CHAPTER 13

South African Agricultural Production and Productivity Patterns

Frikkie Liebenberg and Philip G. Pardey

1. INTRODUCTION

The twentieth century saw substantive shifts in the structure of agriculture and agricultural production in South Africa. Average farm size grew, farm numbers eventually declined, and production increasingly emphasized higher-valued commodities, notably a range of horticultural crops. Real agricultural output grew steadily, by 2.6% per year from 1910 to 1980, but growth slowed thereafter (to just 0.19% per year from 1980 to 2008). Here we document and discuss developments regarding aggregate input, output, and productivity developments within South Africa. To do so we draw on an entirely new set of production data stretching back to 1910/11 reported in Liebenberg 2010, as well as related evidence reported by other studies for South Africa and other countries within sub-Saharan Africa.[1]

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[1]Parts of this chapter also draw heavily on Liebenberg, Pardey, and Khan 2010.

2. AGRICULTURE IN THE SOUTH AFRICAN ECONOMY

After adjusting for inflation, South African agricultural gross domestic product (GDP) contracted by 1.1% per year from 1981 to 2006, compared with growth of 2.62% per year for GDP overall. Thus, agricultural GDP represents a declining share of the South African economy. Since 2005, its share has varied between 2.4% and 2.8%, compared with 12.3% in 1961, although the agricultural economy still employed more than 1.32 million farm workers, about 10.6% of the South African labor force, in 2006.

In 2006, South Africa's agricultural GDP was U.S.$6.9 billion, placing it 35th worldwide on this score (World Development Indicators Database). Agricultural trade constituted 2.7% of South Africa's GDP in 2006, with agricultural exports accounting for about 6.9% of total exports (DAS 2009). This is significantly less than its export share in 1932, when agriculture accounted for 78.4% 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 2007. South Africa has always been a net exporter (by value) of agricultural products. In 1975, agricultural exports exceeded imports by R20.7 billion,[2] but the lingering effects of sanctions on imports from South Africa due to the 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.

In 1910, agricultural output (as indexed by AgGDP, a value-added measure of agricultural output) accounted for 19.3% of total economic output (GDP) (Table 13.1).[3] The agricultural share of total economic output declined steadily throughout the twentieth century, to just 2.5% by 2006. The absolute size of the agricultural economy grew almost every decade until the 1970s—at an overall average annual rate of 3.38% per year, from U.S.$2.4 billion (R9.3 billion) in 1910 to U.S.$11.8 billion (R45.9 billion) in 1974 (both measured in 2000 prices). From 1910 to 1928, real agricultural output grew by 1.8% 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 con-

[2]Here, and throughout this chapter, "R" denotes rand, the local currency unit of South Africa.

[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 like 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.

Table 13.1. The changing structure of South African agriculture, 1910-2007

	Unit	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000 to 2007
Farming Structure						10-Year Average					
Farm number	Number	76,622	88,305	101,299	111,938	112,305	99,114	79,842	64,540	59,289	44,575
Total area	1000 ha	77,042	81,810	84,339	87,392	88,150	89,256	86,814	85,862	82,404	83,701
Average farm size	ha	1,006	928	833	781	788	817	1,094	667	1,260	1,400
Economic Contribution											
AgGDP	R million (2000)	9,207	10,596	10,379	18,223	33,136	35,508	37,594	35,877	30,201	31,217
Contribution to GDP	Percent	19.0	17.6	12.0	12.7	15.2	9.9	6.8	5.0	3.7	3.0
Labor											
Economically active in agriculture	'000	-	-	-	1,913	1,509	1,635	2,483	1,181	1,213	1,406
Agricultural share of total	Percent	-	-	-	42	33	29	31	14	10	12
Farm employees	'000	553	488	749	887	882	968	1,639	1,235	1,185	835
Value of Production											
Field crops	R million (2000)	4,063	4,568	5,339	8,938	14,982	20,267	26,524	23,658	15,677	16,722
Horticulture	R million (2000)	1,180	1,552	2,043	3,593	5,322	7,659	9,526	10,323	11,392	14,493
Livestock	R million (2000)	5,991	6,700	6,748	11,628	19,603	20,531	21,760	24,775	20,518	24,352
Total	R million (2000)	11,234	12,820	14,130	24,159	39,906	48,458	57,810	58,756	47,586	55,567

Table 13.1. Continued

	Unit	1910s	1920s	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000 to 2007
Share of Production Value											
Field crops	Percent	36	36	38	37	38	42	46	40	33	30
Horticulture	Percent	11	12	14	15	13	16	16	18	24	26
Livestock	Percent	53	52	48	48	49	42	38	42	43	44

Source: Liebenberg, Pardey, and Khan 2010.
Note: Data were deflated using the GDP deflator from SARB 2009.

junction with expanded farmer settlement and agricultural development support and reached U.S.$9.1 billion (R35.4 billion) in 1951, an increase of 8.95% per year for the 1934 to 1951 period. During the period 1951 to 1974, output growth slowed to an average of 2.27% per year. The agricultural economy then declined to a low point of U.S.$6.8 billion (R26.1 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 U.S.$9.6 billion (R37.1 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.

The number of people economically engaged in agriculture grew virtually uninterrupted for 60 years from 1910 to the 1970s, when it reached 2.4 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 (2000 prices) terms, from U.S.$3,333 (R12,899) per capita in 1970 to U.S.$6,747 (R26,111) per capita in 2004.

3. AGRICULTURAL OUTPUT

The mix of agricultural output changed markedly over the years (Table 13.1 and Figure 13.1). In 1911 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 still a substantial 44% of agricultural output by value (with poultry production now accounting for 55% of this total). The field crops share was 34% in 1911, grew to 47% in 1971 (largely because of an expansion of cereals and sugarcane production), declined significantly to 28% in 2004, and then regained some market share to reach 33% in 2008. A reduction in corn and wheat production accounted for most of the post-1971 decline. The share of horticultural output expanded steadily over the entire period since 1910, starting at 10% that year and increasing to 23% by 2008. Up until the late 1980s, the growth in the value of horticultural output averaged 3.9% 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 growing at impressive rates, especially

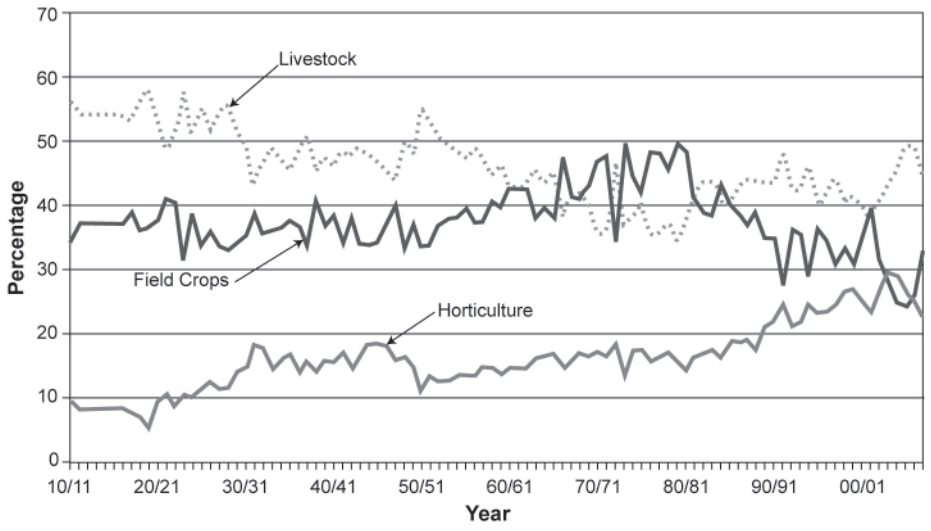

Figure 13.1. Sector shares in gross value of agricultural production, 1910-2008

Sources: Liebenberg 2010 based on data from DAS 2009.
Note: Livestock aggregate includes 11 commodities, field crops includes 22 commodities, and horticulture includes 12 commodities.

in the wine (4.41% per year from 1992 to 2004), deciduous fruit (5.01% per year) and citrus fruit (7.34% per year) sectors, partly in response to improved access to international markets as rest-of-world sanctions against imports from South African were scrapped.

These aggregate economic changes fail to reveal the different development paths followed by black versus white farmers. Throughout most of the post-unification period (specifically from 1913, but intensively so from the 1930s), the sustained and substantial government support to 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 reserve, 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.[4] 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 either failed to materialize or were never developed to the extent they were for the white commercial farming community.

The effect of these discriminatory policies over time is shown in Table 13.2 in which the current relative contribution of black farmers to national production and land ownership is tracked from 1918 to 2002. 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 compared with earlier years. Likewise, the share

Table 13.2. Black farmers' share of area farmed and planted and national production of selected crops, 1918-2002

	Area of						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, Pardey, and Khan 2010 based on data from OCS 1919, 1932, and 1939; BCS 1952, 1963; CSS 1992; and Statssa 2005.

[4]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 help establish a vibrant farming community, often by way of farmer settlement programs and co-sponsored self-help schemes. Tenant farmers were provided with the necessary 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 farmland) 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 a necessarily good indicator of the potential productivity and profitability of farms or the prospective social payoff to public investments in these schemes. Liebenberg (2010) provides new data on the public investments directed to farmer settlement and survival schemes in South Africa during the twentieth century.

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 marginally increased from 1960 to 2000.

In addition to the Land Reform and Restitution initiatives that were implemented beginning in 1994, the South African government established several programs to support black farmers. These include the Land Redistribution for Agricultural Development program (launched in 2000); the Comprehensive Agricultural Support Program that 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.

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 used within agriculture. These sizable structural shifts have important implications for—and in turn have no doubt been affected by—the amount and nature of research and development (R&D) and the accompanying technical and institutional changes striving to sustain economic development and productivity growth in agriculture going forward.

The quantity of total agricultural output grew at an average annual rate of 2.56% from 1911 to 2008. From 1911 to 1945, output grew by only 1.86% per year, accelerating to 3.58% annually over the following three decades, then slowing to just 1.52% per year for the period 1982-2000. Since 2000, output growth has rebounded, growing by 2.07% per year through to 2008. Over the almost one hundred years since 1911, growth in horticultural output (fruit and vegetables) outpaced that of field crops and livestock by almost 0.5% per annum (Figure 13.2). Field crop production kept pace with livestock output from 1911

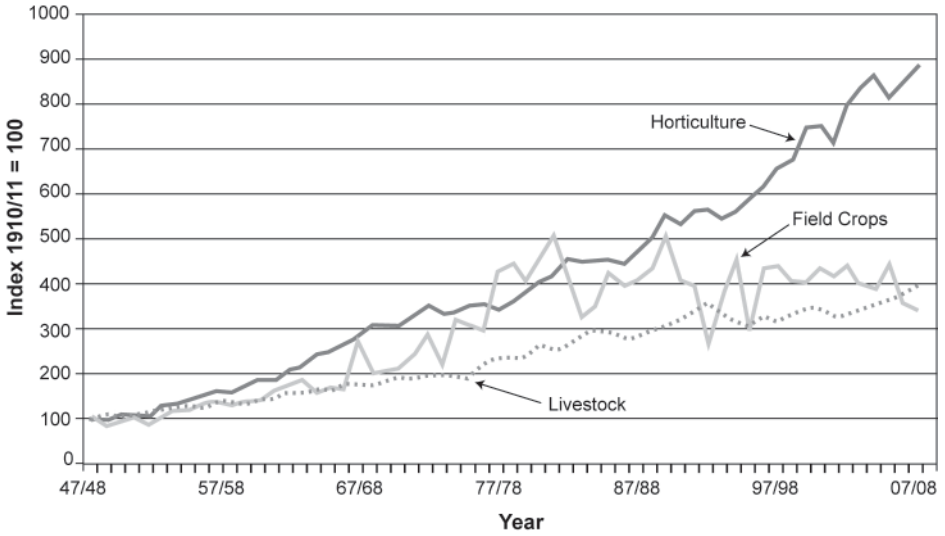

Figure 13.2. Quantity of agricultural output by sector, 1911-2008

Source: Liebenberg 2010.
Note: These series are Divisia (specifically Tornqvist) quantity indexes.

until the mid-1960s; during the subsequent two decades it grew at a faster rate than the livestock sector. However, during the period 1982-2008, field crop production grew by only 0.91% per year, lagging behind the corresponding growth in livestock output of 1.2% per year. Since 2000, growth in field crop production has substantially fallen behind the corresponding growth in livestock output, which increased by 2.02% per year.

The overall growth in total agricultural output is thus largely driven by strong growth in the horticultural sector, with 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 2008, compared with 1.52% per year for overall agricultural output (and just 0.91% per year for field crops).[5] Notably, the slowdown in both total output and crop output in South Africa in recent decades parallels similar trends in the United States, where total output grew by 1.63% per

[5]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 0.74% per year over the same period.

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 et al. 2010, Appendix Table 4-3).[6]

4. AGRICULTURAL INPUTS

Figure 13.3 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 2002 the number of farms had dropped to less than half the number that prevailed five decades earlier. The interplay between changing farm numbers and the total area in farms meant that average farm size declined during the first half of the twentieth century (from 1,019 hectares in 1910 to 730 hectares in 1952) and increased during the second half of the century, to average 1,640 hectares in 2000. Average farm size has continued to grow; in 2002 it was 1,833 hectares per farm.[7]

Figure 13.4 shows trends beginning in 1947/48 in the total cost shares of four agricultural input categories: labor, land, capital, and materials. Material

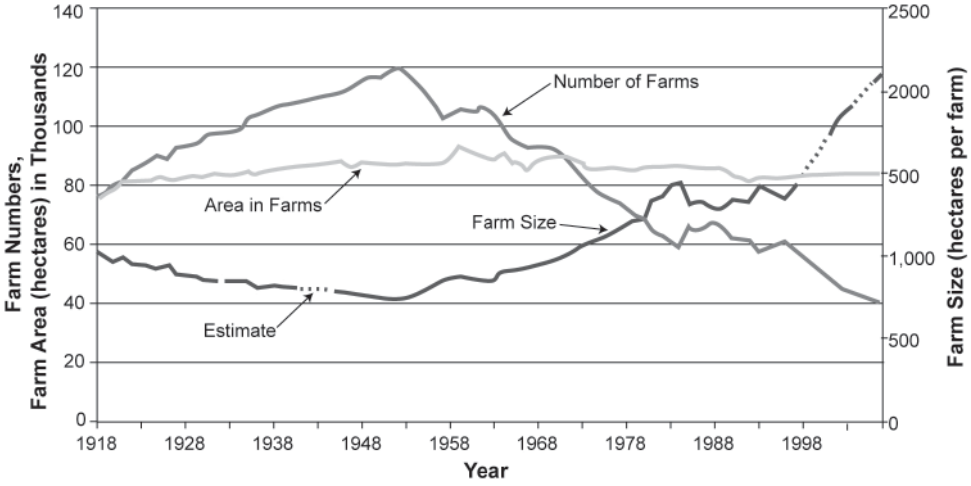

Figure 13.3. Number, total area, and average size of farms, 1918-2007

Source: Liebenberg, Pardey, and Khan 2010.
Note: Dashed sections of farm size plot indicate estimates (via interpolation).

[6]See also Chapter 8 in this volume.

[7]Preliminary agricultural census results indicate a continuing increase in average farm size, to about 2,000 hectares per farm, and a continuing decline in farm numbers, to 39,982 in 2009.

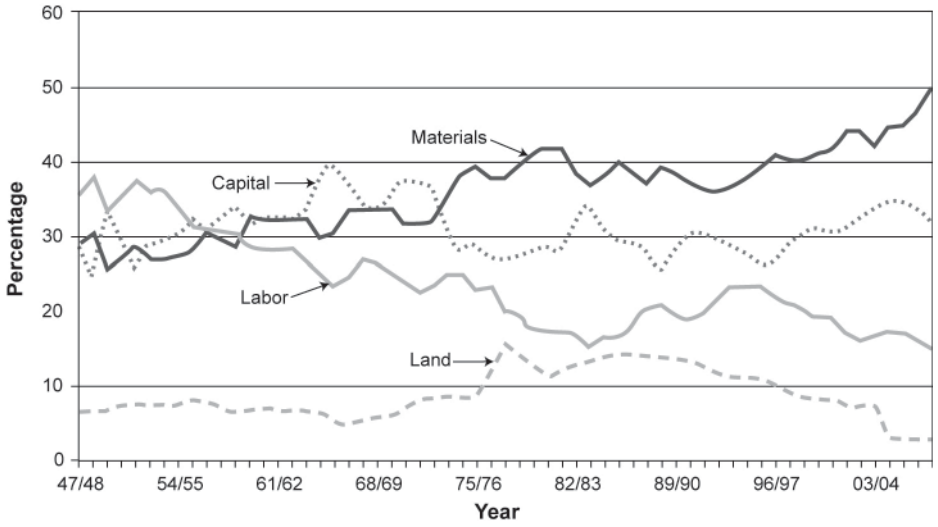

Figure 13.4. Input cost shares, 1947-2008

Source: Liebenberg 2010 based on data from DAS 2009.
Notes: In this compilation, land includes all land in agriculture (irrigated and rain-fed 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.

inputs (largely purchased from off-farm sources) have claimed an increasing share of total costs, 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 et al. (2010) reported land cost shares for the United States that followed a similar trend, starting at 17% of total cost in 1949, growing to 20% during the late 1970s and early 1980s (when land prices soared), then falling to 15% by 2002. However, according to these data, land cost shares are uniformly lower in South Africa compared with the United States, perhaps reflecting a much smaller share of cropped to total land in South Africa versus the United States along with a smaller share of that cropped land under irrigation.[8]

[8]According to DAS (2009, p. 5), 13.7% of South Africa's total land area is potentially arable, and around 69% of that arable area is only suitable for grazing. Moreover, a large share of the grazing area is in the semi-arid Karooveld.

An assessment of the magnitude of the cost share changes for land and labor in isolation reveals more substantive changes than are apparent by inspection of Figure 13.4. Looking in more detail at land costs, in nominal terms they grew by 0.5% per year during the period 1947-1959, when the total area under cultivation was still increasing, but they declined by 0.23% per year thereafter. Total labor costs fluctuated at around an average of R160.3 million during the 1960s but then declined by 3.08% per year until 1983. They increased during the period 1984-1987 but then began to decline and have continued to do so through 2007/08 (the last year for which data are presently available).

According to Thirtle, Sartorius von Bach, and van Zyl (1993), during the period ending in 1970, the cultivated corn area subject to summer rainfall expanded, as oxen were increasingly replaced by tractors. This spurred the expansion of average farm size (as measured by area per farm; see Figure 13.3) along with labor use as well as the use of chemical fertilizers and higher-yielding seed varieties (Payne, van Zyl, and Sartorius von Bach 1990). After 1970, the mechanization of crop harvesting activities through the increased use of combines began to alleviate a peak demand for labor at harvest time, thus contributing to a decline in overall labor use.

The general pattern of labor, land, and machinery use in agriculture in summer and winter rainfall areas evolved in parallel. The overall expansion of cultivated area was largely complete by 1947, with machinery increasingly substituting for labor throughout South African agriculture during this period. The Pass Laws of 1952 may have accelerated this ongoing factor substitution effect (especially during the late 1960s when the conditions of the Act were severely applied); however, other polices likely had a bigger effect.[9] 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 written off within the first year after purchase. 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

[9]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 "pass book" at all times. An employer was defined under the law and could only be a white person. The pass 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 governmental employee could strike out such entries, basically canceling the permission to remain in the area.

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 caused the sector to shed labor.

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, less 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 annum. Nonetheless, the long-run crop yields summarized in Table 13.3 reveal substantial gains in average crop yields during the twentieth century. Corn yields increased more than 4-fold since the 1910s, wheat by 4.4-fold, and sorghum by more than 7-fold. Drought is a recurring reality of South African agriculture and 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 twentieth 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) helping to also spur crop yield growth after the 1960s.

The livestock "yields" presented in Table 13.3 are harder to interpret and may reflect the difficulty of meaningfully measuring productivity in these sectors. 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 (i.e., lamb versus mutton) cuts of meat being preferred—but massive structural changes in the sheep industry have also played their part. As wool demand slackened over the past three decades or so, growers shifted from sheep-for-wool to sheep-for-meat systems of production, with associated shifts in the average age of the sheep population (i.e., a move to younger and

Table 13.3. Average yields for selected commodities for various periods

	Cattle	Sheep	Pigs	Corn	Wheat	Grain Sorghum
		(kg/head)			(kg/ha)	
Five-year averages centered on						
1911/12				765	592	445
1920/21	235	39		737	501	580
1930/31	205	30	90	465	717	952
1940/41	251	29	85	771	488	963
1950/51	226	33	78	826	518	987
1960/61	223	29	81	1,235	590	872
1970/71	217	25	64	1,480	811	1,201
1980/81	215	25	66	2,082	1,103	1,816
1990/91	228	22	61	2,074	1,460	2,360
2000/01	231	18	62	2,606	2,449	2,822
2005/06	259	20	74	3,326	2,583	3,272
Average annual growth (percent per year)						
1910/11-1929/30				-1.29	0.30	-1.43
1930/31-1949/50	0.82	0.59	-0.76	3.39	-2.72	3.29
1950/51-1969/70	-0.26	-1.25	-1.07	2.04	1.29	-1.89
1970/71-1989/90	0.53	-0.26	0.13	0.28	2.33	2.27
1990/91-2007/08	0.98	-0.01	1.19	4.58	3.34	3.03
1920/21-1949/50	0.75	0.03	-0.58	1.95	-2.10	4.32
1950/51-2007/08	0.17	-1.03	-0.35	2.05	3.17	2.53
2000/01-2007/08	2.76	2.34	4.29	4.63	2.64	2.46

Source: DAS 2009.
Notes: Corn and sorghum includes only the crop grown for grain, and wheat includes all types of wheat (mainly durum). Animal weights are slaughtered weights. Growth rates were computed by the natural log regression method.

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 in 2008, with numbers of merino sheep declining from 28.3 million to 11.6 million over the same period (DAS 2009).

From 1911 to 2008, land productivity grew at an average annual rate of 2.49% per year, slightly slower than the corresponding rate of labor productivity growth, which averaged 2.83% per year (see Figure 13.5). Throughout the twen-

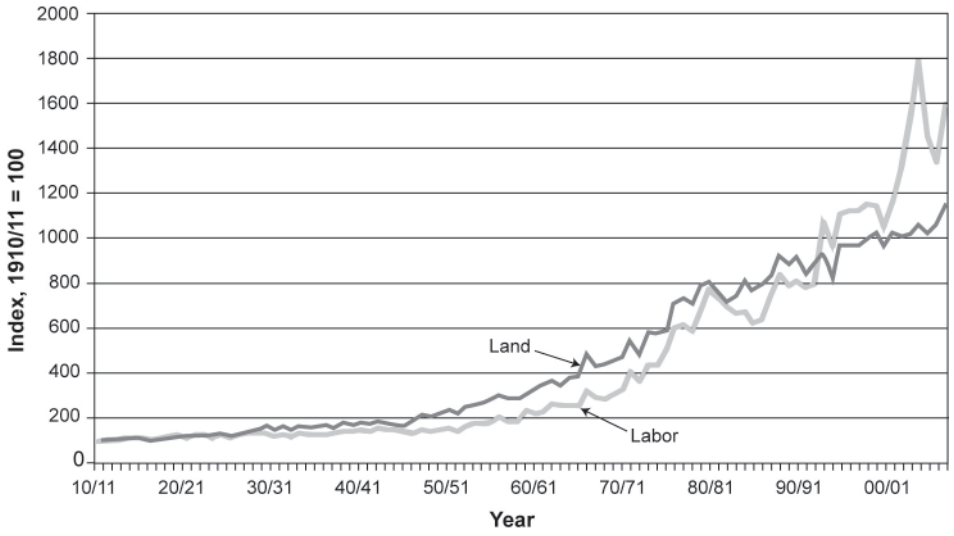

Figure 13.5. Agricultural labor and land productivity in South Africa, 1911-2008

Sources: Authors' calculations based on data from DAS 2009 and Statssa 2009.
Notes: Labor data were adjusted to consistently include seasonal labor. These series are Divisia (specifically Tornqvist) quantity indexes.

tieth century there were three phases of distinct growth patterns in these two partial productivity measures. During the pre-WWII years (from 1911 to 1940), land productivity grew by 1.95% per year, double the corresponding annual rate of growth of labor productivity (0.89% per year). The rate of growth of both land and labor productivity picked up over the subsequent four decades following WWII (i.e., the period 1947-1981), averaging an impressive 4.91% per year for labor productivity and 4.17% 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 1.46% per year for land productivity.

Figure 13.6 draws on Food and Agriculture Organization (FAO) data to place land and labor productivity measures for South Africa into a broader African context. Here we use the graphical technique developed by Hayami and Ruttan (1971) in which the horizontal axis measures labor productivity (in logarithms) and the vertical axis measures land productivity (in logarithms). 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 estimate of the total value of agricultural output (spanning all crops and live-

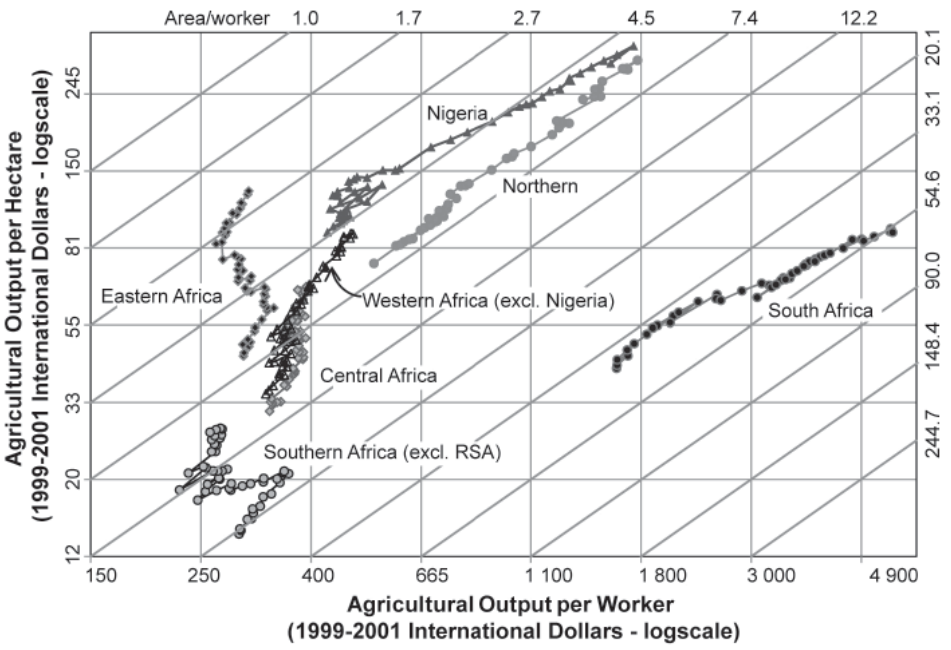

Figure 13.6. Agricultural labor and land productivity in sub-Saharan Africa, 1961-2007

Source: Calculated from data obtained from FAOSTAT Database.
Notes: Central Africa includes Burundi, Cameroon, Cent Afr Rep, Chad, Congo Dem R, Congo Rep, Eq Guinea, Gabon, Rwanda, Sao Tome Prn, Sudan; Eastern Africa includes Comoros, Djibouti, Eritrea, Ethiopia, Ethiopia PDR, Kenya, Madagascar, Malawi, Reunion, Seychelles, Somalia, Tanzania, Uganda; Southern Africa (excluding South Africa) includes Angola, Botswana, Lesotho, Mauritius, Mozambique, Namibia, Swaziland, Zambia, Zimbabwe; and Western Africa (excl. Nigeria) includes Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Senegal, Sierra Leone, Togo. See text for data construction and plotting details. The land-labor ratio is constant along each grey diagonal line, and values for those ratios are given at the terminus of the respective diagonal line on the top and right axes.

stock commodities) expressed in 1999-2001 average purchasing power parity agricultural prices obtained from FAO (FAOSTAT Database). Land is a measure of harvested and permanently pastured area, and labor is a head count of the total economically active workers in agriculture. These ratios were then scaled by the corresponding value ratios of output and input in the base year 1961, and the natural logarithms of the scaled index ratios were then taken.[10] Since both axes are measured in natural logarithms a unit increase in either direction is in-

[10]The output and input indexes are all normalized to a value of 1.0 in base year 1961, which means the productivity paths for each region would begin from the same value if they were not scaled by the respective base-year value ratios.

terpreted 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 2005, 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, it indicates a decrease in the number of economically active workers in agriculture per harvested acre in that region.

The South African and Nigerian productivity loci follow distinctly different paths than the other regions of sub-Saharan Africa plotted in Figure 13.6. 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 2007 for both countries was also considerable higher than the rest of Africa: $5,663 per worker in the case of South Africa and $1,576 per worker for Nigeria compared with an average of $641 per worker for the rest of Africa. South Africa is distinctive in that it is the only entity depicted in Figure 13.6 for which the land-labor ratio increased to any great extent over time (implying more pronounced growth in labor versus land productivity): from 39.1 hectares per worker in 1961 to 56.9 hectares per worker in 2007. In Nigeria, the land-labor ratio (starting from a much smaller initial value) increased a little: from 4.36 to 5.27 agricultural hectares per worker over the comparable period. In almost all the other regions depicted, real output per worker stagnated (or in the case of Eastern 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 were smaller than their vertical spans so that land-labor ratios were smaller on average in 2007 than they were a quarter of a century earlier.

West Africa (excluding Nigeria) is an exception compared with the general rest-of-Africa (i.e., sub-Saharan Africa minus South Africa and Nigeria) productivity pattern. This region saw labor productivity grow by 0.78% per year from 1961 to 2007 (compared with 2.68% per year for South Africa and 3.24% per year for Nigeria). Labor productivity in East Africa barely changed, and in Southern Africa (excluding South Africa) it declined from $291 per worker in 1961 to a lowly $255 per worker in 2007. These productivity trends speak to the dismal record of poverty and chronic food insecurity that befall a large share of the populations in these parts of Africa.

Perhaps ironically, these dismal labor productivity trends in Central, Eastern and Southern Africa (excluding South Africa) belie their comparatively rapid rates of growth in total output. These three regions report real agricultural output growth in the range of 1.35% to 2.85% per year over the period 1961-2007, in some instances much faster than the comparative rates of growth in total output for South Africa, which averaged just 1.65% 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 0.19% to 2.49% 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 less than the rate of growth in agricultural workers. With land-labor ratios ranging from 2.33 to 9.34 hectares per worker, 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 13.4 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 estimates reported in several 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 an overall assessment of these studies problematic.

The upper half of Table 13.4 reports an effort by the 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 indicate that their aggregate output measure consists of a Divisia aggregation of three pre-aggregated groups of outputs, namely, crops, horticul-

Table 13.4. Growth of agricultural output, input, and MFP indexes, various estimates, 1947-2008

	Attributes of Study					Study Source	
Period	Output	Input	MFP	Labor	Land	Authors	Date
	(percent per year)						
1947-1971	3.43	2.81	0.62	3.27	3.36	This study	2010
1971-1989	3.28	0.70	3.98	4.91	3.50	This study	2010
1989-2008	0.95	0.95	0.01	3.22	1.11	This study	2010
1947-2008	2.68	1.20	1.49	3.87	2.78	This study	2010
1947-1991			1.3			Thirtle, Sartorius von Bach, and van Zyl	1993
1947-1997			1.3			Schimmelpfennig et al.	2000
1965-1994			0.28			Nin, Arndt, and Preckel	2003
1952-2002			1.35			Conradie, Piesse, and Thirtle	2009a

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

ture, and livestock. The input index consists of an aggregation of measures of land, labor, intermediate inputs (i.e., packing fuel, fertilizer, dips and sprays, and other non-farm items), and capital inputs (i.e., fixed improvements and machinery). The update reported here in Table 13.4 and Figure 13.7 spans the period 1947-2008. It was developed by extending the Schimmelpfennig et al. 1947-1997 series, and in so doing we sought to faithfully deploy the same methods, data types, and sources used in the earlier compilations.[11]

According to this measure, South African MFP grew, on average, by 1.49% per year from 1947 to 2008. The 1970s and 1980s had the highest rate of growth for the period studied, an impressive (and perhaps questionable) 3.98% per year. This is substantially higher than the 0.62% per year rate reported for the immediate post-WWII decades. Notably, MFP was stagnant during the period 1989-

[11]The authors thank Colin Thirtle for kindly providing the data he and colleagues developed for the 1947-1997 period. Liebenberg (2010) reports an entirely new series constructed from different data sources and using different methods. For example, Liebenberg found that historical capital input and livestock inventory estimates were compromised by especially low participation rates in the national agricultural censuses conducted since 1992/93. DOA statistical agencies subsequently 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 with D. Blignaut, Head of Regional Production Statistics, DOA, in 2009). Liebenberg is also making an effort to correct for significant inconsistencies in the officially reported data on agricultural labor attributable to inconsistencies in the treatment of seasonal, domestic, and family labor.

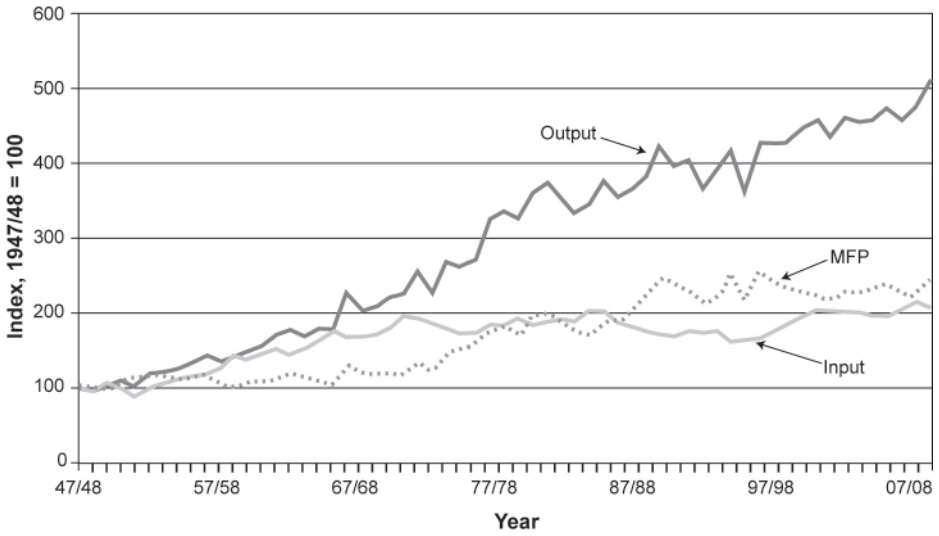

Figure 13.7. Agricultural output, input, and MFP indexes, 1947-2008

Source: See text for details.

2008, apparently owing to a decline in the rate of output growth coupled with an increase in the rate of input use in agriculture.

Recent studies by Conradie, Piesse, and Thirtle (2009a,b) extend the earlier methods used by Thirtle and colleagues to compile regional estimates of aggregate input, output, and MFP growth for South African agriculture (see Table 13.5). They focused on the Western Cape region of the country. This region has distinctive agro-climatic attributes: specifically, it is the only region within 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, Piesse, and Thirtle (2009b) estimate that during the period 1952-2002, MFP in the Western Cape grew on average by 1.22% per year. The regional rate of growth is roughly the same as the long-run measured rate of growth in MFP at the national level. However, there are marked disparities in the regional and national growth rates for specific sub-periods. For example, from 1971 to 2002, the Western Cape region saw productivity growing at 0.89% per year, less than half the corresponding rate of growth at the national level (which Conradie, Piesse, and Thirtle [2009b, p. 12] put at more than 2% per year). Again differences in data sources and treatment may account for some of the disparities, but it is also likely that differences in the composition of output and inputs and other

Table 13.5. Regional growth rates (%) of agricultural output, input, and MFP indexes, 1952-2002

	1952-2002			1952-1971			1971-2002		
Regions	Input	Output	TFP	Input	Output	TFP	Input	Output	TFP
Western Cape	2.1	3.32	1.22	2.71	3.96	1.25	1.85	2.74	0.89
Karoo Region	0.17	-0.55	-0.72	0.27	2.12	1.85	-0.85	-1.32	-1.14
Olifants River Valley	2.8	4.52	1.72	3.57	4.16	0.58	2.53	4.4	1.87
Breede River Valley	2.57	4.79	2.22	3.29	3.2	-0.08	2.28	5.79	3.51
Swartland Region	2.77	3.3	0.53	3.61	3.17	-0.44	2.29	4	1.71
Malmesbury-Moorreesburg	3.17	3.54	0.37	4.61	4.13	-0.48	2.15	3.15	0.99
Piketberg	2.54	3.37	0.83	2.63	2.44	-0.19	2.84	5.61	2.77
Vredenburg-Hopefield	1.3	1.85	0.54	1.85	5.62	3.77	0.85	0.06	-0.79

Source: Conradie, Piesse, and Thirtle 2009b, Table 2.

factors play a role in these regional differences, as they do regarding the considerable national versus state differences in productivity patterns reported for the United States by Alston et al. (2010).

In Table 13.6 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 especially problematic, in part because of substantive differences in data and methods, but also given the paucity of studies that are available. 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 included in this book and elsewhere. That said, differences in sectoral coverage and analytical methods may account for the very considerable differences in reported growth rates for similar periods in the studies by Alene (2009) and Ludena et al. (2006). The Africa-wide results of Alene using Malmquist methods concord with those reported earlier (Table 13.4, upper half) for South Africa using Divisia aggregation approaches, to the extent they suggest that the rate of MFP growth has slowed in recent years. However, the "sequential Malmquist" results from Alene show no evidence of a slowdown. Irz and Hadley (2003) found a marked difference in MFP growth rates for commercial versus traditional farmers in Botswana, highlighting the fact that aggregating over different types of farmers may pose substantive measurement and interpretation challenges analogous to those confronted when forming national versus state or provincial estimates.

7. CONCLUSION

South African agriculture appears to have sustained a competitive edge 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 surplus. 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 Africa, which grew at much slower rates in more recent years compared with 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 the country's agricultural productivity growth has historically outpaced produc-

Table 13.6. Sub-Saharan Africa multifactor productivity growth rates, various studies

Authors	Date	Region	Crop/Industry	Methodology	Sample Period	Average Annual Growth Rate (%/year)
Irz and Hadley	2003	Botswana	Agriculture:	Input Distance		
			Traditional Farmers		1979-1996	-2.3
			Commercial		1968-1990	1.16
Dhehibi and Lachaal	2006	Tunisia	Agriculture	Tornqvist	1961-2000	3.6
Ludena et al.	2006	Middle East & North Africa	Crops	Malmquist	1961-2000	-0.03
			Ruminants		1961-2000	-0.02
			Nonruminants		1961-2000	0.64
			Average		1961-2000	0.03
		Sub-Saharan Africa	Crops		1961-2000	0.15
			Ruminants		1961-2000	0.36
			Nonruminants		1961-2000	0.5
			Average		1961-2000	0.21
Alene	2009	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

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 x can be scaled down to produce a given output vector y with the technology that exists at a particular time t. The premise of the sequential Malmquist TFP index used by Alene (2009) 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.

tivity 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 (staple food) crops and livestock products.

The composition of input use has change too. Notwithstanding high rates of rural unemployment, the evidence reported in this chapter indicates that 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 in a regional and continental context. In 2006 it accounted for 43.6% of the agricultural GDP of Southern Africa and 5.93% of the agricultural GDP for sub-Saharan Africa as a whole (World Development Indicators Database). 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 throughout the rest of Africa, are causes for real 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 evidence presented here indicates that the rate of MFP growth in South African agriculture lost considerable ground in recent years and is now well below the country's corresponding rate of 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 carefully and creatively, and with some urgency, rethink and revitalize those rural development options that promote long-term productivity growth, most notably investments in, and the incentive structures that affect, agricultural R&D. It will take time to turn around these poor productivity performances, and so the policy choices made now, as well as the details of their implementation over the next few years, will determine the destiny of the country's (and the continent's) agricultural sector for a significant share of the century that lies ahead.

REFERENCES

Alene, A.D. 2009. "Productivity Growth and the Effects of R&D in African Agriculture." International Institute of Tropical Agriculture. Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China, 16-22 August.

Alston, J.M., M.A. Andersen, J.S. James, and P.G. Pardey. 2010. *Persistence Pays: U.S. Agricultural Productivity Growth and the Benefits from Public R&D Spending.* New York: Springer.

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

———. 1963. *Agricultural Census No.34. Census Year 1959-60.* Union of South Africa. Pretoria: Government Printer.

CSS (Central Statistical Services). 1992. *Agricultural Survey, 1992. No. 11-01-01(1991).* Republic of South Africa. Pretoria: Government Printer.

Conradie, B., J. Piesse, and C. Thirtle. 2009a. "District-Level Total Factor Productivity in Agriculture: Western Cape Province, South Africa, 1952–2002." *Agricultural Economics* 40: 265-280.

Conradie, B., J. Piesse, and C. Thirtle. 2009b "What Is the Appropriate Level of Aggregation for Productivity Indices? Comparing District, Regional and National Measures." *Agrekon* 48(1): 9-20.

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

Dhehibi, B., and L. Lachaal. 2006. "Productivity and Economic Growth in Tunisian Agriculture: An Empirical Evidence." Poster paper prepared for presentation at the International Association of Agricultural Economists, Gold Coast, Australia, 12-18 August.

DOA (Department of Agriculture, South Africa). 1957. *Handbook for Farmers: Agriculture and Related Services,* vol. 1. Department of Agriculture. Pretoria: Government Printer.

———. 2008. *National Agricultural Research and Development Strategy.* Pretoria: Author.

———. 2009. *Annual Report*. Pretoria: Author.

FAOSTAT Database. United Nations Food and Agriculture Organization, Rome. http://faostat.fao.org/ (accessed 13 August 2009).

Hayami, Y., and V.W. Ruttan. 1971. *Agricultural Development: An International Perspective.* Baltimore: Johns Hopkins University Press (reprinted 1985).

Irz, X., and D. Hadley. 2003. "Dual Technological Development in Botswana Agriculture: A Stochastic Input Distance Function Approach." Contributed paper selected for presentation at the 25th International Conference of Agricultural Economists, Durban, South Africa, 16-22 August.

Liebenberg, F. 2010. "South African Agricultural Productivity and Research Performance in the Twentieth Century." Unpublished PhD dissertation. University of Pretoria (in preparation).

Liebenberg, F., P.G. Pardey, and M. Khan. 2010 "South African Agricultural Research and Development: A Century of Change." Staff Paper P10-1, Department of Applied Economics, University of Minnesota.

Ludena, C.E., T.W. Hertel, P.V. Preckel, K. Foster, and A. Nin. 2006. "Productivity Growth and Convergence in Crop, Ruminant and Non-Ruminant Production: Measurement and Forecasts." Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, 12-18 August.

Nin, A., C. Arndt, and P.V. Preckel. 2003. "Is Agricultural Productivity in Developing Countries Really Shrinking? New Evidence Using a Modified Nonparametric Approach." *Journal of Development Economics* 71(2): 395-415.

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

———. 1932. Statistics of Agricultural and Pastoral Production. *Agricultural Census 1930,* No. 13. Union of South Africa. Pretoria: Government Printer.

———. 1939. Statistics of Agricultural and Pastoral Production. *Agricultural Census 1937,* No. 17. Union of South Africa. Pretoria: Government Printer.

Payne, N., J. van Zyl, and H. Sartorius von Bach. 1990. "Labour-Related Structural Trends in South African Commercial Grain Production: A Comparison between Summer and Winter Rainfall Areas, 1945-87." *Agrekon* 29(4): 407-415.

Schimmelpfennig, D., C. Thirtle, J. van Zyl, C. Arnade, and Y. Khatri. 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.

SARB (South African Reserve Bank). 2009. Long Run Gross Domestic Product (GDP) and Agricultural Contribution to GDP Statistics. Data provided upon request. Pretoria.

Statssa (Statistics South Africa). 2005. *Census of Commercial Agriculture, 2002: Financial and Production Statistics.* Report No. 11-02-01(2002). Pretoria: Republic of South Africa.

Thirtle, C., H. Sartorius von Bach, and J. Van Zyl. 1993. "Total Factor Productivity in South Africa, 1947-1991." *Development Southern Africa.* 10(3): 301-318.

World Development Indicators Database. World Bank. http://ddp-ext.worldbank.org/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=135.