A long-run view of South African agricultural production and productivity

FRIKKIE LIEBENBERG

Department of Agricultural Economics, Extension and Rural Development, University of Pretoria, South Africa

PHILIP G PARDEY*

Department of Applied Economics and International Science and Technology Practice and Policy Center (InSTePP), University of Minnesota, USA

Production and productivity developments in South Africa have regional consequences: South Africa's agricultural economy accounted for 43.1% of the agricultural GDP of southern Africa in 2009. Here we present and discuss newly constructed long-run data on agricultural input and output aggregates for South Africa spanning most of the 20th century. Updated multi-factor productivity (MFP) measures for South Africa for the last half of the 20th century are also presented. For the period after 1961, land and labor productivity trends for South Africa are compared with partial productivity developments in the rest of Africa. The general tendency has been for labor productivity to grow at slower rates throughout sub-Saharan Africa than in South Africa (and Nigeria). We also detect a fairly widespread slowdown in the growth of both these partial productivity measures in more recent years. MFP growth for South Africa has also slowed, as has aggregate agricultural output growth, which has now slipped well below the country's corresponding rate of population growth. A failure to revitalize the rate of productivity growth and sustain that rate over the long run will have far-reaching economic development consequences for South Africa and the continent generally.

Keywords: multi-factor productivity; agricultural outputs; inputs; sub-Saharan Africa

JEL codes: O47; O55; N57

Les développements en matière de production et de productivité en Afrique du Sud ont des conséquences régionales : en 2009, l'économie agricole de l'Afrique du Sud a représenté 43.1 pour cent du PIB agricole de l'Afrique australe. Nous présentons et discutons ici de données sur le long terme, nouvellement construites, concernant les agrégats entrées et sorties agricoles de l'Afrique du Sud sur la quasi-totalité du 20ème siècle. Des mesures mises à jour en matière de productivité multifactorielle (PMF) pour l'Afrique du Sud, et recouvrant la deuxième moitié du 20ème siècle, sont également présentées. En Afrique du Sud, pour la période postérieure à 1961, les tendances en matière de travail et de productivité sont comparées aux développements de la productivité partielle dans le reste de l'Afrique. La tendance générale a agi de telle sorte que la productivité du travail s'est accrue plus

* Corresponding author: ppardey@umn.edu

lentement en Afrique subsaharienne qu'en Afrique du Sud (et au Nigéria). Nous remarquons également un ralentissement passablement généralisé de la croissance de ces deux mesures en matière de productivité partielle au cours des dernières années. La croissance PMF de l'Afrique du Sud a également connu un ralentissement, il en va de même pour la croissance de la production agricole globale qui est aujourd'hui bien en dessous du taux relatif à la croissance démographique du pays. Une incapacité à revitaliser le taux de la croissance de la productivité et à soutenir ce taux sur le long terme entrainera de graves conséquences en matière de développement économique en Afrique du Sud et sur l'ensemble du continent.

Mots-clés : *productivité multifactorielle ; productions agricoles ; intrants ; Afrique subsaharienne*

Catégories JEL : *O47; O55; N57*

1. Introduction

The size and structure of agriculture and agricultural production in South Africa changed markedly as the 20th century unfolded. Average farm size grew, as did farm numbers for the first half of the century before beginning to decline, and production increasingly emphasized higher-valued commodities, notably a range of horticultural crops. The value of agricultural output (in constant 2005 prices) grew steadily, by 2.6% per year from 1910 to 1980, but growth slowed thereafter (to just 0.4% per year from 1980 to 2007). Here we document and discuss developments in aggregate input, output and productivity in South Africa. To do so we draw on an entirely new set of production data stretching back to 1910/11 which we use to update the multi-factor productivity series reported by Thirtle, Sartorius von Bach and Van Zyl (1993) and Schimmelpfennig et al. (2000).[1] Our new partial- and multi-factor productivity estimates for South Africa are assessed in terms of comparable earlier evidence reported by other studies for South Africa and other countries in sub-Saharan Africa.

2. Agriculture in the South African economy

In 2008, South Africa's agricultural GDP (AgGDP) was US$7.9 billion, placing it 41st worldwide on this score – down from 35th in 2006 (World Bank, 2011). Agricultural trade constituted 3.0% of South Africa's GDP in 2010, with agricultural exports accounting for about 7.8% of total exports (DAS, 2011). This is significantly less than its export share in 1932, when agriculture accounted for 80.6% of total South African exports. Since then, agricultural exports as a share of the country's total exports have declined steadily, to bottom out at 6.5% in 1993, after which the agricultural share grew to an average of 8.2% for the period 1994 to 2010. South Africa has always been a net exporter (by value) of agricultural products. In 1975, agricultural exports exceeded imports by R29.3 billion in inflation adjusted terms, but the lingering effects of sanctions on imports from South Africa due to the

[1] An earlier version of the series used in this article is reported in Liebenberg & Pardey (2010). An entirely new version of this same series is being developed for the work to be reported in Liebenberg (in progress).

apartheid regime, combined with a failure to remain internationally competitive, have left the country barely able to sustain its net agricultural exporter status in recent years. [2]

In 1910, agricultural output (as measured by AgGDP) accounted for 19.4% of total economic output (GDP) (Table 1).[3] The agricultural share of total economic output declined steadily throughout the 20th century, to just 2.2% by 2010, although the agricultural economy still employed more than 1.19 million workers, about 6.5% of the South African economically active population that year. The absolute size of the agricultural economy grew almost every decade until the 1970s – at an overall average annual rate of 2.79% per year, from R10.9 billion (US$1.7 billion) in 1910 to R64.9 billion (US$10.3 billion) in 1974 (both measured in 2005 prices). From 1910 to 1928, real agricultural output grew by 2.6% per year. After the depression of the early 1930s and a severe drought for four years that ended in 1934, the agricultural economy experienced a period of strong growth in conjunction with expanded farmer settlement and agricultural development support and reached R50.0 billion (US$7.9 billion) in 1951, an increase of 8.09% per year for the 1934 to 1951 period. During the period 1951 to 1974, output growth slowed to an average of 1.14% per year. The agricultural economy then declined to a low point of R36.9 billion (US$5.8 billion) in 1992, reflecting in part the effects of another severe drought in the 1991 and 1992 cropping seasons. Thereafter agricultural output rebounded to a peak of R52.4 billion (US$8.2 billion) in 2002, after which international market pressures, changing domestic agricultural policies and economy-wide influences and adverse weather conditions drove a period of decline that saw output falling to R41.0 billion (US$6.4 billion) in 2010.

The number of people economically engaged in agriculture grew virtually uninterrupted for 60 years from 1910 to the 1970s, when it reached 2.48 million. As reported, the number of farms increased over the same period from 76,149 to 90,422 in 1970 after peaking at 119,556 in 1952. With farm numbers continuing to decline thereafter, AgGDP per economically active person engaged in agriculture continued to grow in inflation-adjusted (2005 prices) terms, from R18,209 (US$2,862) per capita in 1970 to R34,526 (US$5,427) per capita in 2010.[4]

[2] Here, and throughout this paper, 'R' denotes rand, the local currency unit of South Africa. Unless otherwise stated, ZAR-USD currency conversions in this paper use market exchange rates obtained by the authors from the South African Reserve Bank.

[3] AgGDP excludes output from the (processed) food sector. The combined output of the farm and agribusiness sectors (including food and fiber processors, distributors and the relevant parts of the beverage industries such as wine and beer – all of which are reported in the national accounts as part of the manufacturing sector) would almost double the sectoral share, such that the combined food and agricultural industries would constitute about one third of total GDP.

[4] The statistical basis for enumerating farms changed over time. Up to and including the year 1953/54 a 'farm' encompassed the activities of farmers 'whose farming activities extended over more than one farm or tract or piece of land within the same magisterial district, were at liberty to complete separate returns for each such farm or tract or piece of land or, on the other hand, to consolidate all their farming activities in one return'. This changed in 1954/55, whereafter the census instructions were that 'only one form must be completed in respect of each farming unit, irrespective of whether farming activities are carried on [sic] on one or more farms or tracts of land and whether the farms are adjoining or not, provided the farms are situated within the same magisterial district'. Thus some share of the substantial decline in the reported number of farms, especially during the period 1952/53 to 1955/56, is probably due to this statistical consolidation (BCS, 1958).

3. Agricultural output

From 1910 to 2010 total agricultural output grew at an average annual rate of 2.65%.[5] From 1910 to 1947, it grew by 2.43% per year, accelerating to 3.85% per year over the following three decades, then slowing to just 1.19% per year for the period 1982–2000. Since 2000, output growth has rebounded, growing by 2.16% per year. Over the one hundred years since 1910, growth in horticultural output (fruit and vegetables) has outpaced that of field crops and livestock by almost 1.2% per year (Figure 1). Field crop production kept pace with livestock output from 1910 until the mid-1960s; during the subsequent two decades it actually grew at a faster rate than the livestock sector. However, during the period 1983–2010, field crop production grew by only 0.96% per year, lagging behind the corresponding growth in livestock output of 1.74% per year. Since 2000, growth in field crop production has fallen substantially behind the corresponding growth in livestock output, which increased by 4.31% per year.

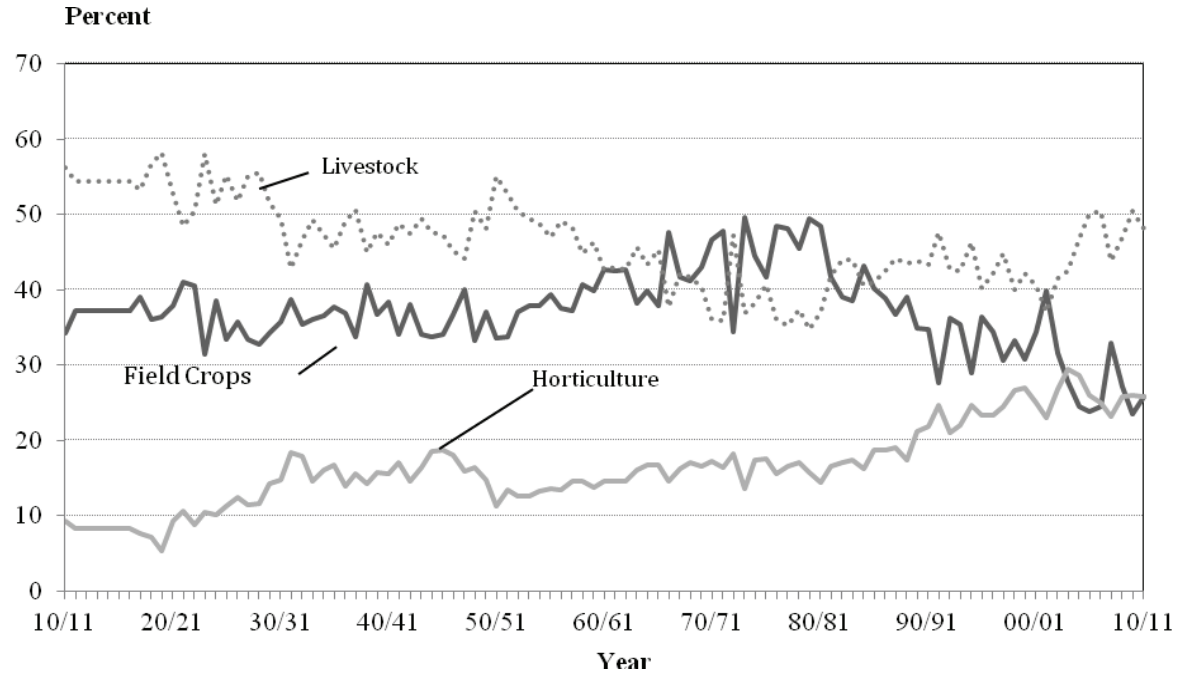

Figure 1: Industry shares in gross value of agricultural production, 1910–2010

Source: Liebenberg (2012), based on data from DAS (2012)

Note: The livestock aggregate includes 11 commodities, the field crops aggregate includes 22 commodities and the horticulture aggregate includes 12 commodities. The plots represent the respective shares in the total value of agricultural production.

[5] Here aggregate output quantities were calculated following the procedure used by Thirtle, Sartorius von Bach and Van Zyl (1993), which formed a type of Tornqvist-Theil aggregate of pre-aggregated Laspeyers indexes of field crops, horticulture and livestock production reported by the Department of Agriculture.

Until the late 1980s, the growth in the aggregate quantity of horticultural output averaged 4.77% per year – aided in part by improvements in cold chain management. After a brief downturn in output growth from 1989 to 1992, the sector resumed its growth at impressive rates, partly in response to improved access to international markets as rest-of-world sanctions against imports from South African were scrapped (Jooste et al., 2003).

As a result of these different rates of sub-sector growth, the mix of agricultural output changed markedly over the years (Table 1). In 1910 about 55% of the value of South African agricultural output was livestock products, with wool (20%), dairy (19%) and cattle and sheep (each contributing 15%) accounting for 68% by value of livestock production. By 2008 the livestock share had shrunk considerably, although it was still a substantial 44% of agricultural output by value (with poultry production now accounting for 55% of this total). The field crop share of the market was 34% in 1911, grew to 47% in 1971 (largely because of an expansion of cereals and sugarcane production) and declined thereafter. A reduction in corn and wheat production accounted for most of the post-1971 decline. The horticulture share, however, increased steadily, more than doubling from around 10% in 1910 to 26% by 2010.

Liebenberg & Pardey – A long-run view of South African agricultural production and productivity – AfJARE 7(1)

Table 1: The changing structure of South African agriculture, 1910–2010

	Units	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s
structure											
number	Number	76,622	88,305	101,299	111,938	112,305	99,114	79,842	64,540	59,289	43,322
area	1000 ha	77,042	81,810	84,339	87,392	88,150	89,256	86,814	85,862	82,404	84,301
ge farm size	ha	1,006	928	833	781	788	817	1,094	667	1,260	1,946
ic contribution											
P	illion (2005)	12,985	14,958	14,651	25,724	46,777	50,126	53,071	50,646	42,637	44,265
ibution to GDP	%	19.0	17.6	12.0	12.7	15.2	9.9	6.8	5.0	3.7	2.9
omically active in agriculture	1000	-	-	-	1,913	1,509	1,635	2,483	1,181	1,213	1,327
ultural share of total	%	-	-	-	42	33	29	31	14	10	11
employees	1000	802	1,025	1,354	1,438	1,661	1,665	1,392	1,241	1,041	896
f production											
crops	illion (2005)	5,736	6,449	7,537	12,618	21,149	28,610	37,444	33,397	22,132	23,821
culture	illion (2005)	1,666	2,191	2,884	5,072	7,513	10,812	13,447	14,572	16,025	21,209
ock	illion (2005)	8,457	9,458	9,526	16,415	27,673	28,984	30,718	34,974	28,964	37,011
	illion (2005)	15,859	18,098	19,947	34,105	56,335	68,406	81,609	82,944	67,120	82,041
f production value											
crops	%	36	36	38	37	38	42	46	40	33	29
culture	%	11	12	14	15	13	16	16	18	24	26
tock	%	53	52	48	48	49	42	38	42	43	45

Source: Liebenberg (2012)

Note: Where relevant, data were deflated using the GDP deflator (long-run GDP and agricultural contribution to GDP statistics 2011 – data provided by the South African Reserve Bank on request by the authors). Farm employees consistently include family, regular, casual and proprietor labor. The entries in the table represent decade averages, except '2000s', which represents the 2000–2007 average.

The overall growth in total agricultural output was thus largely driven by strong growth in the horticultural sector, with the comparatively slower growth in field crop output over more recent decades being a drag on the overall pace of growth of South African agriculture. Moreover, the rate of growth in agricultural output (and especially field crop production, which includes staple food crops such as wheat, corn and grain sorghum) has fallen below the rate of population growth. South Africa's population grew by 2.43% per year from 1982 to 2010, compared with 1.54% per year for overall agricultural output (and essentially no growth in field crop production).[6] Notably, the slowdown in both total output and crop output in South Africa in recent decades parallels similar trends in the US, where the total quantity of agricultural output grew by 1.63% per year during the 1980s (compared with 2.22% per year for the previous decade), slowing to 1.28% per year from 1990 to 2002 (Alston, Andersen et al., 2010, Appendix Table 4-3).[7]

Taken as a group, these agricultural indicators point to a long period of both physical and economic expansion in agriculture stretching from 1910 through to the 1950–1970 period. The 1950s and 1960s were a period of transition (at least for commercial agriculture), characterized by continued economic growth of agriculture, but growth that took place in the context of farm consolidation, a continued and perhaps even accelerating change in the composition of farm output, and a movement of labor out of agriculture as opportunities in other sectors of the economy competed for labor hitherto used within agriculture (Giliomee, 2003).

Racial perspectives

These aggregate economic changes fail to reveal the different development paths followed by black compared with white farmers. Throughout most of the post-unification period (specifically from 1913, but intensively so from the 1930s), the sustained and substantial government support for agriculture was biased toward white commercial farmers. Lacking a commensurate amount of public support, black farmers suffered as a consequence. The Land Act of 1913 and the Co-operatives Act of 1920 are two key examples of discriminatory public policy. The Land Act confined land ownership by blacks to dedicated native reserves, while the Co-operatives Act excluded black farmers from participating in farmer cooperatives. In 1925 the Farmer Assistance Board (the predecessor of the Agricultural Credit Board) was established to assist farmers with soft loans in the aftermath of the recession of the early 1920s. Black farmers were once again excluded from accessing these government-backed credit programs, and they were also excluded from participating in the farmer settlement programs introduced in the late 1930s.[8] Ostensibly, government support structures within the homelands and the self-governing territories were to take care of the needs of black farmers, but in fact these programs

[6] Although the rate of population growth has slowed in more recent years – to 1.34% per year since 2000 – field crop production has slowed even more dramatically, to just 0.03% per year over the same period.

[7] See also Chapter 8 in Alston, Babcock & Pardey (2010).

[8] A host of other initiatives were launched after the unification of South Africa to improve the productivity of the agricultural sector. Government provision of research, extension, training and subsidized soil and veld conservation works were intended to promote the development of farming communities, often by way of farmer settlement programs and co-sponsored self-help schemes. Tenant farmers were provided with training and post-settlement extension support. In addition, the government made available start-up packages that included all the required means of production, with the repayment of these start-up costs (including the cost of purchasing the farm land) beginning after a five-year grace period (with interest for the five-year grace period capitalized into the purchase price). These schemes targeted new farm settlers according to their soldier status, racial status and unemployment status, and incumbent farmers according to their farm size or farm profitability (or lack thereof). None of these attributes is necessarily a good indicator of the potential productivity and profitability of farms or the prospective social payoff to public investments in these schemes. Liebenberg (in progress) provides new data on the public investments directed to farmer settlement and survival schemes in South Africa during the 20th century.

either failed to materialize or were never developed to the extent that they were for the white commercial farming community (Vink & Van Zyl, 1998).

The effect of these discriminatory policies over time is shown in Table 2 in which the current relative contribution of black farmers to national production and land ownership is compared with its share in national farming activities pre-1960 (before the establishment of the homelands and self-governing territories). The share of farmed area owned by black farmers varied little from 1918 to 1991, averaging around 15%. This share then doubled to almost 31% of total farmed area by 2000, while the share of corn, wheat, sorghum and pumpkin output produced by black farmers was substantially less in 2000 than in earlier years. Likewise, the share of the country's cattle and poultry stock held by black farmers had contracted a little by 2000, although the sheep population on black-owned farms had increased marginally from 1960 to 2000.

Table 2: Black farmers' share of area farmed and planted and national production of selected crops, 1918–2002

	Area		Share of quantity produced				Number of		
Year	Farms	Planted	Corn	Wheat	Sorghum	Pumpkins	Cattle	Sheep	Poultry
					Percentage				
1918	16.4	27.2	23.2	03.5	74.3	36.3	24.5	14.4	34.9
1930	-	-	23.0	-	77.0	-	51.1	10.8	-
1937	-	-	-	-	81.0	-	-	9.9	-
1950	-	-	18.8	01.7	46.4	-	41.0	11.7	31.3
1960	15.4	16.9	13.0	01.5	34.7	-	38.8	9.5	38.8
1991	14.4	15.2	-	-	-	-	-	-	-
2002	30.9	14.4	3.0	0.0	0.1	17.3	30.1	10.1	29.1

Sources: Liebenberg et al. (2010), based on data from OCS (1919, 1932, 1939); BCS (1952, 1963); CSS (1992); Stats SA (2005)

Note: All entries in the table represent the black farmer share of the respective national total. Area planted is the area planted to all field crops. The livestock numbers represent the number on farms as of 31 August in each of the years.

In addition to the Land Reform and Restitution initiatives that were implemented beginning in 1994, the South African government has established several programs to support black farmers. These include the Land Redistribution for Agricultural Development program (launched in 2000); the Comprehensive Agricultural Support Program, which provides post-settlement support to targeted black farmers, whether they acquired land through private means or as part of a land reform program; and the Micro-Agricultural Financial Institutions of South Africa (MAFISA) program that extends micro-finance services to economically active poor rural households, small farmers and agribusinesses. MAFISA provides loans to emerging farmers not served by the Land Bank, although the program is administered by the Land Bank on behalf of the Department of Agriculture (DoA, 2009). The rollout of these programs to date has been slow and it is too early to judge their effectiveness.

4. Agricultural input

Figure 2 gives an indication of the significant structural changes in farmland use in South African agriculture since 1910. Total farmed area grew to a peak of 91.8 million hectares in 1960, declining

steadily to 82.2 million hectares in 1996, where it has since more or less stabilized. Total farm numbers followed a similar pattern, peaking in 1953 at 119,600 and declining at an average rate of 1.23% per year thereafter, so that by 2007 the number of farms had dropped to a third of the number that prevailed five decades earlier. The interplay between changing farm numbers and the total area of farms meant that average farm size declined during the first half of the 20th century (from 1,019 hectares in 1910 to 730 hectares in 1952) and increased during the second half of the century, to an average of 1,647 hectares in 2000. Average farm size has continued to grow; in 2002 it was 1,841 hectares per farm.[9]

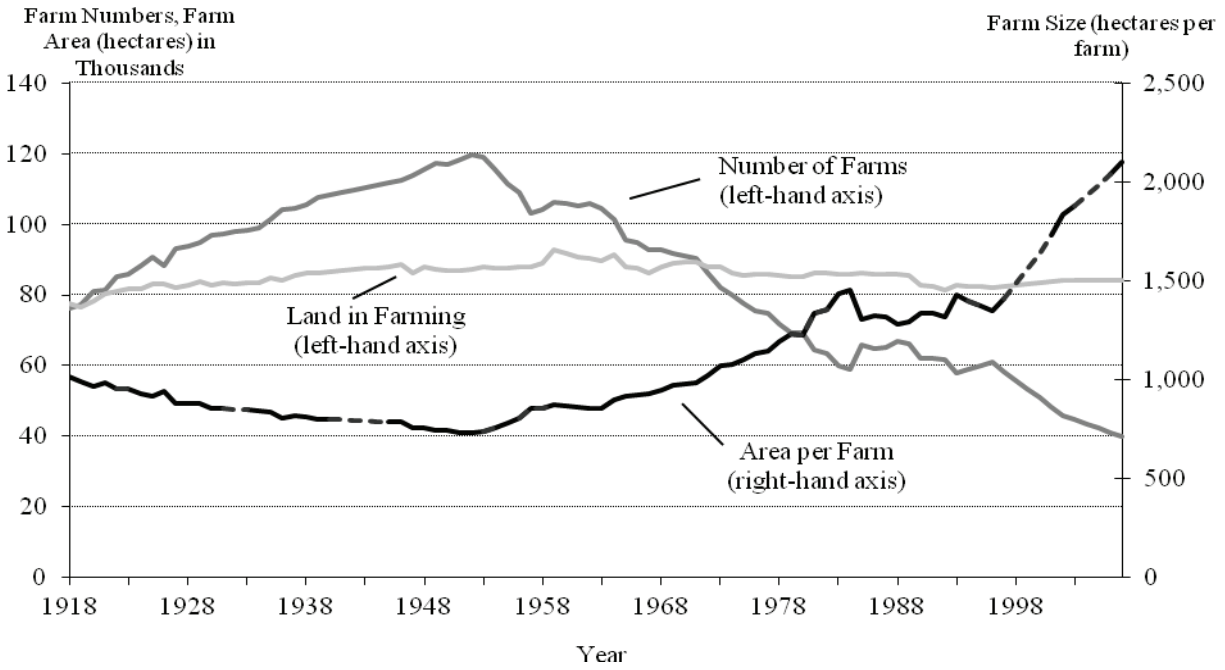

Figure 2: Number, total area and average size of farms, 1918–2007

Source: Liebenberg et al. (2012)

Note: Dashed sections of farm size plot indicate estimates (via linear interpolation).

Figure 3 shows trends beginning in 1947/48 in the total cost shares of four agricultural input categories: labor, land, capital and materials. Material inputs (largely purchased from off-farm sources) have claimed an increasing share of total costs, from around 30% in 1947/48 to 50% in 2006/07. Reported capital costs have fluctuated at around a 30% share of total costs over the same period, while labor inputs have steadily declined as a share of total costs, from almost 36% in 1947/48 to less than half that (15.1%) by 2006/07. At the beginning of the period, land costs accounted for 6.6% of total costs, growing to 15.5% by the mid-1970s, then shrinking to just 3.0% of total costs by 2006/07. Notably, Alston, Andersen et al. (2010) report land cost shares for the US that followed a similar trend, starting at 17% of total cost in 1949, growing to 20% during the late 1970s and early 1980s (when US land prices soared), then falling to 15% by 2002. However, according to these data, land cost shares are uniformly lower in South Africa than in the US, perhaps reflecting a much lower ratio of cropped

[9] Agricultural census results indicate a continuing increase in average farm size, to about 2,113 hectares per farm, and a continuing decline in farm numbers, to 39,966 in 2007. This may misrepresent the total number of farms, as only farming units registered for tax purposes are currently included in the agricultural census (Liebenberg, in progress).

to total land in South Africa than in the US, along with a smaller share of that cropped land being under irrigation.[10]

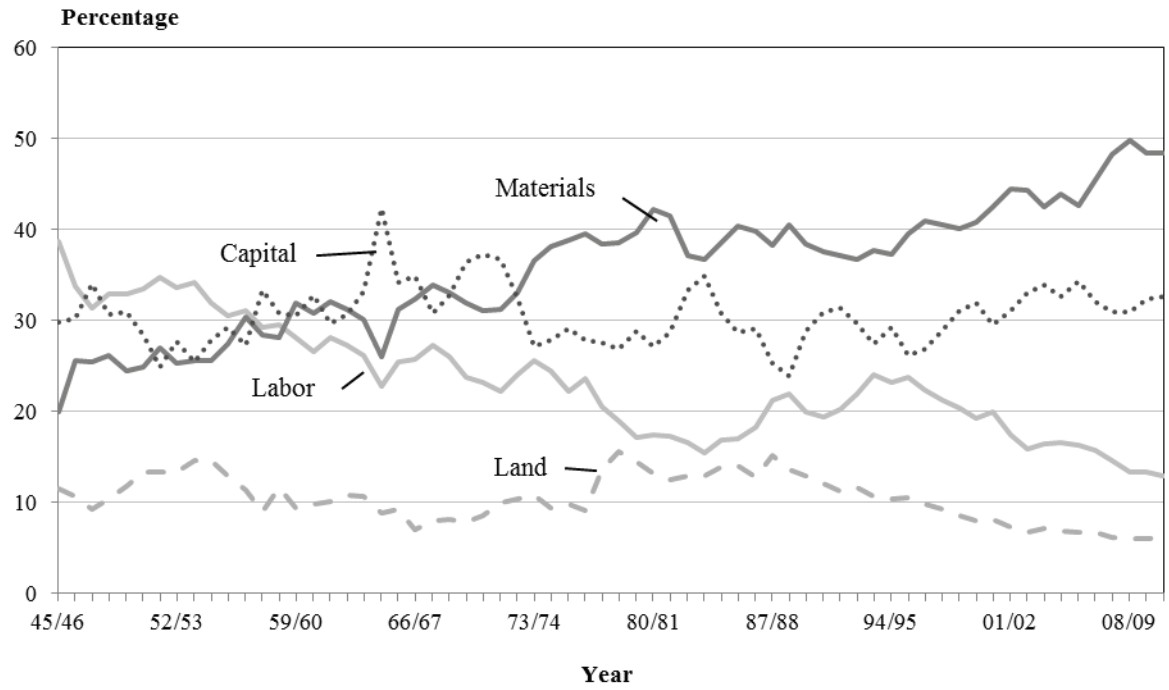

Figure 3: Input cost shares, 1945–2010

Source: Liebenberg (2012) based on data from DAS (2012)

Note: In this compilation, 'land' includes all land in agriculture (irrigated and rainfed crops, permanent and planted pastures and wood- and forest-land); 'labor' includes owner-operator, hired labor (including domestic workers), and family labor; 'capital' includes tractors, machinery and implements, fixed improvements such as buildings erected and development work undertaken; and 'materials' includes dips and sprays, fuel, fertilizer, packaging, feed and so on. The plots represent the respective shares in the total cost of agricultural production.

The steady decline in the reported share of labor costs from 1945/46 to 1983 accords with Payne et al.'s (1990:412) finding that 'labor costs constituted a declining share of total farm costs between 1945 and 1987'.[11] During this same period total capital costs rose in absolute terms and as a share of total costs through to 1965, whereafter the capital cost share declined for several decades as material costs rose more rapidly. According to Van Zyl et al. (1987:249), who studied labor trends in rain-fed maize production, the post WWII decline in labor cost shares in that sector occurred in spite of a rise in unit

[10] According to DAS (2009:5), only 13.7% of South Africa's total land area is potentially arable, and about 69% of that arable area is only suitable for grazing. Moreover, a large share of the grazing area is in the semi-arid Karooveld located in the central northwestern part of the country.

[11] Payne et al.'s finding (1990) refers only to maize and wheat production in certain parts of the country and does not necessarily accord with trends for the agricultural sector as a whole. Maize and wheat as a share of total cultivated area peaked at 80.3% in 1930, declining to 52% in 2008 when maize accounted for 12.7% of the value of agricultural production and wheat for 3.8%.

labor costs, reflecting the net consequences of factor substitution effects stemming from changes in the relative price of inputs and a series of technical changes. The labor use implications of these technological changes were complex. The shift from animal (mainly oxen) draught power to tractors, especially during the 1945–1970 period, no doubt increased the capital-labor ratio per unit of cultivated land, but also spurred the expansion of cultivated area, which had the effect of offsetting increases in the overall demand for labor.[12] In addition, the yield-increasing use of improved seed varieties and fertilizer initially expanded the demand for harvest labor during these same decades, but the eventual widespread use of mechanized harvesting, at least within commercial agriculture, reversed this trend and shrunk the aggregate demand for farm labor.[13] The increased costs share for labor evident in Figure 3 during the 1983–1993 period reflects a reported decline in the (inflation-adjusted) cost of land, capital and materials and not an increase in labor costs per se.

Policies also played their part in shifting the structure of factor use in the second half of the 20th century. The Pass Laws of 1952 may have accelerated the substitution away from labor on commercial farms, especially during the late 1960s when the conditions of the Act were severely applied; however, other polices probably had a bigger effect.[14] Biggs (1982) notes that farmers were given access to cheap credit (which for periods of time involved negative real interest rates) and tax breaks that allowed capital equipment to be completely written off within the first year after purchase. Thirtle, Sartorius von Bach and Van Zyl (1993:313) observe that 'by the end of the [1981–83] drought, the credit and tax concessions were largely gone, the price of gold had plummeted and the rand was drastically devalued. These events had the combined effect of making domestic inputs, especially labor, much cheaper than (imported) capital items, causing a dramatic reversal of the historical trend during the late 1980s and into the early 1990s, with labor use increasing considerably as a substitute for relatively expensive capital during this period'. Since then new legislation regarding security of land tenure for agricultural labor tenants working on large farms and the stipulation of minimum wages has again spurred the sector to shed labor, as the decline in the share of labor in the reported total costs of production during this period shows (Figure 3).

5. Partial productivity patterns

Crop yields in South Africa are susceptible to significant year-on-year variation, given that much of the production comes from rain-fed systems with average rainfall in the range of less than 250 mm per year in the west to 750 mm in the east: at the lower end of the ideal range for the crops in question (DOA, 1957). On average, more than 80% of the country's total land mass receives an average annual rainfall of 750 mm or less, with 30% receiving less than 250 mm per year. Nonetheless, the long-run

[12] Liebenberg (in progress) estimates that the total cultivated area in South African agriculture (including the area in annual and perennial crops and the area spanning commercial and surveyed homeland farming) continued to expand until 1974, when it peaked at 11,491,105 hectares, declining to 7,089,108 hectares by 2010.

[13] Payne et al. (1990) report data from De Klerk (1983) which shows that 81% of the maize farms in the Western Transvaal used hand harvesting methods in 1968, 16% mechanical, and 3% hand and mechanized methods. By 1981 the situation had been reversed: 5% of the farms used hand harvesting methods, 89% were fully mechanized and 6% used both hand and mechanized methods.

[14] The Pass Laws Act of 1952 was part of a historical series of such Acts that in its earliest incarnation in 1797 sought to exclude all 'natives' from the Cape Colony. The 1952 act made it compulsory for all black South Africans over the age of 16 to carry a 'passbook' at all times. An' employer' was defined under the law and could only be a white person. The passbook also documented permission requested and denied or granted to be in a certain region and the reason for seeking such permission. Under the terms of the law, any government employee could strike out such entries, in effect canceling the permission to remain in the area.

crop yields summarized in Table 3 reveal substantial gains in average crop yields during the 20th century. Corn yields have increased more than fourfold since the 1910s, wheat fourfold and sorghum more than sevenfold (Table 3). Drought is an enduring reality for South African farmers and has had a detrimental impact on crop yields, especially during the first half of the 1930s, 1980s and 1990s. The growth in yields during the first half of the 20th century was associated with increased mechanization and increased use of improved seeds (with a corresponding marked increase in the use of chemical inputs, including fertilizers, herbicides and pesticides) also helping to spur crop yield growth after the 1960s.

Table 3: Average yields for selected commodities for various periods, 1910–2010

	Livestock			Crops		
	Cattle	Sheep	Pigs	Corn	Wheat	Grain sorghum
	Kg per head			*Kg per hectare*		
Five-year averages centered on						
1912/13	na	na	na	556	551	445
1920/21	235	39	na	504	525	383
1930/31	205	30	90	473	507	433
1940/41	251	29	85	642	473	561
1950/51	226	33	78	677	496	309
1960/61	223	29	81	1,076	596	506
1970/71	217	25	64	1,426	958	944
1980/81	215	25	66	2,111	1,244	1,519
1990/91	228	22	61	2,237	1,355	1,862
2000/01	231	18	62	2,859	2,453	2,225
2005/06	259	20	75	4,267	2,785	2,404

	Livestock			Crops		
	Cattle	Sheep	Pigs	Corn	Wheat	Grain sorghum
	Kg per head			*Kg per hectare*		
Average annual growth	*Percentage per year*					
1910/11–	na	na	na			
1929/30				4.20	2.13	5.46
1930/31–						
1949/50	0.82	1.74	-0.56	5.79	0.00	0.61
1950/51–	1.00	-1.51	-0.43	7.63	5.88	19.01

1969/70						
1970/71–						
1989/90	-0.32	-0.43	-0.32	10.34	6.64	10.78
1990/91–						
2010/11	1.21	0.00	1.46	14.00	13.19	11.56
1920/21–						
1949/50	-0.10	0.15	-0.18	7.18	1.71	4.11
1950/51–						
2010/11	0.60	-0.63	0.26	10.37	9.36	13.54
2000/01–						
2010/11	2.02	1.81	1.74	5.55	3.93	0.29

Sources: DAS (2012); Liebenberg (in progress)

Note: 'Corn' and 'sorghum' include only the crop grown for grain, but 'wheat' includes all types of wheat (mainly durum). Growth rates were computed by the natural log regression method. Corn and wheat trends are based on data for commercial farms, but sorghum also includes homeland production (an especially significant share of total production, especially in the earlier years of our sample). Livestock 'yields' means the average weight of slaughtered animals.

The livestock 'yields' presented in Table 3 are harder to interpret (in this case measuring the ratio of two alternative output indicators: the slaughtered weight of animals relative to the number of slaughtered animals) and reflect the difficulty of measuring productivity in this sector meaningfully. For instance, the decline in the average slaughter weight of pigs reflects a largely demand-driven shift to leaner pork products. The slaughter weight of sheep also declined steadily after the Second World War, from an average carcass weight of 39.1 kg per head during the 1930s and 1940s to just 19.8 kg per head in more recent years. Again the shift in consumer preferences has played a role – with leaner and much younger (lamb rather than mutton) cuts of meat being preferred – but massive structural changes in the sheep industry have also played their part. As demand for wool has slackened over the past three decades or so, growers have shifted from sheep-for-wool to sheep-for-meat systems of production, with associated shifts in the average age of the sheep population (a move to younger and hence smaller animals) and with direct consequences for average carcass weights. As evidence of this trend, merino sheep accounted for up to 80% of the national sheep herd in the 1960s (and up to 86% if dual-purpose breeds are also included), whereas now the merino share has declined to 50% (or 71% if dual-purpose breeds are included). The total number of sheep in the country has also declined from 37.4 million head of sheep in 1966 to 21.9 million in 2008, with the number of merino sheep declining from 28.3 million to 11.6 million over the same period (DAS, 2011).

Land productivity grew at an average annual rate of 1.41% per year from 1910 to 1924, slightly slower than the corresponding rate of labor productivity growth, which averaged 1.46% per year (Figure 4). The 20th century saw three phases of distinct growth patterns in these two partial factor productivity measures. During the pre-WWII years (from 1910 to 1940), land productivity grew by 1.92% per year, double the corresponding annual rate of growth of labor productivity (1.29% per year). The rate of growth of both land and labor productivity picked up over the four decades following WWII (1946–1980), averaging an impressive 5.11% per year for labor productivity and 4.23% per year for land

productivity. Since then, productivity growth rates for both land and labor have slowed considerably, down to 2.67% per year for labor and only 1.31% per year for land productivity.

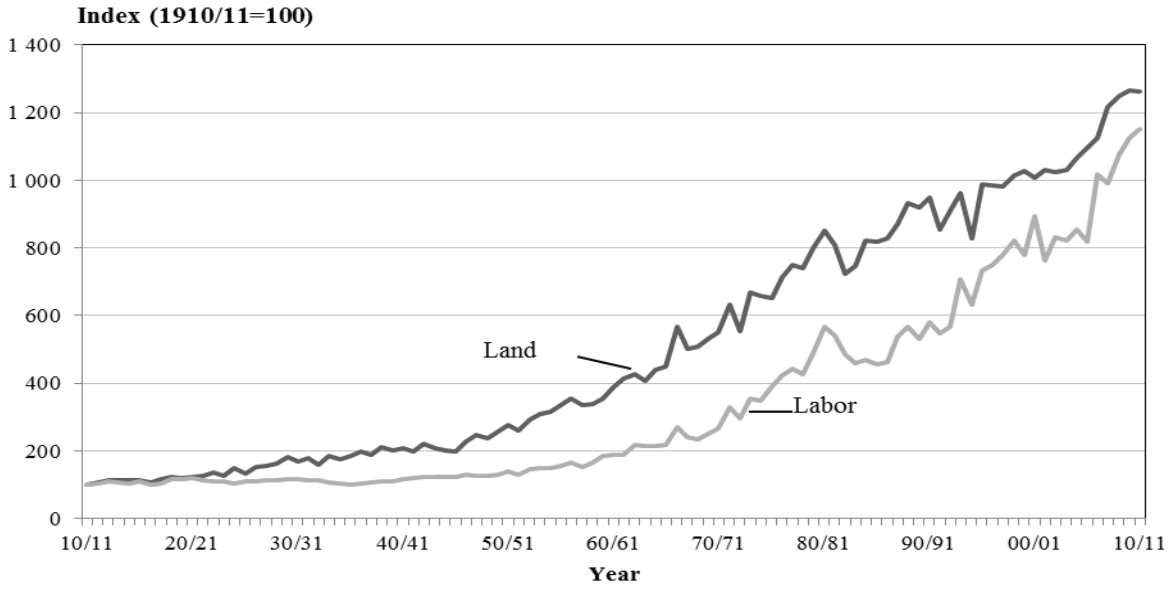

Figure 4: Agricultural labor and land productivity, 1910–2010

Sources: Authors' calculations based on data from DAS (2012) and agricultural census and survey reports since 1918 (obtained by the authors from Statistics South Africa in 2011).

Note: Labor data were adjusted to consistently include seasonal labor. These series are Divisia (specifically Tornqvist) quantity indexes. Beginning in 1993/94 the agricultural employment statistics reported by both the Agricultural Censuses and the Labor Force Survey indicate a marked decline in labor use in South African agriculture, especially after 2002/03. Labor Force Surveys data also indicate substantial (and suspect) year-on-year fluctuations, and so for this analysis the Agricultural Census data were used, even though they are suspected of undercounting the agricultural labor force. The sizable and suspiciously large surge in the agricultural labor productivity estimates for the years 2003/04 to 2004/05 reflect the combined effect of strong growth in agricultural output for these years plus lower than expected (and possibly erroneous) reported labor use estimates for these particular years.

Figure 5 draws on FAO data to place land and labor productivity measures for South Africa in a broader African context. Here we use the graphic technique developed by Hayami and Ruttan (1985[1971]), in which the horizontal axis is a measure of labor productivity and the vertical axis a measure of land productivity for the period 1961–2009. Productivity loci for five regions in sub-Saharan Africa plus Nigeria and South Africa are included. The productivity loci were formed by taking a ratio of the value of aggregate output and the respective land and labor inputs. Output is an FAO estimate of the total value of agricultural production (spanning all crops and livestock commodities) expressed in 2004–2006 average purchasing power parity agricultural prices (FAO, 2011). Land is a measure of harvested and permanently pastured area and labor is a head count of the total economically active workers in agriculture. Both axes are measured in natural logarithms so that a unit increase in either direction is interpreted as a proportional increase in land or labor productivity, and the length of the productivity locus is an indication of the average annual rate of change in productivity. Most, but by no means all, of the productivity paths move generally (but not uniformly) in a northeasterly direction, starting in 1961 and ending in 2009, indicating productivity growth. The diagonals indicate constant labor-to-land ratios. As the productivity locus for a particular country or

region crosses a diagonal from left to right, this indicates a decrease in the number of economically active workers in agriculture per harvested acre in that region.

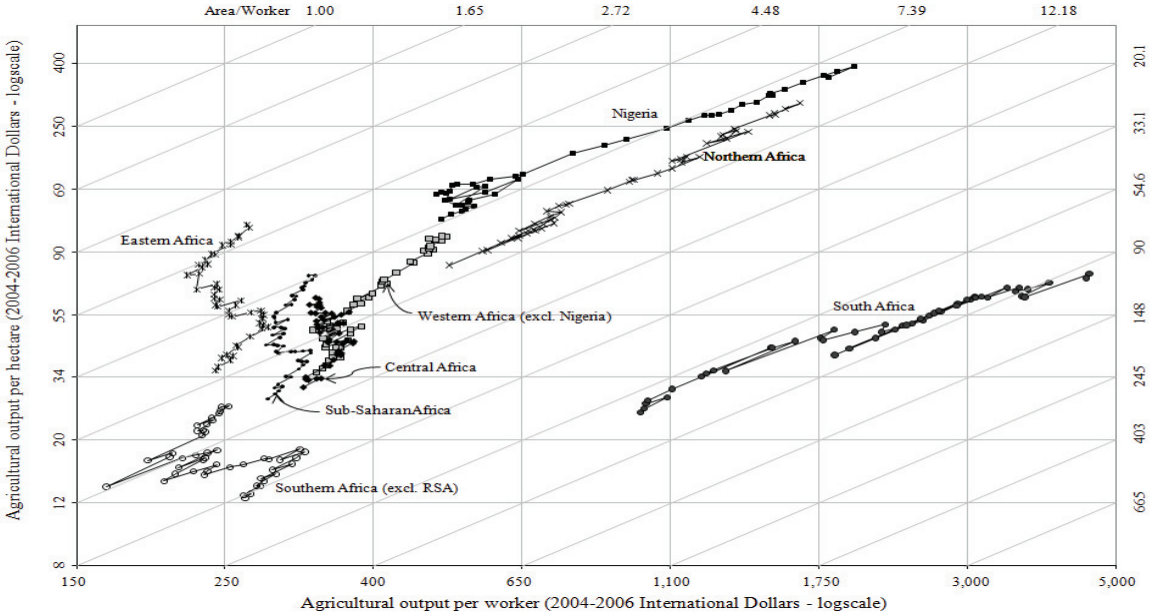

Figure 5: Agricultural labor and land productivity in sub-Saharan Africa, 1961–2009

Source: Calculated from FAOSTAT data (FAO, 2011)

Note: Central Africa includes Burundi, Cameroon, Central African Republic, Chad, Congo Dem R, Congo Rep, Equatorial Guinea, Rwanda, Sao Tome & Prn, Sudan. Eastern Africa includes Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar, Malawi, Reunion, Seychelles, Somalia, Tanzania, Uganda. Western Africa (excl. Nigeria) includes Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Senegal, Sierra Leone, Togo. Southern Africa (excluding South Africa) includes Angola, Botswana, Lesotho, Mauritius, Mozambique, Namibia, Swaziland, Zambia, Zimbabwe. Northern Africa includes Algeria, Egypt, Libya, Morocco, Tunisia, Western Sahara. Sub-Saharan Africa excludes Nigeria, Northern Africa, South Africa. See text for data construction and plotting details. The land-labor ratios are constant along each grey diagonal line and values for these ratios are given at the terminus of the respective diagonal line on the top and right axes.

The South African and Nigerian productivity loci follow paths that are distinctly different from the other regions of sub-Saharan Africa plotted in Figure 5. Both countries had increases in land and, especially, labor productivity that were at considerably higher rates than the rest of Africa. Moreover, the value of output per unit of labor in 2009 for both countries was also considerably higher than the rest of Africa: $4,452 per worker in the case of South Africa and $1,713 per worker for Nigeria compared with an average of $465 per worker for the rest of Africa. South Africa is notable in that it is the only entry in Figure 5 for which the land-labor ratio increased substantially over time (implying more pronounced growth in labor than in land productivity): from 39.6 hectares per worker in 1961 to 60.1 hectares per worker in 2009. In Nigeria, the land-labor ratio (starting from a much smaller initial value) increased a little: from 4.36 to 5.13 hectares per worker over the comparable period. In almost all the other regions depicted (except northern Africa), real output per worker stagnated or (in the case of eastern, central and southern Africa, excluding South Africa) actually declined, although land productivity in all regions improved over time. Thus the horizontal spans of the productivity loci are smaller than their vertical spans, indicating that land-labor ratios were smaller on average in 2009 than they were half a century earlier.

Northern and western Africa (excluding Nigeria) are exceptions to the productivity pattern of the general rest-of-Africa (sub-Saharan Africa minus South Africa and Nigeria). These regions saw labor productivity grow by 2.41 and 0.96% per year respectively from 1961 to 2009 (compared with 2.88% per year for southern Africa and 3.28% per year for Nigeria). Labor productivity in eastern Africa barely budged and in southern Africa (excluding South Africa) it declined from $262 per worker in 1961 to a lowly average of $245 for the period 2000 to 2009. These productivity trends are a dismal record of the poverty and chronic food insecurity that afflict a large share of the population in these parts of Africa.

Notably, the lackluster growth in labor productivity in central, eastern and southern Africa (excluding South Africa) belies their comparatively rapid rates of growth in total output. These three regions experienced real agricultural output growth in the range of 1.40% to 2.88% per year over the period 1961–2009, in some instances much faster than the comparative rates of growth in total output for South Africa, which averaged just 1.82% per year. However, South African agriculture ended the period with fewer agricultural workers than it had in 1961, whereas the economically active population in agriculture in the rest-of-Africa regions (like their populations generally) grew in the range of 0.18% to 2.48% per year. Thus, the poor labor productivity performance of central, eastern and southern Africa (excluding South Africa) reflects a failure of labor to leave agriculture for gainful employment elsewhere in these economies rather than a comparatively low rate of growth in agricultural output. Moreover, although the land area in agriculture has continued to expand in these parts of Africa, it has done so at a rate lower than the rate of growth in agricultural workers. With land-labor ratios ranging from 2.30 to 8.97 hectares per worker in these regions, it is difficult to envisage raising output per worker to substantial levels, especially given the generally poor rural infrastructure and other market and environmental constraints that limit the transition to higher-valued forms of agricultural output.

6. Multifactor productivity in South African agriculture

Table 4 reports a series of measures of aggregate input, output and multifactor productivity (MFP) growth for South African agriculture over the period 1947–2007. The bottom half of the table includes alternative MFP estimates reported in several other studies. They indicate a large disparity in the measured rates of MFP growth for South African agriculture, with no apparent consensus or pattern emerging from or evident in the different measures. Some of these differences may be attributable to differences in the range of years covered by each study, but differences in data coverage and treatment no doubt play a role too, making a collective assessment of these studies problematic.

Table 4: Growth of South African agricultural output, input and MFP indexes, various estimates, 1945–2010

Period	Attributes of study					Study source	
	Output	Input	MFP	Labor	Land	Authors	Date
	Percentage per year						
1945–1970	4.52	3.38	1.14	3.50	4.49	The present study	
1970–1988	2.54	-0.93	3.47	3.39	2.76	The present study	
1988–2010	1.34	1.38	-0.04	3.13	1.39	The present study	
1945–2010	2.45	0.97	1.48	3.41	2.51	The present study	
1947–1991			1.30			Thirtle, Sartorius von Bach& Van Zyl	1993
1947–1997			1.30			Schimmelpfennig et al.	2000
1965–1994			0.28			Nin et al.	2003
1952–2002			1.87			Conradie et al.	2009a

Sources: See text for details of entries in the upper half of the table.

Note: For the four other studies reported here our corresponding MFP growth rates are 1.70% per year for the period 1947–91, 1.67 per year for 1947–97, 2.59% per year for 1965–94 and 1.31% per year for 1952–2002. Thirtle, Atkins et al. (1993) report an MFP growth rate of 0.0% per year for 1947–65 (compared with our 0.19 rate), 2.15% per year for 1965–81 (cf. 3.62) and 2.88% per year for 1981–91 (cf. 1.35).

The upper half of Table 4 reports an effort by the present authors to extend the aggregate input, output and MFP measures first reported by Thirtle, Sartorius von Bach and Van Zyl (1993) for the period 1947–1991 and updated in Schimmelpfennig et al. (2000) for the period 1947–1997. Thirtle, Sartorius von Bach and Van Zyl's aggregate output measure consists of a Divisia aggregation of three pre-aggregated groups of outputs, namely crops, horticulture and livestock. Their input index consists of an aggregation of measures of land, labor, materials (packing materials, fuel, fertilizer, dips and sprays and other non-farm items) and capital inputs (fixed improvements and machinery). Our reworking and update of these series is reported in Table 4 and Figure 6 and spans the period 1947–2007. Our series was developed by extending the Schimmelpfennig et al. 1947–1997 series, and in so doing we strove to deploy the same methods, data types and sources used in the earlier compilations, but with several notable differences.[15]

[15] The authors thank Colin Thirtle for providing the data he and colleagues developed for the 1947–1997 period. Liebenberg (in progress) is developing an entirely new series constructed from different data sources and using different methods. Many measurement issues require attention in the official statistics, e.g. historical capital input and livestock inventory estimates were compromised by especially low participation rates in the national agricultural censuses conducted since 1992/93. Moreover, DoA statistical agencies have adopted alternative estimation methods that resulted in significant changes to the previously reported national capital and livestock inventory estimates back to the 1980s (personal communication, Dirk Blignaut, Head of Regional Production Statistics, Department of Agriculture, South Africa, Pretoria, 21 August 2009). Liebenberg is also attempting to correct for significant inconsistencies in the officially reported data on agricultural labor, attributable to the inconsistent inclusion of seasonal labor, beyond the corrections to address this problem that we have undertaken for this study.

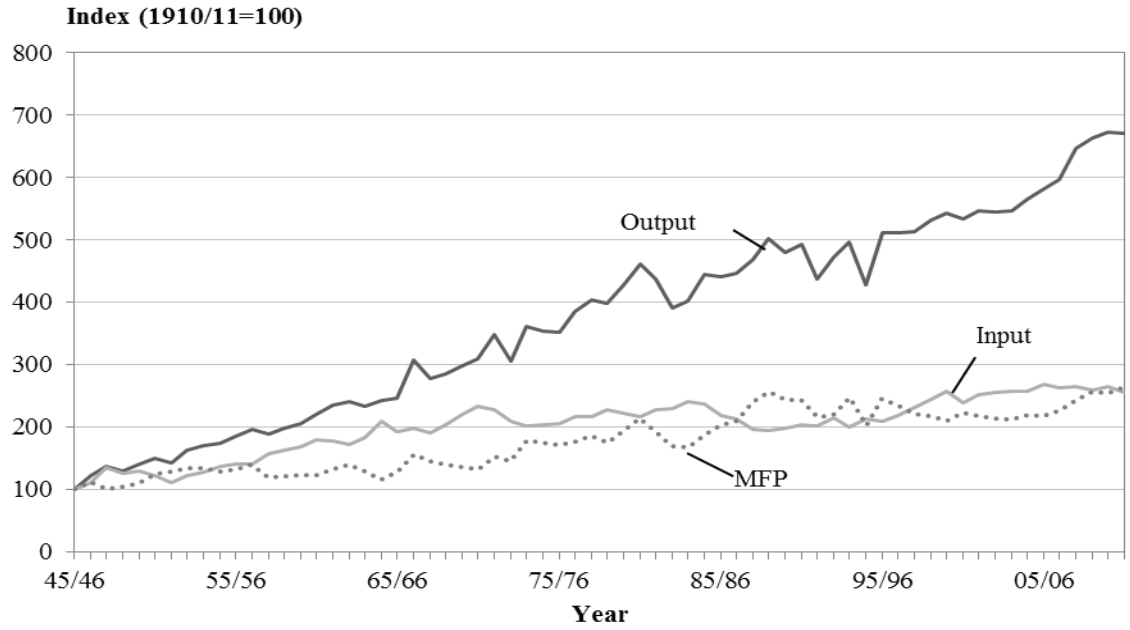

Figure 6: Agricultural output and input quantity, and MFP indexes, 1945–2010

Sources and notes: See text for details.

The data used by Thirtle, Atkins et al. (1993) and Schimmelpfennig et al. (2000) were largely taken from the Abstract of Agricultural Statistics published by the Department of Agriculture's Directorate of Agricultural Statistics and supplemented with additional information obtained from other DoA sources. Annual issues of the Abstract rarely report data for periods longer than 30 to 40 years, which means that a long-run series beginning in 1945/46 has to be formed by splicing together data from several issues of the Abstract. For our compilation we used more detailed underlying data from past agricultural censuses to reveal and help resolve inconsistencies over time in the composition and construction of the three pre-aggregated components used to form the output aggregate reported here.

Our approach also resulted in substantial adjustments to the land in farms series and agricultural employment series compared with the earlier compilations. In summary, our estimates of land in farms excludes land allocated to timber plantations and other (e.g. residential) uses, whereas the earlier Thirtle, Atkins et al. (1993) and Schimmelpfennig et al. (2000) estimates inconsistently included this area. To exclude domestic workers (employees who are mainly or exclusively engaged in domestic work) from their farm labor totals, Thirtle, Atkins et al. (1993) and Schimmelpfennig et al. (2000) used a time-invariant domestic workers to farm employees (regular farm workers) ratio, whereas we used census data to adjust this ratio over time. For years in which the number of casual farm employees (seasonal and occasional employees, excluding contractors and their employees) was not reported, Thirtle, Atkins et al. (1993) and Schimmelpfennig et al. (2000) again used an invariant casual farm employees to regular farm employees ratio to estimate total farm employees. In forming our estimates we took account of changes in the cropped area and quantity of production (which affect the demand for seasonal labor) to develop our total farm employee estimates. In addition, we included family labor in our labor-use totals, whereas this component of labor was excluded from the earlier estimates. Finally, all our data were compiled on a crop-year basis in accordance with the census reports, while Thirtle, Atkins et

al. (1993) and Schimmelpfennig et al. (2000) used a mix of crop and calendar years for the various data elements used to form their estimates.

According to our revised and extended measure, South African MFP grew, on average, by 1.48% per year from 1945 to 2010. The 1970–1988 period had the highest rate of growth for the post-1945 period studied, an impressive (and perhaps questionable) 3.47% per year. This is substantially higher than the 1.14% per year rate reported for the immediate post-WWII decades. Notably, MFP was stagnant during the period 1988–2010, reflecting a decline in the rate of output growth coupled with an increase in the rate of measured input use in agriculture.

Recent studies by Conradie et al. (2009a,b) focusing on the Western Cape extend the earlier methods used by Thirtle and colleagues to compile regional estimates of aggregate input, output and MFP growth for South African agriculture. The Western Cape has distinctive agro-climatic attributes: specifically, it is the only region in South Africa that experiences winter rainfall, and so its agricultural output is dominated by deciduous fruit and wine grapes, whereas output in the rest of the country consists mainly of field crops and livestock products.

Conradie et al. (2009b) estimate that during the period 1952–2002, MFP in the Western Cape grew on average by 1.22% per year. This is about the same as the overall rate for MFP growth at the national level, but the regional pattern of growth was considerably different from the national pattern of growth over comparable time periods. Measured MFP at the national level grew at a considerable pace beginning in the mid-1960s (averaging 4.02% per year from 1965 to 1975) whereas MFP growth in the Western Cape only began to pick up in the early 1970s. Moreover, MFP growth in the Western Cape was just 0.89% per year from 1971 to 2002 (compared with 1.73% per year for the period 1971–2002), less than half of the corresponding national rate of growth, which Conradie (2009b:12) puts at more than 2% per year compared with our estimate of 1.73% per year. Again, differences in data sources and treatment may account for some of the national and regional disparities in South African MFP growth, but it is also likely that differences in the composition of outputs and inputs and other factors played a role, as they did in the case of the considerable differences in productivity patterns for the nation and for individual states for the same era reported for the US by Alston, Andersen et al. (2010).

In Table 5 we summarize estimates of MFP growth for a series of other studies for other countries in sub-Saharan Africa. Extracting plausible patterns from this evidence is difficult, in part because of substantive differences in data and methods. One fairly consistent finding is that the reported rates of MFP growth in Africa are generally low compared with those reported for other countries worldwide (e.g. the cross-country evidence reported in Alston, Babcock and Pardey 2010). Summarizing the changing pattern of MFP performance over time, the 'sequential Malmquist' results produced by Nin-Pratt and Yu (2008) and Alene (2010) suggest that MFP growth in more recent times, beginning in the early- to mid-1980s, has increased relative to the rates typically reported for the preceding two decades.[16] The empirical basis for this result is an increase in the measured rate of growth in aggregate

[16] In contrast, the Africa-wide Malmquist results of Alene (2010) suggest that the rate of MFP growth has slowed in recent years.

agricultural output, largely without offsetting increases in the estimated rate of growth of aggregate input use.[17]

Table 5: Estimated MFP growth rates for sub-Saharan Africa – various studies

Authors	Publication date	Region	Crop/Industry	Methodology	Sample period	Average annual growth rate
						Percentage per year
Thirtle, Atkins et al.	1993	Zimbabwe	Agriculture	Tornqvist		
			Commercial		1970–1989	3.43
					1970–1979	3.87
					1980–1989	3.98
			Communal		1970–1989	4.64
					1970–1979	-1.99
					1980–1989	7.26
Block	1994	Sub-Saharan Africa	Agriculture	Regression and growth accounting	1963–1968	0.02 to 1.45[a]
					1968–1973	-0.83 to 9.20[a]
					1973–1978	-0.46 to 4.50[a]
					1978–1983	-6.20 to -0.02[a]
					1983–1988	-3.10 to 2.15[a]
Thirtle et al.	1995	Sub-Saharan Africa	Agriculture	Malmquist	1971–1986	0.84
Lusigi & Thirtle	1997	Sub-Saharan Africa	Agriculture	Malmquist	1961–1991	1.27
Irz & Hadley	2003	Botswana	Agriculture:	Input distance		
			Traditional farmers		1979–1996	-2.3
			Commercial		1968–1990	1.16
Fulginiti et al.	2004	Sub-Saharan Africa	Agriculture	Semi-nonparametic	1960s	0.68
				Fourier production function	1970s	-0.32
					1980s	1.29
					1990s	1.62
					1961–1999	0.83
Dhehibi & Lachaal	2006	Tunisia	Agriculture	Tornqvist	1961–2000	3.6

[17] Commenting on this recovery in MFP growth rates, Nin-Pratt & Yu (2008:42) conclude that 'the evidence in this study points to policy changes conducted by sub-Saharan African countries between the mid-1980s and the second half of the 1990s as one of the many factors determining the agricultural sector's improved performance'.

Ludena et al.	2006	Middle East & North Africa	Crops	Malmquist	1961–2000	-0.03
			Ruminants		1961–2000	-0.02
			Non-ruminants		1961–2000	0.64
			Average		1961–2000	0.03
		Sub-Saharan Africa	Crops		1961–2000	0.15
			Ruminants		1961–2000	0.36
			Non-ruminants		1961–2000	0.5
			Average		1961–2000	0.21
Nin-Pratt & Yu	2008	Sub-Saharan Africa	Agriculture	Malmquist	1964–1973	-2.35
					1974–1983	-1.67
					1984–1993	1.65
					1994–2003	1.83
Alene	2010	Africa (incl. sub-Saharan and North Africa)	Agriculture	Malmquist	1970–1980	-0.9
					1981–1990	1.4
					1991–2004	0.5
					1971–2004	0.3
				Sequential Malmquist	1970–1980	1.4
					1981–1990	1.7
					1991–2004	2.1
					1971–2004	1.8
Block	2010	Sub-Saharan Africa	Agriculture	Regression	1960–1984	0.14
					1985–2002	1.24
					1960–2002	0.61
Avila & Evenson	2010	Africa (incl. sub-Saharan and North Africa)	Agriculture	Growth accounting	1961–1980	1.20
					1981–2001	1.68
					1961–2001	1.44
			Crops		1961–1980	1.03
					1981–2001	1.74
					1961–2001	1.49
			Livestock		1961–1980	1.09
					1981–2001	1.20
					1961–2001	1.68

Notes: The input distance function used by Irz and Hadley (2003) is a conventional measure of the largest factor of proportionality by which the input vector can be scaled down to produce a given output vector with the technology that exists at a particular time. The premise of the sequential Malmquist TFP (total factor productivity) index used by Alene (2010) is that past production techniques are also available for current production activities. The distance metrics in this instance are calculated using linear programming techniques formulated with respect to a 'sequential' technology frontier.

[a] Reports four MFP growth rates per period based on different measures of output.

The weight to be given to even these limited 'stylized facts' about MFP growth in sub-Saharan Africa is questionable. For example, there is a large variation in the reported longer-run average rates of MFP growth for the region included in Table 5. Lusigi and Thirtle's (1997) estimate is 1.27% per year (for the period 1961–1991), Fulginiti et al. (2004) report a rate of 0.83% per year (1961–1999) and Ludena et al. (2006) estimate 0.21% per year growth (1961–2000), which are all less than Avila and Evenson's (2010) figure of 1.44% per year (1961–2001). And even for the earlier years where there is a consensus that MFP growth rates were comparatively low, the variance in the estimates is large. Block's (2010) recent estimate puts MFP growth for the 1961–1980 period at 0.14% per year, Nin-Pratt and Yu (2008) have much lower estimates spanning a similar period (-2.35 and -1.67% per year for the 1964–1973 and 1974–1983 periods respectively), and Avila and Evenson (2010) report a much higher rate (1.20 for the period 1961–1980). The large discrepancies between ostensibly similar MFP growth rates points to the overall fragility of the estimates. They may also reflect more fundamental sources of variation in African agriculture, which is heavily exposed to the vagaries of climate and related (and typically unmeasured) natural factors of production such as pest and diseases, thus making MFP growth rates for particular periods especially sensitive to fluctuations in (end-point) MFP values.

7. Conclusion

South African agriculture appears to have sustained a competitive edge internationally during the decades prior to the late 1980s, with strong growth in agricultural exports and more muted, but still pronounced, growth in net agricultural trade surpluses. However, the country's agricultural exports and net trade balances have declined precipitously in more recent years. These trade trends are loosely concordant with changes in the pattern of MFP growth for South African agriculture, which has grown at much slower rates in recent years than in earlier decades.

The rate of growth in agricultural output has also slowed since the 1980s, largely as a result of a slowdown in the rate of growth in field crop production. Indeed, agricultural output growth in South Africa (and for that matter southern Africa) has lagged behind the rest of Africa in recent decades, even though historically the country's agricultural productivity growth has outpaced productivity growth elsewhere in the continent. The composition of agricultural outputs in South Africa has also changed, with higher-valued horticultural crops gaining market share at the expense of other (staple food) crops and livestock products.

The composition of input use has changed too. Notwithstanding high levels of rural unemployment, South African agriculture has substantially increased its use of material inputs and continued to invest significantly in capital inputs, while the use of labor in agriculture has declined.

South African agriculture is important regionally and in Africa as a whole. In 2009 it accounted for 43.1% of the agricultural GDP of southern Africa and 5.84% of the agricultural GDP for sub-Saharan Africa as a whole (World Bank, 2011). Thus the recent and substantive declines in the pace of South African MFP growth, when coupled with the persistence of historically low rates of labor productivity growth throughout the rest of Africa, are cause for concern. It is difficult to conceive how the chronic hunger and serious bouts of food

insecurity that befall many people throughout Africa can be ameliorated if agricultural productivity fails to pick up pace. Indeed, the estimates presented here indicate that MFP growth in South African agriculture has lost ground in recent years and is now much slower than the country's population growth. The same holds true for Africa generally (at least for the land and labor productivity metrics presented here). These realities make it imperative to rethink and revitalize those rural development options that promote long-term productivity growth, most notably by investing in and encouraging agricultural R&D. It will take time to turn around the poor productivity performance, and so policy choices made now, and how they are implemented, are likely to have profound economic development consequences for South Africa (and the continent generally) for much of the coming century.

Acknowledgements

The research supporting this paper was funded principally by the South African Agricultural Research Council, with additional support from the International Food Policy Research Institute, InSTePP, the University of Pretoria, the Bill and Melinda Gates Foundation by way of the HarvestChoice project and the South African Department of Agriculture, Forestry and Fisheries. The authors thank Colin Thirtle and Dirk Blignaut for their assistance in the analysis leading to this paper.

References

Alene, AD, 2010. Productivity growth and the effects of R&D in African agriculture. Agricultural Economics 41, 223–38.

Alston, JM, Andersen, MA, James, JS & Pardey, PG, 2010. Persistence Pays: U.S. Agricultural Productivity Growth and the Benefits from Public R&D Spending. Springer, New York.

Alston, JM, Babcock, BA & Pardey, PG (Eds), 2010. The shifting patterns of agricultural production and productivity worldwide, CARD-MATRIC on-line volume, Iowa State University. www.matric.iastate.edu/shifting_patterns Accessed 1 January 2012.

Avila, AFD & Evenson, RE, 2010. Total factor productivity growth: The role of technological capital. In Pingali, P & Evenson, RE (Eds), Handbook of Agricultural Economics, Vol. 4, Agricultural Development: Farmers, Farm Production and Farm Markets, Chapter 72, 3769–822. North-Holland, Amsterdam.

BCS (Bureau of Census and Statistics), 1952. Agricultural Census No. 24. Census Year 1949–50: Special Report Series. Government Printer, Pretoria, Union of South Africa.

BCS (Bureau of Census and Statistics), 1958. Agricultural Census No. 30. Census Year 1955–56. Government Printer, Pretoria, Union of South Africa.

BCS (Bureau of Census and Statistics), 1963. Agricultural Census No. 34. Census Year 1959–60. Government Printer, Pretoria, Union of South Africa.

Biggs, FP, 1982. Aspects of combining capital and labour in South Africa, with special reference to the modern agriculture. Unit for Future Research Report No. 82/4. University of Stellenbosch, Stellenbosch.

Block, SA, 1994. A new view of agricultural productivity in sub-Saharan Africa. American Journal of Agricultural Economics 76(3), 619–24.

Block, SA, 2010. The decline and rise of agricultural productivity in sub-Saharan Africa since 1961. NBER Working Paper No. 16481, National Bureau of Economic Research, Washington, DC.

Conradie, B, Piesse, J & Thirtle, C, 2009a. District-level total factor productivity in agriculture: Western Cape Province, South Africa, 1952–2002. Agricultural Economics 40, 265–80.

Conradie, B, Piesse, J & Thirtle, C, 2009b. What is the appropriate level of aggregation for productivity indices? Comparing district, regional and national measures. Agrekon 48(1), 9–20.

CSS (Central Statistical Services), 1992. Agricultural Survey, 1992. No. 11-01-01(1991), Government Printer, Pretoria.

DAS (Directorate of Agricultural Statistics, South Africa), 2009. Abstract of Agricultural Statistics. Directorate of Agricultural Information, Pretoria.

DAS (Directorate of Agricultural Statistics, South Africa), 2011. Abstract of Agricultural Statistics. Directorate of Agricultural Information, Pretoria.

DAS (Directorate of Agricultural Statistics, South Africa), 2012. Abstract of Agricultural Statistics. Directorate of Agricultural Information, Pretoria.

De Klerk, MJ, 1983. Technological change and employment in southern Africa agriculture: The case of maize harvesting in the western Transvaal, 1968–1981. MA thesis, Department of Economics, University of Cape Town, Cape Town.

Dhehibi, B & Lachaal, L, 2006. Productivity and economic growth in Tunisian agriculture: An empirical evidence. Poster paper presented at the International Association of Agricultural Economists, 12–18 August, Gold Coast, Australia.

DoA (Department of Agriculture), 1957. Handbook for Farmers: Agriculture and Related Services, Vol. 1. DoA, Pretoria.

DoA (Department of Agriculture), 2009. Annual Report. DoA, Pretoria.

FAO (Food and Agricultural Organization), 2011. FAOSTAT database, 2011. http://faostat.fao.org/ Accessed 12 November 2011.

Fulginiti, LE, Perrin, RK & Yu, B, 2004. Institutions and agricultural productivity in sub-Saharan Africa. Agricultural Economics 4, 169–80.

Giliomee, H, 2003. The Afrikaners: Biography of a People. (Expanded and updated version) Tafelberg, Cape Town.

Hayami, Y & Ruttan, VW, 1985[1971]. Agricultural Development: An International Perspective. Johns Hopkins University Press, Baltimore.

Irz, X & Hadley, D, 2003. Dual technological development in Botswana agriculture: A stochastic input distance function approach. Paper presented at the 25th International Conference of Agricultural Economists, 16–22 August, Durban.

Jooste, A, Van Schalkwyk, H & Groenewald, J, 2003. South African agriculture and international trade. In Nieuwoudt, L & Groenewald, J (Eds), The Challenge of Change: Agriculture, Land and the South African Economy, Chapter 11. University of Natal Press, Pietermaritzburg.

Liebenberg, F, (in progress). South African agricultural productivity and research performance in the twentieth century. PhD thesis, Department of Agricultural Economics, Extension and Rural Development, University of Pretoria.

Liebenberg, F & Pardey, PG, 2010. South African agricultural production and productivity patterns. In Alston, JM, Babcock, BA & Pardey, PG (Eds), The Shifting Patterns of Agricultural Production and Productivity Worldwide, Chapter 13. CARD-MATRIC on-line volume, Iowa State University. www.matric.iastate.edu/shifting_patterns/pdfs/chapter13.pdf Accessed 1 January 2012.

Liebenberg, F, Pardey, PG & Khan, M, 2010. South African agricultural research and development: A century of change. Staff Paper P10-1, Department of Applied Economics, University of Minnesota, St. Paul, MN.

Ludena, CE, Hertel, TW, Preckel, PV, Foster, K & Nin, A, 2006. Productivity growth and convergence in crop, ruminant and non-ruminant production: Measurement and forecasts. Paper presented at the International Association of Agricultural Economists Conference, 12–18 August, Gold Coast, Australia.

Lusigi, A & Thirtle, C, 1997. Total factor productivity and the effects of R&D in African agriculture. Journal of International Development 9, 529–38.

Nin, A, Arndt, C & Preckel, PV, 2003. Is Agricultural Productivity in Developing Countries Really Shrinking? New Evidence Using a Modified Nonparametric Approach. Journal of Development Economics 71(2), 395–415.

Nin-Pratt, A & Yu, B, 2008. An updated look at the recovery of agricultural productivity in sub-Saharan Africa. IFPRI (International Food Policy Research Institute) Discussion Paper No. 00787. IFPRI, Washington, DC.

OCS (Office of Census and Statistics), 1919. Statistics of Agricultural and Pastoral Production. Agricultural Census 1918, No. 1. Government Printer, Pretoria, Union of South Africa.

OCS (Office of Census and Statistics), 1932. Statistics of Agricultural and Pastoral Production. Agricultural Census 1930, No. 13. Government Printer, Pretoria, Union of South Africa.

OCS (Office of Census and Statistics), 1939. Statistics of Agricultural and Pastoral Production. Agricultural Census 1937, No. 17. Government Printer, Pretoria, Union of South Africa.

Payne, N, Van Zyl, J & Sartorius von Bach, H, 1990. Labour-related structural trends in South African commercial grain production: A comparison between summer and winter rainfall areas, 1945–87. Agrekon 29(4), 407–15.

Schimmelpfennig, D, Thirtle, C, Van Zyl, J, Arnade, C & Khatri, Y, 2000. Short and long-run returns to agricultural R&D in South Africa, or will the real rate of return please stand up? Agricultural Economics 23(1), 1–15.

Stats SA (Statistics South Africa), 2005. Census of commercial agriculture, 2002: Financial and Production Statistics. Report No. 11-02-01(2002). Government Printer, Pretoria.

Thirtle, C, Atkins, J, Bottomley, P, Gonese, N, Govereh, J & Khatri, Y, 1993. Agricultural productivity in Zimbabwe, 1970–90. Economic Journal 103, 474–80.

Thirtle, C, Hadley, D & Townsend, R, 1995. Policy induced innovation in sub-Saharan African agriculture: A multilateral Malmquist productivity index approach. Development Policy Review 13(4), 323–42.

Thirtle, C, Sartorius von Bach, H & Van Zyl, J, 1993. Total factor productivity in South Africa, 1947–1991. Development Southern Africa 10(3), 301–18.

Van Zyl, J, Vink N & Fényes, TI, 1987. Labor-related structural trends in South African maize production. Agricultural Economics 1, 241–58.

Vink, N & Van Zyl, J, 1998. Black disempowerment in South African agriculture: A historical perspective. In Kirsten, J, Vink, N & Van Zyl, J (Eds), The Agricultural Democratisation of South Africa, Chapter 2. Francolin, Cape Town.

World Bank, 2011. On-line World Development Indicators Database. http://databank.worldbank.org/ddp/home.do Accessed 5 October 2012.