Contributed paper submission to the 4th International conference of the African Association of Agricultural Economists (*Commercializing Agriculture in Africa: Social, Economic and Environmental Impacts*).

186- South Africa's economy-wide effects as result of increased total factor productivity (TFP) on the country's agricultural sector: a preliminary investigation

By

Mr. Bonani Nyhodo[1],
Dr. Hans Grinsted Jensen[2], and
Prof. Ron Sandrey[3]

Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, 2013, Hammamet, Tunisia

[1] Is a Senior Researcher of the National Agricultural Marketing Council (South Africa) and a PhD student of the University of Stellenbosch (corresponding author bonani@namc.co.za)
[2] Is a Researcher at the Institute of Food and Resource Economics (University of Copenhagen, Denmark), he also serves as an Associate of Tralac (South Africa) also member of the Board of the GTAP
[3] A Professor Extraordinaire, Dept of Agr Economics, University of Stellenbosch, South Africa, an Adjunct Associate Professor, Agribusiness and Economics Research Unit, Lincoln University, New Zealand

1. Introduction

The world economy is expected to grow moderately over the period to 2025 with South Africa's real GDP growth rate average estimates of 3.5 percent. During the same period South Africa's population growth is anticipated to average 0.5% average annually with total factor productivity (TFP) increases of 0.2% annually. However, Africa as a continent is estimated to grow much faster with some countries experiencing real GDP growth rates of greater than 5 percent, while India and China are expected to continue with their spectacular performances of real GDP growth rates above 6 but both Brazil and Russia are expected to have similar growth rates to South Africa's 3.5 percent forecast (Foure et al 2012). Importantly, both China and India are expected to have annual TFP growth rates over 1.3% on average each year, significantly above the South African 0.2 percent figure. The objective for this paper is to analyse the impacts of South Africa being able to increase its TFP in agriculture to be nearer that of the Chinese overall TFP levels. There is no doubt that productivity has been the driving force in Brazil's spectacular growth in recent years (Sandrey and Vink 2013), while similarly the same has held for Chinese agriculture (Edinger and Sandrey, 2010). To undertake this analysis we use the GTAP AEZ model and examine changes to the agricultural sector only.

This paper extends the GTAP analysis of the economy-wide TFP in South Africa by Sandrey et al (2012) to a more specialist agriculture-only approach using disaggregated land types with an updated GTAP model. It is presented as a preliminary analysis of a more detailed investigation of the impacts of enhanced TFP on the agricultural sector in South Africa. In general, using enhanced TFP from 0.2 to 0.6 percent across all production sectors, Sandrey et al found that, keeping everything else constant, the South African economy increased by an additional four percentage points over the 2007 to 2020 time period, leading to a South Africa's aggregate welfare being around $250 billion higher over this period. Most of this gain was from increased capital as investment flowed into the more efficient South African economy, and the gains were concentrated in the manufacturing sectors partially at the expense of agriculture. This paper concentrates on agriculture with a more agricultural-specific model, and note that we eschew a detailed discussion of the role of TFP in agriculture but rather refer to Sandrey et al for that discussion.

2. Model description, aggregation and policy design - the GTAP-AEZ

The GTAP agro-ecological zone (AEZ) model with its associated database, the GTAP – AEZ database, is outlined here along with the outline of the database aggregations and the policy scenarios used to shock the model. The theoretical foundation of a standard model underpins the GTAP - AEZ model. It is an augmented standard GTAP model where the land account is disaggregated into 18 agro-ecological zones (AEZ) as outlined by Lee et al (2005). Agriculture, unlike other sectors of any economy, uses land as primary factor of production more extensively (Hertel, 1997). The GTAP – AEZ is a valuable development within the GTAP framework, and it is documented in Lee et al (2005) and Baldos et al (2012).

The land disaggregation followed the geographical classification of land upon their natural characteristics. Agro-ecological zoning as described in Lee et al (2005) categorises land according to the agro-ecological features such as soil types, temperature regimes, land form and moisture content. This methodology depended on the two major databases and their design developed by the Food and Agriculture Organisation (FAO) and International Institute of Applied System Analysis (AIASA) at Purdue University (FAO, 2000 and Fischer *et al,* 2002). The GTAP AEZ model main interest as outlined in Lee et al (2005) tended to be more on the length of growing period[4] that leads to the concept of attainable crop productivity. The length of a growing period (LGP) is divided into six classifications of about 60 days each that is considered along the humidity gradients with the world divided into three climatic zones: tropical, temperate and boreal. These LGPs are calculated as the number of days with enough temperature and precipitation/soil moisture for crops to grow. To come up with the GTAP customised AEZ (18 in total) for this paper a process of overlapping the six LGP with three climatic zones was done.

The total size of an agro-ecological zone is fixed, meaning land is not mobile between different AEZs. An elaboration of how this assumption does not run against the anticipated shifts in AEZs as a function of changing climate is presented in Lee et al (2005). Land within an AEZ is mobile between land uses. This means within AEA1 land can be shifted from wheat production into soybean production or animal production. Relative returns determine land determines land cover as sectors with the highest returns will crowd-out those with lower returns. The AEZ database resembles the standard GTAP database version 8 in that it has 129 regions/countries (an increase from 113 in GTAP database version 7) with 57 tradable commodities (the same as with the earlier version). The 129 regions are mapped or aggregated into **23 regions.** Important to note is that 11 of the regions are African regions with the BRIC countries mapped as individual regions and other regions (actual mapping or aggregation is presented in APPENDIX A). The 57 tradable commodities are mapped into **33 tradable commodities** off-which 12 of these are agricultural commodities with forestry and fishing mapped individually. All other agriculture related products such as textile and leather were mapped individually with manufacturing mapped into light and heavy manufacturing (APPENDIX B present mapping of the tradable commodities).This study simulations and modifications to get the right policy shocks followed a sequence as presented in APPENDIX C.

[4] The length of growing period is defined as the time (in days) of the year where the temperatures (normally above 5 degrees Celsius) and soil moisture content are good for crop growth.

In order to present a clear picture of the effects of enhanced TFP, the tables in the analysis show results of (a) a Base run where 'business as usual' is modelled and then (b) a scenario whereby agricultural TFP is increased from the base run or 0.2 percent to 0.6 percent. No attempt is made to discuss how this TFP may be raised; only that it has been in order to assess the results should it be raised to levels closer to those from both Brazil and China in recent years. To examine changes brought about by increasing TFP results from that scenario are compared to the values (results) of the base scenario by subtracting the values of the base scenario from the enhanced TFP scenarios.

At this juncture, it is important to provide brief descriptions of each of the three scenarios.

Policy scenario one (base scenario): This scenario was run by projecting the world economy based on the IMF forecasts, Foure et al (2012) and own assumption (on a number of macroeconomic variables) from 2007 to 2025 (18 years). The specific macroeconomic variables that were shocked (determined exogenously) to the model are real GDP growth rates, population growths, labour force growths (skilled and unskilled labour growths) and natural resources. The shock to the model of the exogenous variables allowed the model to calculate the required capital accumulation (investment) and TFP growth rate (required to generate the forecasted growth rates). The aim of all this was to get the TFP growth rates required and having calculated them, then a swap between the real GDP growth and TFP was made in the modelling procedure allowing the model to determine the real GDP while using the TFP growths to shock the model (population growths, labour growths together with natural resources were kept as exogenous). The model then calculated the required real GDP growth rates and capital required within the model.

- **Policy scenario two:** This simulations runs on the same database as the base scenario (allowing for direct comparison of the results) with only one modification. All the TFP values calculated under the base scenario for other regions (except South Africa) were not changed, meaning these regions are allowed to have their TFP growths as originally simulated, and this includes keeping South Africa TFP for non agricultural products unchanged as well. Then the only change is that TFP values for South African agricultural products (inclusive of forestry and fishing) were simulated to increase to 0.6% (from the 0.2% at the base scenario) annually on average over the whole period.

The aim of the second scenario is to pick up changes to the South African economy to be attributed to changes in agricultural total factor productivity. The results are analysed as annually average changes over the period of 18 years from 2007 to 2025.

3. Model results and analysis

Foure et al (2012) use IMF macroeconomic projections where they project the performance of the world economy up to 2025 with a number of their own assumptions. South Africa's real gross domestic product (GDP) growth over the period from to 2025 is projected to averaged 3.5 % each year. This is low compared to other African regions where projected real GDP growths are bigger than 4% with only SACU expected to grow much slower than even South Africa. Importantly, Zambia, ECOWAS and SADC are projected to grow at 7.5%, 6.6% and 5.7% respectively. Within the context of BRICS, South Africa's projected growth is slightly lower than that of Brazil while higher than that of Russian with China and

India performing exceptional well (with growth higher than 6%). The developed economies (not shown in Table2) of the Europe and North America are expected to see moderate growths of around 2% per annum on average over this period (see Table 1).

The real GDP projections for Africa are promising, but a closer look at the labour growth projections is warranted. South Africa's projected growth of skilled and unskilled labour per year over the period under review is modest: on average South Africa's skilled and unskilled labour are anticipated to increase by 1.94% and 1.01% annually respectively. Note that Skilled labour growths are much higher while unskilled labour growths, as this gives an indication that the projected growths will not be as a result of primary sector growths – they will come from secondary and tertiary sectors that do not have high labour intensity. Africa is expected to see much higher population's growth rates, although note that South Africa has a low growth rate. Of interest for a BRIC-related study is that population growth in Russia is negative, China's is lower than even South Africa's. South Africa's capital growth (determined within the model) is impressive at 4.76% on average per year over this period, providing a good picture of a country with a thriving manufacturing sector that attracts investment. As discussed, South Africa's TFP is anticipated to increase by 3.6% over the 18 year period meaning a 0.2% average annual growth rate, but note especially from the right hand column that our scenario of increasing South African TFP to 0.6 percent is not unrealistic when viewed against many other countries.

Table 1: Macroeconomic projections as average annual growth rates, 2007–2025 (policy scenario one)[5]

	Real GDP	**Unsklab**	**Sklab**	**Population**	**Capital**	**NatRes**	**TFP**
South Africa	3.5	1.01	1.94	0.50	4.76	1.08	0.20
Botswana	4.0	1.30	3.36	0.90	4.36	1.08	0.50
South Africa	4.1	1.05	3.41	1.30	4.79	1.08	0.30
SACU[6]	2.1	1.58	5.22	1.00	2.39	1.08	0.00
Kenya	5.4	2.74	6.09	2.60	6.99	1.08	0.40
Egypt	5.5	1.59	6.30	1.50	6.08	1.08	0.50
Mauritius	4.3	0.33	2.01	0.40	5.89	1.08	0.60
Zambia	7.5	3.10	4.29	3.10	9.26	1.08	1.10
ECOWAS	6.6	2.70	5.30	2.50	9.49	1.08	1.00
SADC	5.8	3.03	5.78	2.70	5.93	1.08	0.90
Sub-Saharan Africa	4.4	2.94	5.66	2.40	3.81	1.08	0.60
North Africa	4.3	0.85	4.91	1.00	4.99	1.08	0.50
Brazil	3.9	0.75	3.76	0.70	5.14	1.08	0.40
Russia	3.3	-1.35	0.04	-0.20	3.27	1.08	0.90
India	6.8	1.58	4.78	1.20	7.06	1.08	1.30
China	8.7	-0.05	3.48	0.30	7.71	1.08	1.60

Source: Foure et al (2012), GTAP results and own assumptions.

Table 1 showed that South Africa's annual real GDP of 3.5% is projected. This expected growth rate is equally matched by 3.6% increase in incomes at constant prices, as shown in

[5] Capital and TFP are the results determined within the model while the rest were determined outside the model.
[6] SACU in this study only includes Lesotho and Swaziland as all other members are included in this study as separate regions.

Table 2 where prices are anticipated to decrease by almost 1.3% under the base scenario. Under the policy scenario two (enhanced TFP in agriculture only) income levels will increase by a similar 2.4% while prices will experience a decline of the same 1.3%.

Table 2: South Africa's yearly changes in income and prices (% changes Base and TFP scenario)

	Income	**Prices**	**Income constant prices**
Policy scenario one (Base)	2.3	-1.3	3.6
Scenario two (TFP increase)	2.4	-1.3	3.8

Source: GTAP output and own calculation

A closer look at South Africa's welfare changes (the average changes in income) on annual basis is presented in Table 3. As this presents as picture of a uniform increase expressed in the average growth rates used, it may not depict a realistic picture given changes in South Africa's growth rate over time as the model used is a static model. The results show that at the end of the 18 year period under policy scenario two, South Africa's income is expected to experience a US$12.2 billion increase over the Base run outcome.

Table 3: South Africa's annual changes in income with constant prices over the period ending in 2025, expressed in millions of US dollars

	Total income over the period		**Changes in total income per year**		**Difference**
	Base	**TFP increase**	**Base**	**TFP increase**	**Base-TFP**
2007	248,051	248,051			
2008	257,010	257,377	8,960	9,326	366
2009	266,293	267,053	9,283	9,677	393
2010	275,912	277,094	9,618	10,040	422
2011	285,878	287,512	9,966	10,418	452
2012	296,204	298,321	10,326	10,810	484
2013	306,903	309,537	10,699	11,216	517
2014	317,988	321,175	11,085	11,638	552
2015	329,473	333,250	11,486	12,075	590
2016	341,374	345,779	11,901	12,529	629
2017	353,704	358,780	12,330	13,000	670
2018	366,480	372,269	12,776	13,489	713
2019	379,717	386,265	13,237	13,996	759
2020	393,433	400,788	13,715	14,522	807
2021	407,643	415,856	14,211	15,068	858
2022	422,367	431,491	14,724	15,635	911
2023	437,623	447,714	15,256	16,223	967
2024	453,430	464,547	15,807	16,833	1,026
2025	469,808	482,012	16,378	17,466	1,088
			221,757	**233,961**	**12,204**

Source: GTAP output and own calculation

3.1 Policy effect of scenario two on macroeconomic in South Africa

In South Africa unemployment is one of the biggest challenges facing the current government. Before the economic recession began is 2007, South Africa had experienced one of its longest period of high economic growth. This justifies a look at the impact of the TFP policy simulation on the country's economic growth rates – real GDP. Even though is it important to look at real GDP growths as an indication of the vibrancy of an economy the argument has always been most of South Africa's growth has not generated the much needed jobs (jobless growth). In this regard, the anticipated real GDP growth on top of the baseline growth of real GDP growth rate is expected to average 3.65% (policy scenario two). This

means a 0.14% average yearly increase under policy scenario two over and above the expected 'business as usual' baseline. (See Table 4 for details).

Increases in average growth rate of South Africa's unskilled and skilled labour of expected at 1.05% and 1.99% from the TFP scenario, and this is 0.04% for unskilled labour and 0.05% for skilled labour higher than the Base growths respectively. These annual growths in both skilled and unskilled labour are too small for a country where the current level of unemployment at around 24% is expected to only reduce by one percentage point over this period with enhanced TFP. Under policy scenario two increases in capital growth are more significant; 4.93% from a base value of 4.76%. Therefore, the simulated annual TFP increases[7] of 0.6% will not have meaningful impact on unemployment. This gives a clear indication that increasing agricultural total factor productivity is only a partial answer to the country's unemployment challenge.

Table 4: Changes in selected macroeconomic variables as average yearly growths, 2007–2025

	Base	**TFP**	**Policy 2-1**
Real GDP	3.5	3.64	0.14
Unskilled labour	1.01	1.05	0.04
Skilled labour	1.94	1.99	0.05
Capital	4.76	4.93	0.17
Natural Resources	1.08	1.08	0

Source: GTAP output

3.2 Impact on Equivalent Variation (EV)

The welfare measure used in the study is the equivalent variations (EV) for each region, expressed in millions of US dollars. This means the results can be interpreted as the change in regional incomes at constant prices induced by the proposed policy change as shown in Table 5 for the EV of the countries / regions of African and the BRIC countries as represented at 2025. South Africa is expected to experience a US$12.2 billion (5.50%) increase under policy scenario two at 2025 (cumulatively). Changes in EV from the base scenario to the TFP increase provide a picture where South Africa's increases of EV are much bigger than any other regions, but of course the only change from the base scenario is that of TFP in South African agriculture. In Africa a number of regions will experience reduced welfare incomes and these include a significant decline in SACU and smaller ones in Kenya and Egypt. Most BRIC countries are expected to experience minimal changes, although note that India is expected to see increased EV resulting from a more efficient South African economy suggesting a complementary relationship.

[7] These simulated increases in TFP for South Africa only cover agriculture, forestry and fishing products excluding other products (keeping them at 0.2%)

Table 5: Effect of the TFP scenario on equivalent evaluations – 2025 (*US$ billions*)

EV	Base	TFP	Increase from TFP
South Africa	***221,757***	***233,961***	5.50%
Botswana	12,078	12,097	0.16%
Namibia	8,393	8,406	0.15%
SACU	2,076	2,054	-1.06%
Kenya	42,164	42,130	-0.08%
Egypt	177,720	177,686	-0.02%
Mauritius	7,667	7,681	0.18%
Zambia	26,353	26,403	0.19%
ECOWAS	573,403	574,062	0.11%
SADC	51,368	51,671	0.59%
Sub-Saharan Africa	231,964	232,312	0.15%
North Africa	319,210	319,225	0.00%
Brazil	1,265,054	1,264,888	-0.01%
Russia	1,066,850	1,066,756	-0.01%
India	2,535,430	2,535,627	0.01%
China	11,424,973	11,424,783	0.00%
United States of America	7,732,530	7,730,474	-0.03%
European Union – 27	3,922,061	3,921,477	-0.01%
Latin America	1,475,903	1,475,777	-0.01%
North America	1,169,183	1,168,816	-0.03%
Oceania	673,023	672,825	-0.03%
Asia	3,993,101	3,993,020	0.00%
Rest of world	2,814,549	2,814,853	0.01%

Source: GTAP output

The regional welfare changes (presented in Table 5) form an important part of general equilibrium analysis, however, further details regarding the real reasons for the increased EV are equally important. The decomposition of the EV is possible within the GTAP modelling framework. In this study the EV decomposition for South Africa is outlined in five components as presented in Table 7; namely factor endowment, allocative efficiency, TFP change, other effects, and terms of trade. South Africa's increase in EV are primarily driven by factor endowment while allocative efficiency and TFP change are contributing significantly and terms of trade and other effects modestly. The allocative efficiency presents the welfare effects due to reallocation of already available resources.

Under policy scenario two South Africa's welfare increase of US$12.2 billion have been reported. About US$6.3 billion will be accounted for due to factor endowment, US$2.5 billion accounted by technical change effect (tfp), US$2.3 billion as a result of allocative efficiency with the remainder accounted for by terms of trade effects and other effects (Table 6). The largest increase in percentage terms is from the terms of trade effect (9.74%), while the TFP contribution is 7.55 percent from the base scenario.

Table 6: South Africa's EV welfare decomposition (at 2025)

	Base	**TFP**	**Change $**	**Change %**
Allocative efficiency effects	41 224	43 588	2 363	5.73%
Endowment effects	109 919	116 208	6 289	5.72%
Technical change effect (TFP)	33 384	35 903	2 520	7.55%
Terms of Trade effect	6 640	7 287	647	9.74%
Other effects	30 588	30 972	384	1.26%
Total	***221,757***	***233,961***	***12,204***	**5.50%**

Source: GTAP output

3.3 Impact of the policy changes on yields and area harvested of crops in South Africa

Engaging in the ongoing discussion about whether or not will the world natural resources be able to feed a world population that is estimated to reach 9 billion people in 2050 Vink (2012) argues that agricultural output can increase in four ways; namely expansion of area, the relocation effect, crop pattern effects and crop intensification. He further argues using a table from Bruinsma (2009) that over the period from 1961-2005 that 31% of increase in Sub-Saharan Africa's crop production was accounted by land expansion while 38% percent increase is attributed to improvements in yields with the remainder accounted for by crop intensity. Taking the issue of yield further Cramon-Taubadel et al (2009) show that from 1975-2007, annual world total factor productivity increase on agriculture was 1.7% with Sub-Saharan Africa's total factor productivity of 0.9% (Latin America and the rest of Asian countries experienced increases of 1% and 1.4% with China at 2.1%). In this study the simulated changes in yields are higher than these other studies. This is attributed to the simulated higher increases in total factor productivities as the only agricultural variable to account for the increase. This is caused in part by a limitation of this study that there was no simulated expansion of agricultural land, as we are arbitrarily forcing the model to increase factor productivity.

Overall crop production in South Africa can increase in only two ways. These are by (1) increases in yield and (2) changes in harvested area among the different crops on a total fixed land area. The simulation results are presented in Table 8, with changes in yields on the left hand side and changes in harvest area on the right hand side. South Africa's **crop yields** under the base scenario are expected to increase annually over the period of 18 years by amounts ranging from 2.9% for wheat to 3.1% for plant based fibre from their initial values of 1905 thousand tons and 29 thousand tons respectively. With an increase in TFP to 0.6 further increases of 0.5% percent yields in all cases are expected on top of their base scenarios figures.

On the **area harvested** side under the base scenario South Africa's decline of 357 hectares will be reduced to 332 thousand hectares with increased total factor productivity (to 0.6%) annually[8]. An outline of which of the crops will gain and lose land area is outlined in Table 7.

[8] Both forest and pasture land under the base scenario were experiencing increases in the area harvested, however with increased total factor productivity both lose land area (even though the loss is minimal).

Some products are expected to gain (area harvested increases) while other are expected to lose as returns to land determines the winners and losers in the substitution effects. For example, wheat production increases come from both yield increases and an increase of the wheat producing area as the area harvested will increase from 632 thousand hectares in the base case to 657 thousand hectares with increased TFP across the agricultural sector. With enhanced TFP the wheat area is anticipated to increase by 25 thousand hectares on top of the base scenario land areas. Conversely, products that are simulated to lose area are other cereals, oil seeds and sugar cane & beet, thus any increase in production will have to come from yield increases. Note however that simulated increases to plant based fibre are from a very low base of only 29 thousand tons produced on 11 thousand hectares (see Table 7).

Table 7: Changes in South Africa's crop yields (%) and area harvested (area - ha)

	Yields			**Area harvested**		
	Base production in 000 tons	**TFP**	**Policy 2-1**	**Base harvested area 000 ha**	**TFP 0.6 Area 000 ha**	**Change in land allocation**
Wheat	1,905	2.9	0.5	632.0	657.0	25.0
Other cereal grains	7,598	2.8	0.5	2,770.7	2,511.4	-259.3
Veg, fruits and nuts	9,625	2.9	0.5	499.0	442.8	-56.2
Oil seeds	573	2.9	0.5	546.2	586.9	40.7
Sugar cane and beet	19,724	3.0	0.5	323.0	285.4	-37.6
Plant based fiber	29	3.1	0.5	11.0	15.3	4.3
Crop nes	21,472	2.9	0.5	1,422.2	1,348.1	-74.1
Total crop land				6,204.2	5,846.7	-357.4
Pasture land						245.1
Forest						112.3
Total area						0.0

Source: GTAP output

It needs to be pointed out that under the model specification the productive land size was kept unchanged (or there is no simulated land expansion accompanying increased total factor productivity). Therefore there is a substitution of land away from cropland even though with increased total factor productivity the rate of land taken from crop land declines. This of course does not reconcile with the 'real world' picture as outlined by Vink above whereby there also an area expansion in Africa. This clearly shows that there needs to be more work undertaken on modelling land expansion as well as crop yields in an updated new GTAP baseline.

3.4 Impact on quantity of production at market prices (in 2007 prices)

After examining South Africa's production increase induced by both yield and area harvested we now turn to the value of output at market prices in real 2007 prices and expressed in US dollars where the production value and output taxes are added together. In short this means that the monetary value of South Africa's output expressed in 2007 prices at 2025 or annually (the percentage changes are yearly growth rates in values from 2007 to 2025). Under the base scenario most of primary agricultural product values are anticipated to increase through to 2025 by more than 2% on average each year. The biggest increases are plant based fibre and

wool which are expected to increase by 5.1% from US$1,090 and 4.7% from US$1,030 respectively, while the lowest is from forestry at 1.0% (Table 8).

Simulating an increase in TFP for the agricultural, forestry and fisheries sectors we find a further increase in all sectors ranging from 0.2 percent from sugar crops (not processed sugar) to 1.1 percent in plant-based fibre production (albeit from a low base as discussed above). Not shown are the increases in the other sectors of the economy, but suffice to say that it was initially expected that increase in production would be larger in agricultural products (both primary and unprocessed), and this is indeed the case. However, with increased TFP in agriculture there are also increased investments leading to increases in sectors like light manufacturing flowing through from the demand for agricultural machinery. Secondly increase in factor incomes also leads to increased demand for other goods outside of the agricultural sector.

Table 8: Changes in the value of output for South Africa, US dollars expressed in 2007 prices (%)

	Initial VOM (2007 prices)	**Base increase (%)**	**Difference Base to TFP (%)**
Wheat	13	3.1	0.7
Cereal Grains	743	2.3	0.2
Vegetables, Fruits and Nuts	2,160	2.2	0.6
Oil Seeds	5,347	3.3	0.5
Sugar Cane and Sugar Beet	339	2.3	0.2
Plant-Based Fiber	1,090	5.1	1.1
Crop Nec	136	2.6	1.0
Bovine Cattle, Sheep, Goats and Horse	375	2.5	0.4
Animal Product Nec	1143	2.9	0.5
Raw Milk	2,064	2.6	0.3
Wool, Silk-Worm Cocoons	1,030	4.7	0.7
Forestry	543	1.0	0.5
Fishing	2,586	2.1	0.7

Source: GTAP output

3.5 Effects on South Africa's aggregate quantities of exports and imports at market prices

As discussed, overall production in South Africa is expected to increase as the TFP changes to the agricultural sector result in more demand for non agricultural products. Presented in Table 9 are the anticipated changes in the value of aggregate exports and imports expressed in world market prices expressed in real 2007 prices. Under the base scenario the value of South Africa's aggregate exports are all expected to increase through time in real terms. For example, it is expected that the export value of wheat will increase by 7.4% on average over this period, and this will increase by a further 2% above the base line with enhanced TFP. The value of aggregate imports changes from the initial values are very minimal compared to those of exports, meaning that a desirable degree on import substitution is taking place in the more efficient agricultural sector in particular. Again looking at wheat, the expected increase in the value of annual aggregate imports under the base scenario of 0.7% is expected to decline marginally. In the agricultural sectors only the vegetables- fruit group, processed rice and beverages and tobacco sectors are expected to see marginal increases in imports relative to what they would have been under the base scenario. Conversely, many of the non-agricultural sectors witness a marginal increase in import value as substitution effects take place in the overall economy.

Table 9: Annual changes in the value of tradable (exports and imports at world prices of 2007) products of South Africa (%)

	South Africa's value of exports			**South Africa's value of imports**		
	Value of world exports (at world prices)	Base	TFP increase	Value of world imports (at world prices)	Base	TFP increase
Wheat	34.42	7.4	2.0	383	0.7	-1.0
Cereal Grains	135.58	4.5	1.0	248	0.6	-0.4
Vegetables, Fruits and Nuts	2037.07	3.1	1.2	178	2.6	0.1
Oil Seeds	16.82	4.9	1.9	80	2.9	-0.2
Sugar Cane and Sugar Beet	5.88	5.4	3.1	0.2	0.6	-1.2
Plant-Based Fiber	63.83	6.4	1.4	94	1.2	-0.1
Crop Nec	198.47	3.2	1.3	315	2.0	-0.1
Cattle, Sheep, Goats and Horse	24.37	8.1	2.1	119	2.9	-0.7
Animal Product Nec	164.42	5.2	1.4	91	1.2	-0.4
Raw Milk	1.82	13.2	6.8	2	0.9	-2.7
Wool, Silk-Worm Cocoons	169.45	8.1	1.2	8	2.6	-0.2
Bovine Cattle, sheep and goat meat products	55.16	6.5	1.0	254	0.0	-0.2
Meat products	134.07	5.4	1.6	319	1.3	-0.7
Vegetable Oils and Fats	135.9	5.7	0.4	956	1.0	-0.1
Dairy Products	148.41	6.0	0.5	173	0.5	-0.3
Processed Rice	21.51	2.9	0.0	296	1.5	0.1
Sugar	460.27	8.2	0.5	208	0.1	-0.1
Food Product Nec	1478.19	3.4	0.2	1032	1.9	0.0
Beverages and Tobacco	1249.01	3.0	0.1	512	2.1	0.1
Textile	673.01	1.9	-0.2	1841	3.0	0.2
Wearing Apparel	468.51	1.4	-0.2	1050	4.0	0.3
Leather Products	327.67	4.6	-0.1	858	2.3	0.2
Wood Products	74.08	-2.3	1.7	968	5.5	-0.4
Paper Products, Publishing	1540.84	0.0	0.4	1440	4.6	-0.1
Forestry	74.08	4.2	2.7	31	4.5	-1.4
Fishing	125.06	1.6	1.0	20	2.4	-0.4
Coal, Oil, gas and other minerals.	11158.72	1.2	-0.1	11502.5	2.7	0.1
LightMnfc	16430.46	2.1	-0.1	14402	3.2	0.1
HeavyMnfc	36237.42	2.5	-0.1	40843	4.3	0.2
Util_Cons	475.74	3.2	-0.1	1145	3.5	0.2
TransComm	5344.98	3.1	-0.1	7034	2.9	0.2
OthServices	5541.81	2.7	-0.2	3142	3.3	0.2

Source: GTAP output

4. Conclusion

The objective for this study was to test whether or not increase total factor productivity for South Africa's agriculture from an annual average increase of 0.2% to 0.-6% will affect the economy, and if it does will these effects be positive or negative. The results indicate that the

whole economy stands to benefit as the incomes will increase from increases to factor endowment, allocative efficiency, increase technical change, and other effects. The continued dominance of the share of output by livestock in the agricultural sector continues through the relative share of pasture land in South Africa. The area harvested will shift between agricultural commodities as relative returns result in substitution for the fixed land supply, with wheat in particular expected to gain[9]. The value of output in South Africa is expected to increase even for non agricultural products as a more efficient agricultural sector drives a wider expansion. The value of aggregate exports in South Africa as a result of the policy changes is expected to increase while the value of aggregate imports is expected to decrease. South Africa position in terms of self sufficiency expected to improve considerably, and even for traditionally import-augmented products such as wheat. The paper indicates that increase total factor productivity in South Africa's agriculture will have positive but minimal changes to the whole economy but profound positive changes to the agricultural sector.

[9] The results discussed in the paper are perhaps potentially estimated, as we have curtailed any production increases from previously poorer marginal land by prohibiting an expansion to the land area.

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APPENDIX A: REGIONAL AGGREGATION

Code	Regional description	Countries in the aggregation
ZAF	South Africa	South Africa
BWA	Botswana	Botswana
NAM	Namibia	Namibia
SACU	SACU	Rest of SACU
KEN	Kenya	Kenya
EGY	Egypt	Egypt
MUS	Mauritius	Mauritius
ZMB	Zambia	Zambia
ECOWAS	ECOWAS	Cameroon, Cote d'Ivoire, Ghana, Nigeria, Senegal and Rest of West Africa.
SADC	SADC	Malawi, Mozambique, Tanzania and Zimbabwe.
SSA	SSA	Central Africa, South Central Africa, Madagascar, Uganda and Rest of Eastern Africa.
NAFRICA	NAfrica	Morocco, Tunisia and Rest of North Africa
BRA	Brazil	Brazil
RUS	Russia	Russia
IND	India	India
CHN	China	China
USA	United States	United States of America
EU-27	European Union-27	Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Bulgaria and Romania.
LATINAMER	LatinAmer	Argentina, Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Rest of South America, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Rest of Central America, Caribbean
NAMERICA	NAmerica	Canada, Mexico and Rest of North America
OCEANIA	Oceania	Australia, New Zealand and Rest of Oceania
ASIA	Asia	Hong Kong, Japan, Korea, Mongolia, Taiwan, Rest of East Asia, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Philippines, Singapore, Thailand, Vietnam, Rest of Southeast Asia, Bangladesh, Nepal, Pakistan, Sri Lanka, and Rest of South Asia.
RESTOFWORLD	Rest of the World	Switzerland, Norway, Rest of EFTA, Albania, Belarus, Croatia, Ukraine, Rest of Eastern Europe, Rest of Europe, Kazakhstan, Kyrgyzstan, Rest of Former Soviet Union, Armenia, Azerbaijan, Georgia, Bahrain, Iran, Israel, Kuwait, Oman, Qatar, Saudi Arabia, Turkey and United Arab Emirates.

APPENDIX B: COMMODITY AGGREGATION

Code	Regional description
Pdr	Paddy Rice
Wht	Wheat
Gro	Cereal Grains
v_f	Vegetables, Fruits and Nuts
Osd	Oil Seeds
c_b	Sugar Cane and Sugar Beet
Pfb	Plant-Based Fiber
Orc	Crop Nec
Ctl	Bovine Cattle, Sheep, Goats and Horse
Oap	Animal Product Nec
Rmk	Raw Milk
Wol	Wool, Silk-Worm Cocoons
Frs	Forestry
Fsh	Fishing
Extractions	Coal, Oil, gas and other minerals.
Cmt	Bovine Cattle, sheep and goat meat products
Omt	Meat products
Vol	Vegetable Oils and Fats
Mil	Dairy Products
Pcr	Processed Rice
Sgr	Sugar
Ofd	Food Product Nec
b_t	Beverages and Tobacco
Tex	Textile
TexWapp	Wearing Apparel
Lea	Leather Products
Lum	Wood Products
Ppp	Paper Products, Publishing
LightMnfc	Manufactures Nec; Transport Equipment Nec; Motor and Vehicle Parts and Metal Products.
HeavyMnfc	Petroleum, coal products; chemical, rubber, plastic products; Mineral Product Nec; Ferrous Metals, Metals Nec; Electronic equipment and Machinery, equipment.
Util_Cons	Electricity, gas manufacture and distribution, water and construction.
TransComm	Trade, Transport Nec, Water Transport, Air Transport and Communication.
OthServices	Financial Service Nec, Insurance, Business Service Nec, Recreational and Other Service Nec, Public Admin. And Defence, Education, health, ownership of dwellings

APPENDIX C: POLICY EXPERIMENTS USED IN THIS STUDY

This appendix presents in a Table format the outline of policy shocks as described in the body of this paper.

Policy Scenario	Policy shock	Variables
Base	Shock the model with the TFP values from the results of the first shock (for all regions).	- Exogenous: TFP - Endogenous: Capital - Endogenous: GDP - Exogenous: Natural resources - Exogenous: Labour
TFP	TFP for other regions not changed and only increase South Africa's agriculture, forestry and fishing TFP (to 0.6%) and for other product kept at original level.	- Exogenous: TFP - Endogenous: Capital - Endogenous: GDP - Exogenous: Natural resources - Exogenous: Labour