raising trees species and producing timber need to take into account the opportunity cost or the impact of potential Pigovian tax on their net-income earnings. A potential Pigovian tax could have a significant bearing on this sector by reducing the viability for some commercial timber plantations. Differences in break-even levels across commercial plantations uncovered by our empirical analysis provide valuable evidence that a geographical Pigovian tax differential can be implemented and comparatively a higher tax rate could be charged on commercial plantations in Zululand, which are doing better in terms of net-income earnings or profitability than the ones in the midlands. In addition, the differences in break-even levels across commercial plantations can inform institutions involved in policy-making about the levels and/or structure of water uptake by the commercial plantations sector.

VI. RECOMMENDATIONS

Pollution-free environment policies and regulations that South Africa is striving to impose have to take into consideration the competitiveness of the country's businesses. Commercial plantations are facing a challenge to experiment new plantations that use water-efficient species to alter their water use. The implementation of a fiscal policy that incorporates a Pigovian tax will be strongly dependent upon the accuracy of information gathered. Communication among stakeholders will be key, otherwise, uncertainty or imperfect information and knowledge will hinder the entire taxation process and competitiveness in global market. The implementation of a fiscal policy that incorporates a Pigovian tax will be strongly dependent upon the accuracy of information gathered. This study is suggesting a more selective Pigovian taxation system as any additional taxation on any industry or sectorfirms increases their operational cost rendering them less competitive on global market. This strategy has not been suggested in South Africa so far, but a selective Pigovian taxation system would be very useful. In practice, globally, maintaining low costs is becoming harder for businesses, and global competition is on the rise. The government will not be able to control the businesses' sourcing of inputs and operational cost as well as their related individual production conditions and sets a fair Pigovian taxation. There are growing concerns that government eventually will harm the sector with new taxes. Government has to holistically take into account the tradeoffs in curbing water use and the commercial plantations sector development and competitiveness. Future studies can probe the ways and scope in which the required information on businesses' sourcing of inputs, operational cost, and production conditions can be fed into the system and used for pollution-free environment fiscal policies and regulations purposes.

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