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South African Agricultural Productivity in the Global Context

Comparisons using FAO Data

Channing Arndt and Alejandro Nin Pratt

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Towards Inclusive Economic Development in Southern Africa

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ABSTRACT

This paper seeks to address the following questions: (a) How productive is South Africa's agricultural sector? (b) How does it compare to other countries in terms of productivity? The approach taken uses neoclassical growth accounting in defining total factor productivity (TFP) growth as the ratio of output and input growth. There are three distinctive periods in the performance of South Africa's agricultural sector. The first period, from 1961 to 1980-1981, is one of sustained growth in output driven by growth in input. TFP remains stagnant during this period. The second period, between 1981 and 1994 is characterized by a decreased trend in the use of inputs and by a large drop in output in 1982 followed by a period of output growth and recovery. In 1991, and after almost ten years of growth, however, output was only reaching its 1981 level. During this period, output growth and recovery is driven by TFP. The last period, starting in 1995–1996 is one of accelerated growth in output and TFP and the end of decline in aggregated input, which reverts the trend of the previous two decades and started a period of growth. Relative to other countries, growth in TFP was rapid in South Africa from 1995–2004 (3.4 percent, which was fastest of all comparator countries). After 2005, it has been relatively slow (1.5 percent) compared to other countries and compared to the previous period. Relative to the global production possibilities frontier (PPF), South African agriculture has been approaching the global PPF. Efficiency, as measured by proximity to the global PPF, improved from 0.66 from 1981 to 1994 to 0.81 in 1995-2004 and to 0.88 in 2005-2014. Overall, South African agriculture is reasonably productive in terms of TFP and has been approaching the global PPF. However, productivity growth slowed in the most recent period, 2005-2014, pointing to a need for efforts to identify the sources of the slowdown and address them.

1 INTRODUCTION

Average large-scale farms in South Africa are characteristically very large, even by international standards. While farm sizes are on average below 20 ha in Europe, below 100 ha in Latin American countries such as Brazil or Chile, and less than 5 ha in the Sub-Saharan African region, they are almost 2 500 ha in South Africa's commercial sector (Cochet et al., 2015; Fanzo, 2017). These large farms, which have consolidated into about 29,000 farming units in recent years, exist alongside high levels of poverty and land hunger among two million smallholders, a heterogeneous category in itself (Aliber et al., 2006; Binswanger-Mkhize, 2014; Cherry, 2014; Cochet et al., 2015). This paper seeks to address the following questions: (a) How productive is South Africa's agricultural sector? (b) How does it compare to other countries in terms of productivity?

2 CONCEPTUAL FRAMEWORK AND APPROACH

The approach taken here uses neoclassical growth accounting in defining total factor productivity (TFP) growth as the ratio of output and input growth. Within this neo-classical framework, which also disentangles technical change along the technological frontier from changes in technical efficiency, the Cobb-Douglas functional form with constant returns to scale representing potential output as the product of an input index and available technology *T* is imposed:

$$y_i = E_i \times \left[T_i \prod x_{ij}^{\alpha_j}\right] \text{ where } TFP_i = E_i \times T_i \qquad (1)$$

where y is output of country *i*, E is technical efficiency, T is the level of technology, and X= $\prod x_{ij}^{\alpha_j}$ is total aggregated input calculated as the weighted product of inputs used where α_j is the weight used to aggregate input j. Unlike neoclassical growth accounting, the present model deals exclusively with the best practice technology, not the average practice technology. In other words, the Cobb-Douglas production function is a frontier production function where TFP is decomposed into efficiency and available technology levels. Using a growth accounting approach (dropping the country index) we can express the output growth decomposition between periods 0 and 1 as:

$$\frac{y_1}{y_0} = \frac{E_1}{E_0} \times \frac{\bar{T}_1}{T_0} \times \prod \left(\frac{x_{j1}}{x_{j0}}\right)^{\alpha_j} \qquad (2)$$

This specification allows for two determinants of TFP differences: country-specific levels of efficiency and country-specific levels of available technology. The TFP of a multiple-output multiple-input production unit is defined as the ratio of an aggregate output to an aggregate input. For the case of a production unit ***i*** using input vector x_i=(x_{1i},…,x_{Ni}) to produce output q_i=(q_{1i},…q_{Mi}), TFP is defined as:

$$TFP_i \equiv \frac{Q_i}{X_i} \qquad (3)$$

where $Q_i=Q(q_i)$ is aggregate output, $X_i=X(x_i)$ is aggregate input, and *Q(.) and X(.)* are non-negative, non-decreasing and linearly homogeneous aggregator functions. Different indices can be constructed by choosing different aggregator functions.

TFP estimates are obtained by using a Lowe-type TFP index. This index uses a fix aggregator function for all possible binary comparison which satisfies transitivity, which means that a direct comparison of the TFP of two production units should yield the same estimate of TFP change as an indirect comparison through a third unit.

$$Q_i = p'_o q_i \text{ and } X_i = w'_o x_i \qquad (4)$$

where p_o and w_o are representative price vectors. This index is spatially and temporally transitive and can be used to make multilateral firm comparisons of TFP and efficiency (O'Donnell 2008). To define prices used to aggregate inputs and outputs we followed O'Donnell et al. (2012), who suggest the use of the arithmetic average of the shadow prices associated with linear programming (LP) in equation (5) below if input market prices are not available. The output price vector p_0 in equation (4) is set equal to the average prices from the Food and Agriculture Organization (FAO) (2017) while the input price vector w_0 is set equal to the average of the shadow prices associated with the input constraints in LP in equation (15). Input shares derived from shadow input prices used to calculate the total input index can be found in the Appendix.

The frontier and associated measures of efficiency are estimated using data envelopment analysis (DEA). For example, LPs for measuring Farrell (1957) measures of output and input-oriented technical efficiency with respect to the meta-frontier are:

$$EFF_{it} = D_I(x_{it}, q_{it}, t)^{-1} = min_{\theta,\gamma}\{\theta: Q\gamma \geq q_{it}; \theta x_{i,t} \geq X\gamma; \theta \geq 0\} \quad (5)$$

where D_I is the input distance function, Q is a matrix of outputs, X is a matrix of inputs, θ is a vector of estimated parameter representing the proportional contraction of inputs (expansion of outputs) needed to project each DMU to the technological frontier, and γ is an LP decision variable.

3 DATA

The output values from the United States Department of Agriculture (USDA) (2017) dataset used to estimate TFP are gross agricultural outputs. Inputs are agricultural land, in hectares of "rainfed cropland equivalents," measured as the sum of rainfed cropland (weight equals 1.00), irrigated cropland (weight varies from 1.00 to 3.00 depending on region) and permanent pasture (weight varies from 0.02 to 0.09 depending on region); a measure of labour is approximated using the number of economically active persons in agriculture; fertilizer is expressed in tons of fertilizer nutrients used; total stock of farm machinery is measured as the number of "40-CV tractor equivalents"; total livestock capital on farms is in "cattle equivalents" calculated using USDA (2017) estimates of animal stocks on farms with species weighted by their respective size (non-dairy cattle taking a weight of 1.00). Finally, total animal feed from crops and crop-processing residues is measured in dry-matter equivalents. Land and labour productivity measures for the regions reflect a weighted average of individual country productivity measures using average outputs of each country as weights.

4 ANALYSIS

4.1 Performance of agriculture and policy changes

Figure 1 shows three distinctive periods in the performance of South Africa's agricultural sector. The first period, from 1961 to 1980-1981, is one of sustained growth in output driven by growth in input. TFP remains stagnant during this period. The second period, between 1981 and 1994 is characterized by a decreased trend in the use of inputs and by a large drop in output in 1982 followed by a period of output growth and recovery. In 1991, and after almost ten years of growth, however, output was only reaching its 1981 level. During this period, output growth and recovery is driven by TFP. The last period, starting in 1995–1996 is one of accelerated growth in output and TFP and the end of decline in aggregated input, which reverts the trend of the previous two decades and started a period of growth.

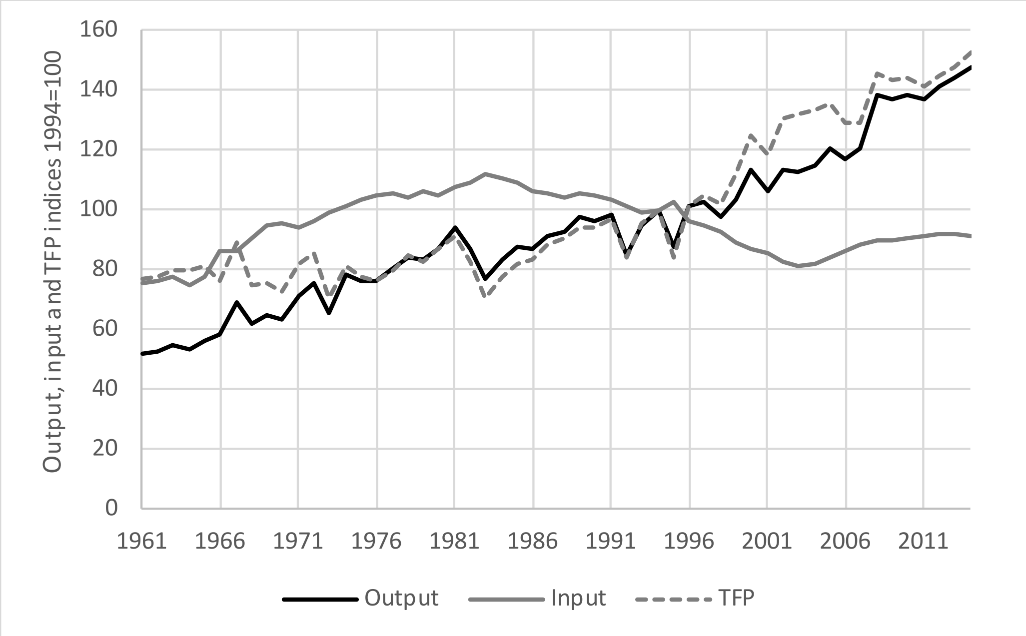


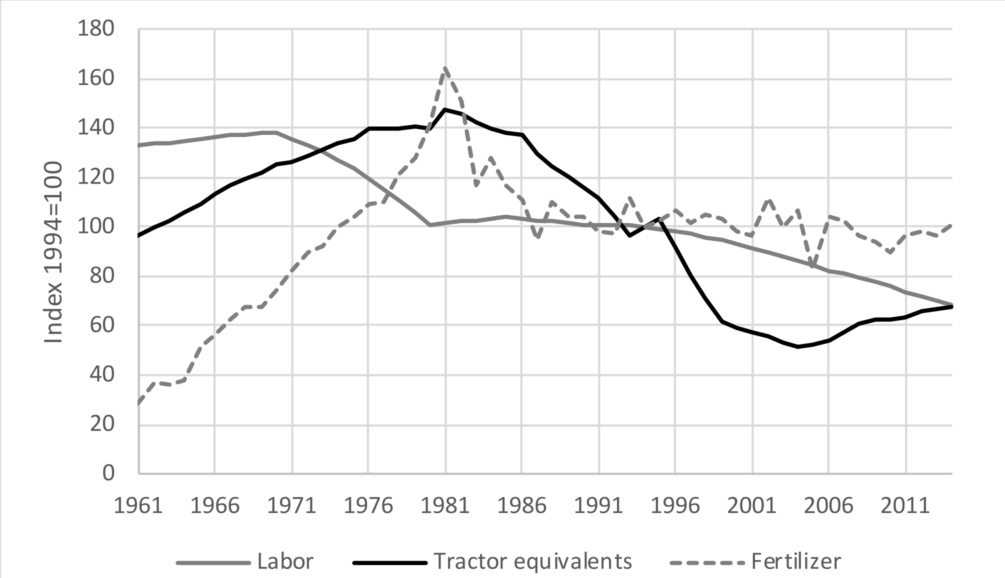
Figure 1: Trends in output, input and TFP for South Africa, 1961–2014 (Index 1994=100)
Source: Elaborated by authors based on data from USDA (2017)

The three periods identified in Figure 1 are highly correlated with the political process and the policy and institutional changes that occurred in the analysed period. The first period (1961–1981) saw the mechanization of commercial farming, the consolidation of marketing schemes, the tightening of control over prices, and an increase in subsidies to white farmers. Among these measures, the most important instrument used was marketing intervention, mainly through the Marketing Act. This enabling legislation set out the conditions under which farmers or the Minister of Agriculture could set up a marketing scheme, to be administered by a Control Board on which farmers were guaranteed a majority of the seats. By the 1970s more than 20 Boards were in operation, covering some 80 percent of total agricultural production. According to Vink (1993), the combination of segregation of land ownership and a two-track approach to access to support services had major effects on the farming sector, creating "two agricultures" which differed in productivity and access to land and support services, while the processes of forced removals and homeland consolidation created a high level of uncertainty among individual farmers, both black and white.

In this context, the agricultural sector was hit by a major drought in 1982, with disastrous consequences, which explains the drop in output shown in Figure 1. Major marketing policy changes for agriculture occurred after 1982, although still within the framework of the Marketing Act and the Control Boards. These changes mark the start of the second period in the evolution and performance of agriculture observed in Figure 1.

Vink (1993) argues that changes in agricultural policy were the result of macroeconomic pressures after monetary policy reforms, financial sector liberalization and deregulation of the real sector of the economy in the late 1970s and early 1980s. The most immediate effect on agriculture came from changes in the external value of the currency and in the interest cost of farm borrowing. With the decline in value of the rand, farm input prices, which have a relatively large import component, rose faster than farm output prices. At the same time, interest rapidly became the single largest cost of production in agriculture. This impact on input prices is clearly represented in the decline in the use of inputs observed after 1982 in Figure 1. A more detailed account of changes in the use of inputs during the period is shown in Figure 2. The total number of hired workers in South African agriculture grew until 1970, despite increased mechanization, because the increase in area planted led to increased demand for labour to harvest the bigger crop. The 1970s turning point in labour coincides with the introduction in the late 1960s of combine harvesters, stimulated by preferential tax treatment. This period simultaneously saw the highest rates of forced removal of permanent labour from farms and an increasing use of temporary or seasonal labour (Kirsten, Edwards and Vink 2007).

Figure 2: Trends in the use of labour, machinery and fertilizer, 1961–2014 (Index 1994=100)



Source: Elaborated by authors based on USDA (2017)

The third and last period observed in Figure 1, of accelerated output and productivity, starts with the election of the government of national unity in 1994, the withdrawal of the National Party from that government, and the appointment of an ANC Minister of Agriculture in 1996. According to Kirsten, Edwards and Vink (2007), the most important policy initiatives taken during this period were: land reform, institutional restructuring in the public sector, the promulgation of new legislation including the Marketing of Agricultural Products Act and the Water Act, and trade policy and labour market policy reform. All these measures were taken within the framework of wider macroeconomic policy reform. It should be noted that, while deregulation and liberalization started in the 1980s, isolation from the world market meant that the deregulation steps that did take place were aimed at the domestic market. During the 1980s, foreign trade still largely consisted of managing imports and exports to manipulate domestic prices, or of monopoly export schemes. Policy changes in the 1990s resulted in major changes in agricultural trade policies. Quantitative restrictions, specific duties, price controls, import and export permits and other regulations were replaced by tariffs after South Africa became a signatory to the Marrakech Agreement following the GATT's Uruguay Round. Policy changes in the 1990s also resulted in reduced government spending in agriculture. Figure 3 shows trends in the quantities of agricultural imports and exports between 1961 and 2016. Liberalization and changes in the 1990s resulted in rapid growth of agricultural imports but less impressive growth of exports.

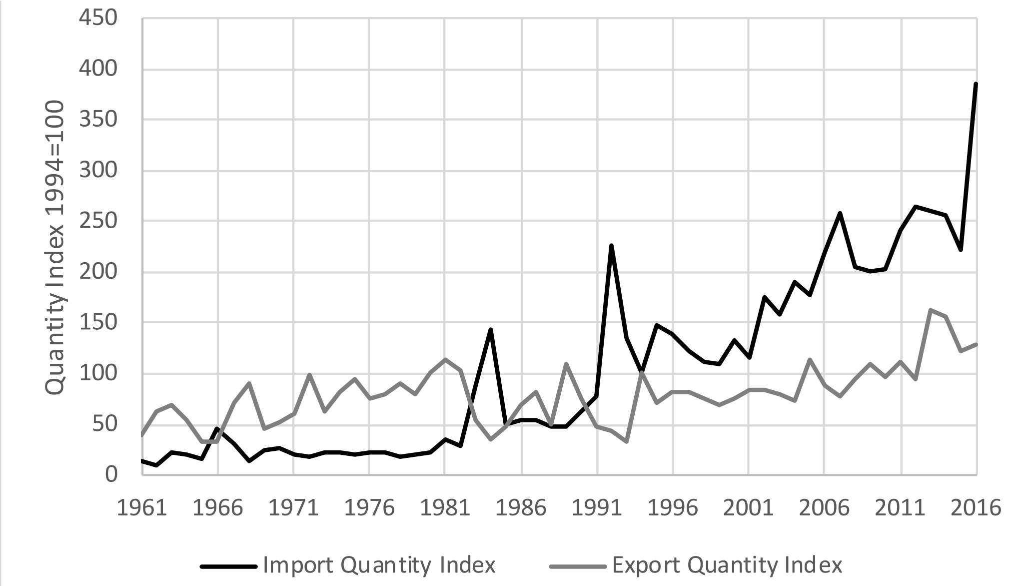


Figure 3: Trends in agricultural imports and exports 1961–2016 (quantity index 1994=100)
Source: Elaborated by authors based on USDA (2017)

TFP decomposition
Figure 4 shows that TFP in South Africa was driven by technical efficiency during most of the analysed period. Stagnated TFP until 1982 results from no changes in technical change and fluctuations of technical efficiency around its level in 1961. It is only after the policy changes in the early 1980s and the recovery of production after the drought of 1982 that agriculture in South Africa starts a period of fast and steady growth that lasted approximately ten years. In the 2000s, growth in technical efficiency stops and TC becomes the driver of TFP growth.

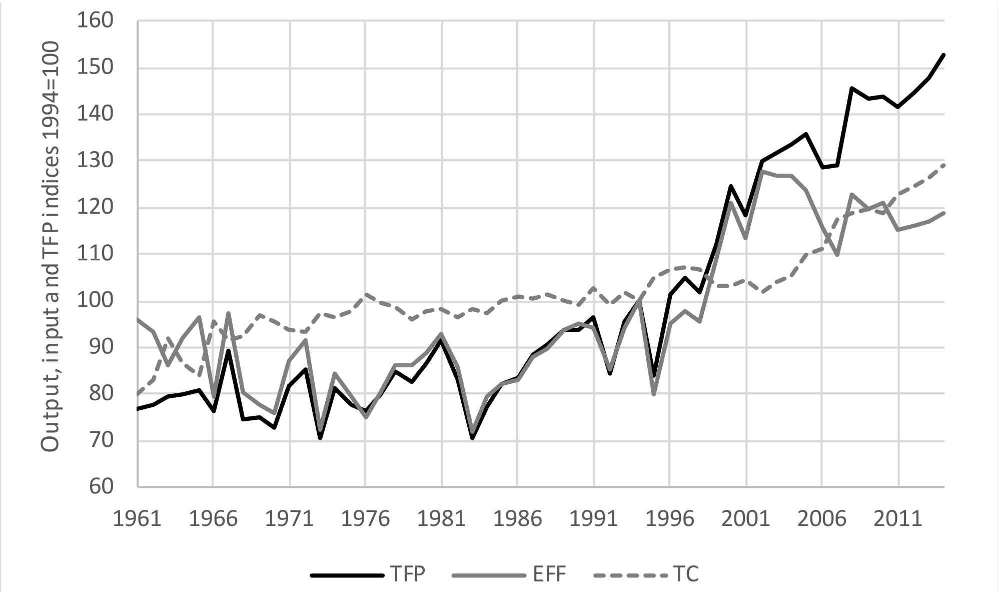


Figure 4: Total factor productivity decomposition into technical efficiency (EFF) and technical change (TC) 1961–2014 (index 1994=100)
Source: Elaborated by authors based on USDA (2017)

To give a better understanding of the role played by technical efficiency in TFP growth, Figure 5 presents its evolution between 1961 and 2014.[1]. The figure shows that technical efficiency declined from 1961 (0.70) until 1982, when efficiency reached its lowest value of the period (0.55). Lowest efficiency occurred in the year of a major drought, but the trend since 1961 was clearly negative until at least 1976. After 1982, growth in efficiency accelerates, with South Africa catching up to the global frontier until 2001, when efficiency reaches 0.95. Since then efficiency values have fluctuated just below the global frontier, which explains why, after 2001, TFP growth is driven by technical change.

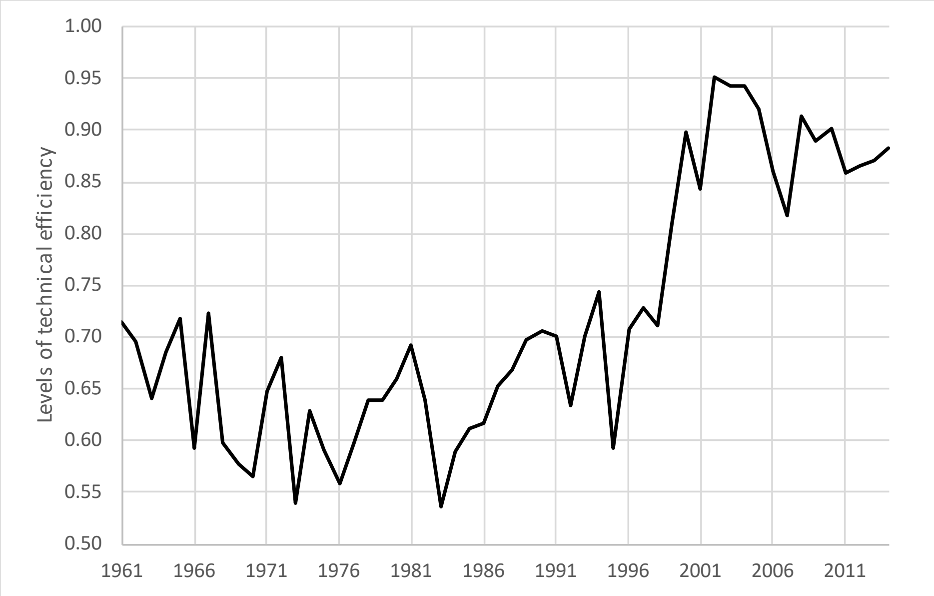


Figure 5: Levels of technical efficiency, 1961-2014
Source: Elaborated by authors

4.2 Land and labour productivity

Figure 6 compares average annual growth rates of TFP with those of land and labour productivity in different periods. Notice how growth in partial productivity was higher than TFP growth from the mid-1970s until the major institutional and policy changes of 1994. In the last twenty years, land and labour productivity increased steadily, but labour productivity grows faster (4–5 percent annually in recent years compared to 2–3 percent for land productivity).

[1] Technical efficiency of production unit i is defined as the ratio between the value of output produced by unit i using total input quantity x ($y_{(x)}$) and the maximum output that can be produced using the same quantity x of input given available technology ($y^*_{(x)}$): $E_i = y_{(x)}/y^*_{(x)}$. Note that the maximum efficiency value is 1, which means $y_{(x)}=y^*_{(x)}$: the production unit is producing at the technological frontier.

Figure 6: Average annual growth rates of land and labour productivity and total factor productivity in different periods (percentage)

Source: Elaborated by authors based on USDA (2017)

4.3 Output composition and growth

Table 1 shows the contribution of major groups of commodities to total agricultural output growth in 1975-1994 and during the period of improved performance (1995-2014). Livestock and fruit production are the drivers of agricultural growth in South Africa. Together, these two groups of commodities explain about 82 percent of total growth in both periods, with an increase in the contribution of livestock and a decrease in the contribution of fruits in the second period. Other changes observed between the two periods are that the contribution of maize and vegetables, roots and tubers dropped from 15 to only 3 and from 14 to 7 percent, respectively. On the other hand, the contribution of oilseeds to growth in 1995-2014 increased by more than four times compared to that in 1975-1994 (8.8 and 2.0 percent, respectively).

Table 1: Contribution of different groups of commodities to agricultural output growth in two periods (percentage)

	1975–1994	*1995–2014*
Maize	15.2	3.0
Fruits	28.7	24.7
Livestock	53.1	56.7
Oilseeds	2.0	8.8
Vegetables, roots and tubers	14.0	7.3
Other	-12.9	-0.5
Total	100.0	100.0

Source: Elaborated by authors based on FAO (2017)

The contribution of different commodity groups to growth, as presented in Table 1, does not capture some of the most significant changes that occurred in South Africa's agriculture in the 2000s, as changes within these commodity groups are larger than changes between groups. To see this, following Pineres and Ferrantino (1997), an index "of "traditionality" of commodities produced by South Africa is calculated. A step-by-step calculation of the index for beef and poultry provides some intuition of the meaning of this measure (see Appendix B).

Table 2 shows the traditionality index (Ti) for different commodities or group of commodities produced by South Africa. Commodities are sorted by the value of Ti and divided in three groups, with the first group (with the lowest values of Ti) being the group of non-traditional commodities, and the last being the group of "most traditional" commodities (highest values of Ti). Group 2, called "traditional", has intermediate values of Ti.

Results show that the most traditional commodities have contributed with only 6 percent of total growth between 1995 and 2014 and show a negative contribution in 1975–1994. The most relevant comparison is between the non-traditional and the intermediate groups. Group 2, of traditional activities, includes major cereals like maize and wheat, temperate fruit and grapes, vegetables and tomatoes, and tea. The group of nontraditional commodities includes barley, poultry, citrus, tropical fruits and nuts, oilcrops like soybean and sunflower, and potatoes and onions. The period of best performance of South Africa's agriculture is driven by growth of these non-traditional commodities, which explains almost 60 percent of total growth, compared to 35 percent of growth explained by the intermediate group of traditional commodities and only 6 percent of growth explained by the most traditional commodities.

Figure 7 shows trends of the three groups of traditional and non-traditional commodities for the whole period with available information (1961-2016). The figure clearly shows how the non-traditional activities out-performed the other two groups. While output of the non-traditional commodities almost tripled after 1995, output of the traditional commodities increased by less than 20 percent.

Table 2: Activities sorted by the traditionality index and their contribution to total output growth in two periods

	T(i)	*1975–1994*	*1995–2014*
Non-traditional	**30**	**48.1**	**59.0**
Nuts	16	0.4	0.6
Soybean	16	0.6	5.5
Lemon	26	0.9	2.3
Poultry	28	33.5	34.1
Onion	32	1.4	1.9
Sunflower	35	1.4	2.9
Potato	36	5.3	3.7
Barley	36	1.2	0.1
Orange	37	2.8	4.0
Fruits, tropical	37	0.6	3.9

	T(i)	1975–1994	1995–2014
Intermediate (traditional)	**42**	**70.1**	**35.2**
Fruits, temperate	39	8.8	4.8
Pig meat	39	2.1	3.2
Spices	40	0.2	0.2
Grapes	41	15.4	8.6
Tomato	41	2.2	1.1
Tea	42	0.4	-0.2
Beef	43	18.5	13.8
Vegetables	44	5.2	1.0
Maize	45	15.3	3.1
Wheat	46	1.9	-0.3
Most traditional	**52**	**-18.6**	**5.8**
Sweet potato	46	0.1	0.0
Sugarcane	46	-2.0	1.5
Rice	47	0.0	0.0
Milk	48	-1.4	6.7
Cotton	51	-1.1	-0.7
Pulses	52	-1.5	0.5
Shoats	54	-1.3	-0.1
Millet and sorghum	54	-1.3	-0.9
Fibre crops	55	-0.1	0.0
Tobacco	55	-1.1	-0.2
Groundnuts	62	-8.9	-1.0

Source: Elaborated by authors based on FAO (2017)

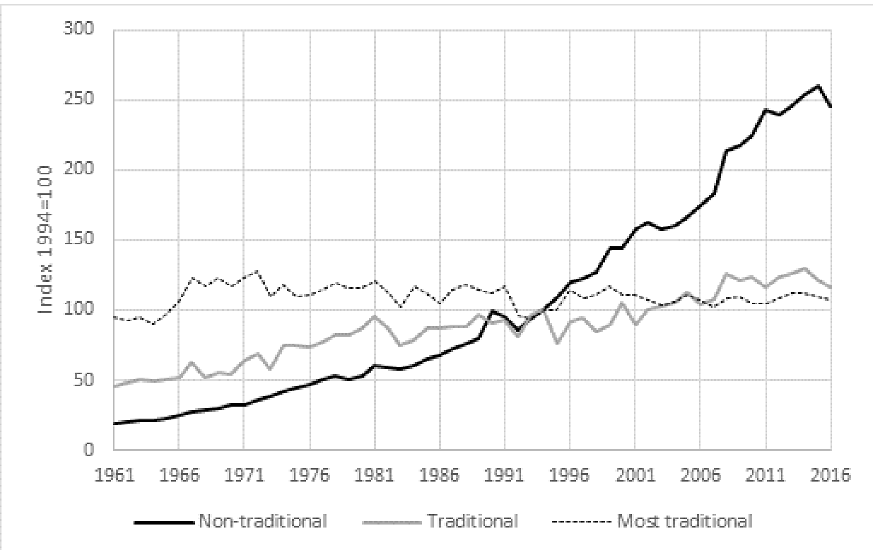


Figure 7: Output indices for three groups of commodities grouped by level of the traditionality index, 1961–2016 (Index 1995=1)

Land size variability

Table 3 shows that smallholder holdings have an average area of 5.6 ha. However, a provincial breakdown shows an average of 36 ha for African farmers (Table 4). There is no data showing the farm size of different farmer types. The data reported in many documents tend to divide land size across race of farmer (Table 4). Thus, in attempt to divide the size of farms, these data will be relied on, and some reasonable assumptions made.

Table 3: Land size by type of owner

Type of farm	Extent (000 ha)	No. of landowners (000)	Farmsize per farmer (ha)
Erven (township plots)	3 197.76	8 469.85	0.4
Agricultural holdings	340.27	60.62	5.6
Farms	110 685.2	527.42	209.9

Source: Calculated from RDLR (2017)

Table 4: Farm size by race of farmer

Province	Whites	African	Indian	Other
		Farm size (ha)		
EC	497.4	91.2	518.1	430.9
FS	373.5	90.9	327.2	295.9
GP	10.3	3.4	13.1	14.1
KZN	97.5	24.1	91.6	18.1
LP	138.5	38.6	131.5	148.8
MP	131.2	37.6	139.6	115.8
NW	196.4	25.9	165.6	115.1
NC	2 191.4	407.9	1 891.2	1 848.6
WC	248.8	95.5	193.7	131.5
Total	278.7	32.5	242.8	130.2

Note: EC = Eastern Cape; FS = Free State; GP = Gauteng; KZN = KwaZulu-Natal; LP = Limpopo; MP = Mpumalanga; NW = North-West; WC = Western Cape.
Source: RLDR (2017)

Productivity

Unlike the sections above, this analysis investigates crop yield only – which is partial productivity. We divide the farm size and corresponding yield into three major groups, as reported in Table 5. The yield is determined by external input and biophysical characteristics, namely: weather (rainfall, sunlight, day length, wind); topography (slope, elevation); soil properties (type, depth, organic and nutrient content) and pest and disease pressure (Pardey and Pingali 2010). Maize is used to represent all other crops, since it accounts for 48% of South Africa's cropland (FAOSTAT data).

Table 5: Types of farms and corresponding productivity

	Large-scale commercial farmers	*Commercial medium-scale farmers*	*Small-scale farmers*
Farm size	210	33	6
Yield (maize), tons/ha	4.4	3.2	1.8
Turnover (million rand)	>22.5	13.5–22.5	<13.5
Level of mechanization (no. of tractors)[a]	High	Medium	Limited – hired
Animal power	Not used	Limited	Significant use
Labour	Hired labour	Hired & family labour	Family labour
Contribution to total turnover (percent)	64	6	28

Notes: [a] South Africa has 67 700 agricultural tractors (Mrema et al. 2018). Smallholder farmers largely hire tractors

Source: Farmsize: RDLR (2017). Yield: FAOSTAT raw data (largescale commercial farmers), Commercial farmers (DSSAT simulation results – Nkonya et al 2016).

Commercial farmer yield is lower than the yield in high-income countries. For example, maize yield in north America is about twice the level realized in South Africa. This is largely due to including medium and smallholder farmers in the national-level FAOSTAT data. At country level, the yield of smallholder farmers is lower than half of that realized by commercial farmers. This is largely due to the limited use of external inputs, limited access to credit, and mechanization and other constraints.

The level of mechanization also heavily determines yield since it enhances labour and land productivity. While commercial and medium-scale farmers are fully mechanized, mechanization among smallholder farmer is limited. Those who use tractors mainly hire rather than own them. About 40–80% of smallholder farmers in South Africa use animal draft power for cultivating, transportation and other operations, its use being especially significant in KwaZulu-Natal, Transkei, Ciskei and KaNgwane (Starkey et al 1995). Animal power is more cost-effective than tractors for smallholder farmers with farming areas not exceeding 20 hectares (Manjengwa 2011).

Use of external inputs among smallholder farmers is limited by restricted access to credit. Most smallholder farmers are located in former homelands, where market infrastructure and institutions are weak (DAFF 2012). This leads to high transaction costs and postharvest losses (Manjengwa 2011). All of this results in the low yield reported.

4.4 South Africa's agriculture in a global perspective

Tables 3 and 4 and Figure 7 compare input mix and partial productivity measures of South Africa and countries with different characteristics, most of them major agricultural producers. Table 3 shows that South Africa is relatively abundant in land, showing higher values of land/labour ratios (hectares per worker) and tractor equivalents per worker than all other countries except Argentina, Australia and the USA. In terms of fertilizer use per hectare, South Africa applies on average more fertilizer per hectare of cropland than Argentina and Australia, but less than all other countries. The number of animals, measured as cattle equivalents, is relatively high, lower only than major livestock producers like Argentina, Australia, Brazil and the USA.

The input mix in South Africa's agricultural production corresponds to relatively low values of land productivity and land productivity growth, compared to Brazil, China, Chile and India. Values and growth rates of land productivity are closer to those of Argentina and Mexico, but still only one-half and one-third of the levels of these two countries respectively. On the other hand, labour productivity in South Africa is relatively high, close to that of Brazil and only below that of Argentina, Australia and the USA.

Table 3: Comparisons of different input ratios between South Africa and other countries

	Hectares/worker			*Tractor eq/1000 workers*			*Kg of fertilizer per ha of cropland*			*Cattle eq./1000 workers*		
iso3	*1981-1994*	*1995-2004*	*2005-2014*	*1981-1994*	*1995-2004*	*2005-2014*	*1981-1994*	*1995-2004*	*2005-2014*	*1981-1994*	*1995-2004*	*2005-2014*
Argentina	21	22	29	131	135	138	7	30	36	45	42	45
Australia	196	194	184	788	798	806	28	50	45	98	99	90
Brazil	4	5	8	13	14	15	62	102	137	12	16	23
Chile	5	3	3	52	52	52	83	221	259	6	7	7
China	1	1	1	1	1	2	152	240	307	1	1	1
India	1	1	1	1	1	1	58	97	146	2	1	1
Mexico	3	4	4	14	14	15	76	66	68	6	6	7
Turkey	3	3	3	14	15	17	61	72	82	3	2	3
USA	65	74	84	1 226	1 238	1 249	99	112	123	38	46	56
South Africa	***9***	***11***	***13***	***81***	***83***	***86***	***67***	***55***	***56***	***12***	***14***	***17***

Source: Elaborated by authors based on USDA (2017)

Table 4: Comparisons of levels of land and labour productivity and growth rates 1995–2014 between South Africa and other developing regions (in 2004–2006 $I)

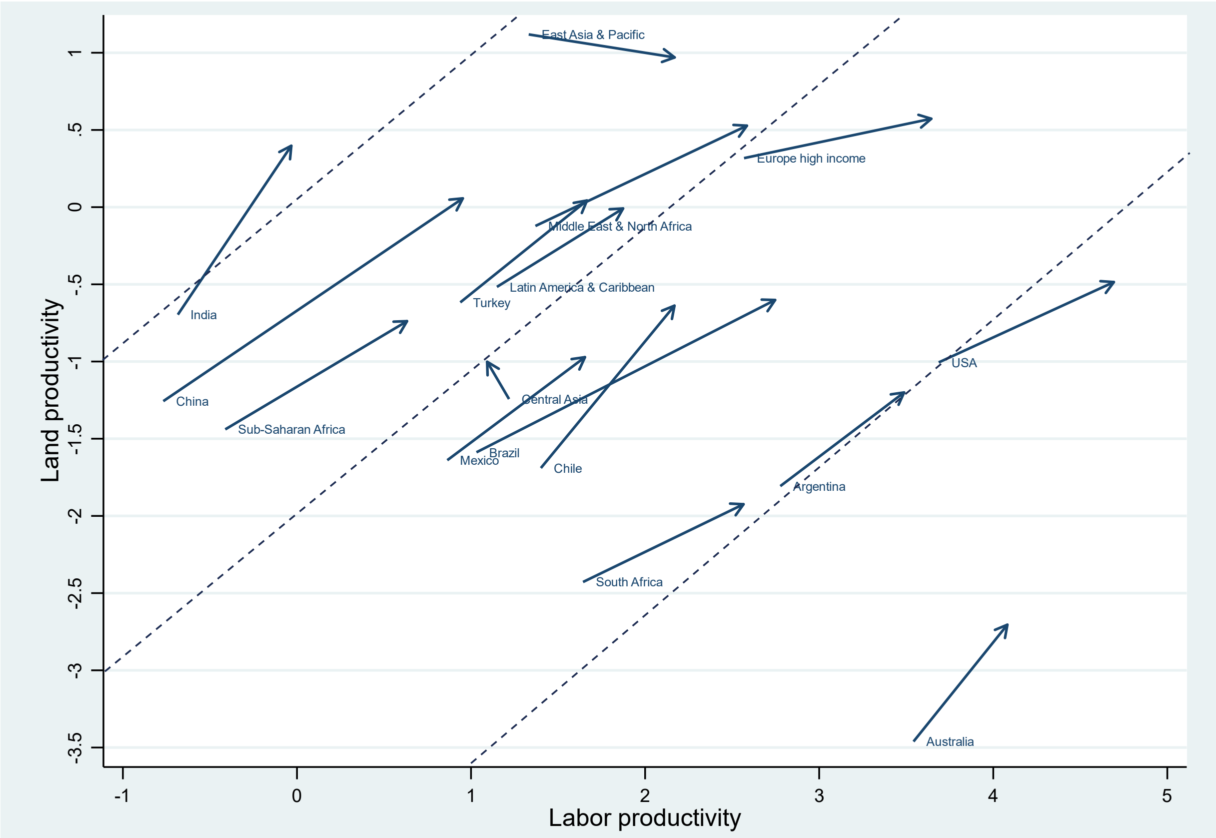
	Land productivity[(a)]				*Labour productivity[(a)]*			
iso3	*1981–1994*	*1995–2004*	*2005–2014*	*Growth 1987–2010[(b)]*	*1981–1994*	*1995–2004*	*2005–2014*	*Growth 1987–2010[(a)]*
Argentina	185	243	285	1.9	16 734	21 573	29 508	2.5
Australia	38	54	62	2.1	39 619	55 005	56 002	1.5
Brazil	247	342	498	3.1	3 962	6 803	12 385	5.1
Chile	248	415	510	3.2	4 473	6 544	8 325	2.7
China	401	673	953	3.8	604	1 033	1 913	5.1
India	662	918	1 272	2.9	594	702	863	1.6
Mexico	215	277	342	2.0	2 609	3 349	4 482	2.4
Turkey	637	755	945	1.7	2 594	3 254	4 597	2.5
USA	405	505	574	1.5	46 574	67 540	92 703	3.0
South Africa	***91***	***103***	***132***	***1.6***	***5 350***	***6 795***	***10 610***	***3.0***

Note: (a) Labour productivity is the value of total output in 2004–2006 I$ per worker; land productivity is also the value of total output but per hectare of agricultural land, (b) Average annual growth between 2005–2014 and 1981–1994.

Source: Elaborated by authors based on USDA (2017)

Figure 7 plots agricultural labour productivity (total output per worker) in logarithmic units on the horizontal axis and land productivity measured as agricultural output per hectare of agricultural land, also in logarithms, on the vertical axis. Arrows for each country are defined by two points whose coordinates are the value of land and labour productivity in 1980 and 2014, with the arrows pointing to 2014. The length of the arrows represents rates of growth, the longer the arrow the faster the growth between 1980 and 2014. The dotted diagonal lines in the figure intersect points with constant land/labour ratios. Note that the higher the arrow is in terms of the vertical axis, the larger the land productivity in that country or region. Equivalently, the further to the right an arrow is, the larger the labour productivity of the country. Also note that when country arrows are parallel to the dotted iso-land/labour ratios, growth in those countries occurs at fixed land/labour ratios, given that growth in land and labour productivity is the same or similar. When country arrows cross the dotted lines from above, agriculture in those countries is growing by faster increasing labour productivity (saving labour). Country arrows intersecting dotted lines from below are increasing land productivity faster (saving land).

Figure 8 shows land productivity in South Africa lower than land productivity in all other regions represented in the figure, except for Australia. Low land productivity in the case of South Africa is explained in part by the poor quality of natural resources and in part by the relative abundance of land and natural resources relative to labour, which have resulted in South Africa following a labour-saving growth path, with labour productivity increasing faster than land productivity. Notice that South Africa is following a similar growth path to those of Argentina and the USA but still at much lower levels of labour productivity than theirs. These trends seem to show that South Africa's growth will continue to be driven by growth in labour productivity, with growing land/labour ratios.



Note: Arrows for each country are defined by two points which coordinates are the value of land and labour productivity in 1980 and 2014, with the arrow pointing to 2014. The length of the arrow represents the rate of growth with longer arrows meaning faster growth. The dotted diagonal lines in the figure intersect points with constant land/labour ratios.

Figure 8: Comparisons of labour and land productivity, 1980 data points connected to the 2014 data points by an arrow showing the direction of time (in logs)
Source: Elaborated by authors based on USDA (2017)

Table 5 compares total output, input and TFP growth in South Africa with growth in other countries. Growth in TFP after 2005 has been relatively low in South Africa (1.5 percent) compared to other countries and compared to TFP growth in South Africa in 1995–2004 (3.4 percent). However, growth before 2005 still benefited from efficiency growth that resulted from policy and institutional changes after 1994. Once this effect ran out, TFP growth went back to a similar level of that observed in 1981–1994 (1.3 compared to 1.5 in 2005-2014).

Efficiency levels for South Africa and other regions are compared in Table 6. Notice that the nine countries and major producers used as reference in the comparisons all show high levels of efficiency in the three periods. With average efficiency values of 1, China, Brazil, India and the USA are at the technological frontier. Values of efficiency between 0.99 and 0.95 for Argentina, Australia, Turkey and Chile indicate that these countries have been at the frontier in most years or that they are producing with high levels of efficiency close to the production frontier. South Africa has improved efficiency significantly since the 1980s, showing higher levels of efficiency than average values for all regions and Mexico.

Table 5: Comparisons of annual growth rates of TFP, total output and input in three periods

	Output			***Input***			***TFP***		
iso3	*1981–1994*	*1995–2004*	*2005–2014*	*1981–1994*	*1995–2004*	*2005–2014*	*1981–1994*	*1995–2004*	*2005–2014*
Argentina	1.7	2.8	3.1	2.5	1.2	1.8	-0.8	1.5	0.9
Australia	1.9	2.6	1.4	1.0	1.5	0.4	0.8	0.8	0.9
Brazil	3.4	4.5	3.3	1.2	2.0	0.7	2.1	2.4	2.5
Chile	4.2	2.8	1.6	2.3	1.6	-0.6	1.8	1.2	2.1
China	5.4	4.5	3.1	2.5	2.0	1.4	2.8	2.4	1.7
India	3.6	2.0	4.3	2.7	1.7	1.9	0.8	0.1	2.3
Mexico	2.0	3.0	2.0	2.2	0.3	-0.1	-0.3	2.6	2.1
Turkey	2.1	1.7	2.4	1.1	0.8	0.5	0.9	0.8	1.9
USA	2.2	1.2	1.0	0.0	-0.2	-1.2	1.9	1.3	2.2
South Africa	1.3	1.7	2.6	-0.3	-2.0	1.1	1.3	3.4	1.5

Source: Elaborated by authors based on USDA (2017)

Table 6: Efficiency levels for South Africa and other countries and regions for three periods

	1981–1994	*1995–2004*	*2005–2014*
Australia	0.99	0.98	0.96
USA	0.99	1.00	1.00
Europe high-income	0.86	0.85	0.84
Eastern Europe	0.75	0.84	0.83
China	1.00	1.00	1.00
East Asia & Pacific, other	0.81	0.81	0.81
India	1.00	1.00	1.00
South Asia, other	0.89	0.84	0.87
Central Asia	0.77	0.83	0.83
Argentina	0.99	1.00	0.99
Brazil	1.00	1.00	1.00
Chile	0.89	0.97	1.00
Mexico	0.81	0.81	0.84
Latin America & Caribbean, other	0.76	0.75	0.77
Turkey	0.94	0.98	0.99
Middle East & North Africa, other	0.81	0.86	0.87
Sub-Saharan Africa	0.72	0.73	0.76
South Africa	**0.66**	**0.81**	**0.88**

Source: Elaborated by authors based on USDA (2017)

5 CONCLUSIONS

This paper sought to address the following questions: (a) How productive is South Africa's agricultural sector? (b) How does it compare to other countries in terms of productivity? We found three distinctive periods in the performance of South Africa's agricultural sector. The first period, from 1961 to 1980-1981, was one of sustained growth in output driven by growth in input while TFP remained stagnant. The second period, between 1981 and 1994 was characterized by a decreased trend in the use of inputs. Output growth was driven by TFP. The last period, starting in 1995–1996 is one of accelerated growth in output and TFP and the end of decline in aggregated input. Relative to other countries, growth in TFP was rapid in South Africa from 1995–2004. After 2005, it has been relatively slow (1.5 percent). Relative to the global production possibilities frontier (PPF), South African agriculture has been approaching the global PPF. Efficiency, as measured by proximity to the global PPF, improved from 0.66 from 1981 to 1994 to 0.81 in 1995-2004 and to 0.88 in 2005-2014. Overall, South African agriculture has been reasonably productive in terms of TFP and has been approaching the global PPF.

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Appendix A

Table A1: Input shares calculated from input shadow prices used to aggregate inputs into an index of total input

iso3	Land	Labour	Animal Stock	Tractor eq.	Fertilizer	Feed
Argentina	0.09	0.24	0.20	0.20	0.07	0.20
Australia	0.02	0.25	0.19	0.16	0.15	0.22
Brazil	0.23	0.17	0.09	0.22	0.13	0.16
Chile	0.05	0.18	0.26	0.19	0.06	0.26
China	0.33	0.08	0.19	0.06	0.10	0.23
India	0.20	0.14	0.22	0.03	0.03	0.39
Mexico	0.24	0.13	0.16	0.27	0.08	0.11
Turkey	0.05	0.08	0.19	0.09	0.12	0.47
USA	0.06	0.13	0.23	0.20	0.09	0.29
South Africa	0.02	0.16	0.24	0.31	0.01	0.26

Appendix B

The first step to calculate the traditionality index (Ti), is to calculate the total amount of output of each agricultural activity produced between 1975 and 2014. Production of each activity in each year is then divided by the respective total for the period 1975–2014 to find the proportion of total output of each commodity in each year. This is shown in Figure B.1 comparing beef and poultry. The figure shows that a much higher proportion of beef than poultry was produced before 1995 (almost 50 percent and 28 percent, respectively). Using the values in Figure B.1 we calculate what Pineres and Ferrantino (1997) call the Production Experience Index (C_{it}) for year *t* and activity *i* by adding up the value shares in Figure B1 for poultry and beef between 1975 and a particular year t.

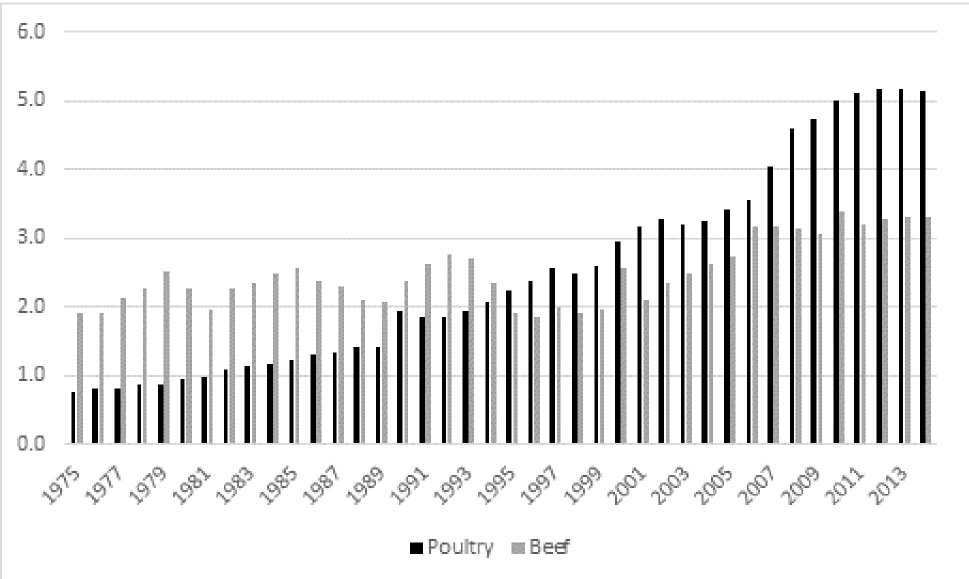

Figure B1: Annual distribution of total production of beef and poultry produced by South Africa between 1975 and 2014 (total output for 1975–2014= 100)

Source: Elaborated by authors based on FAO (2017)

The production experience index for beef and poultry is presented in Figure B.2. For example: C(beef,1996) = 50; and C(poultry,1996) = 30, that is, the value of the cumulative index is the sum of the value shares of each year between 1975 and 1996. The values of the C index reveal that beef is the more "traditional" activity, compared to poultry, as the proportion of poultry production was smaller at the beginning of the period, increasing its importance in the 2000s as a "new" activity. Finally, the average of the annual values in Figure 8 for each activity is what we call the traditionality index (Ti). This index can be understood as an indicator of the differences between the distribution of output of beef and poultry observed in Figure 8. In this example T_{beef}= 46 while $T_{poultry}$=33. The higher the Ti index, the more traditional the commodity.

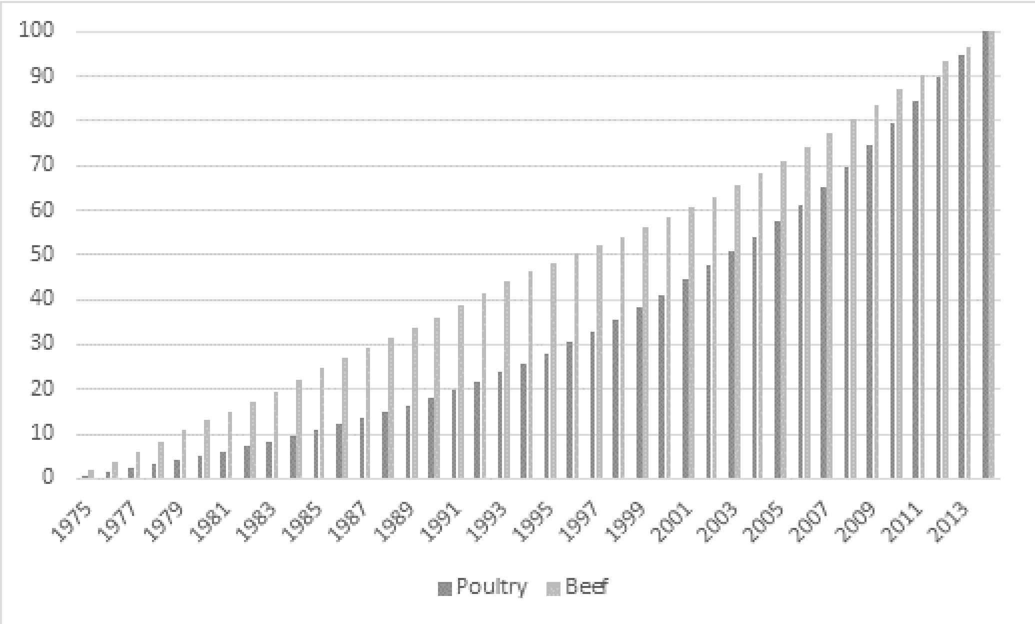

Figure B2: Cumulative production experience index (C_{it}) for beef and poultry in South Africa (total production 1975-2014 = 100)

Source: Elaborated by authors based on FAO (2017)

The average of the annual values in Figure B2 for each activity is what we call the Traditionality Index (Ti). This index can be understood as an indicator of the production experience of an activity in a country, the higher the index, the more traditional the activity. In this example T_{beef}=46 and $T_{poultry}$=33

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