

# SOUTH AFRICAN AGRICULTURAL R&D INVESTMENTS: SOURCES, STRUCTURE, AND TRENDS, 1910–2007\*

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## ABSTRACT

The twentieth century saw substantive shifts in the structure, funding and conduct of public agricultural research and development (R&D) and related regulatory and extension activities in South Africa. Following a long period of steady (and at times quite rapid) growth beginning in the early twentieth century, real spending on public agricultural R&D has essentially flat lined since the 1970s. There has also been an erratic pattern of funding per scientist and a loss of scientific personnel in recent decades. Notably, South Africa has lost ground relative to its competitors in international commodity markets, such as the United States (US) and Australia in terms of the intensity of investment in agricultural R&D. In the absence of changes to these trends, these developments may well have enduring, and detrimental, consequences for the productivity performance and competitiveness of South African agriculture. They deserve serious policy attention as the twenty-first century unfolds, with a firm eye to the long-run given the lengthy lags (often many decades) that typify the relationship between public agricultural R&D spending and productivity growth.

Keywords: public agricultural R&D, R&D investments, institutional history, R&D structure

## 1 INTRODUCTION

The South African agricultural economy changed markedly throughout the twentieth century. In 1910/11, agricultural output (as indexed by AgGDP) accounted for 19.3 per cent of total economic output (GDP) (Liebenberg and

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Pardey, 2011).<sup>1</sup> By 2008, the agricultural share of the total economy had shrunk to just 2.8 per cent of the overall economy even though the agricultural economy grew in absolute terms from R9.3 billion (US\$1.4 billion) in 1910 to R38.1 billion (US\$5.6 billion) in 2008 (both measured in 2000 prices). The structure of agricultural output changed substantially as well. As the twentieth century dawned horticulture constituted 9.4 per cent of the value of agricultural output, field crops accounted for 34.3 per cent, and livestock for 56.3 per cent. By 2008, horticulture, field crops and livestock accounted for 23.6, 31.4 and 45.0 per cent respectively of the country's agricultural output value.<sup>2</sup>

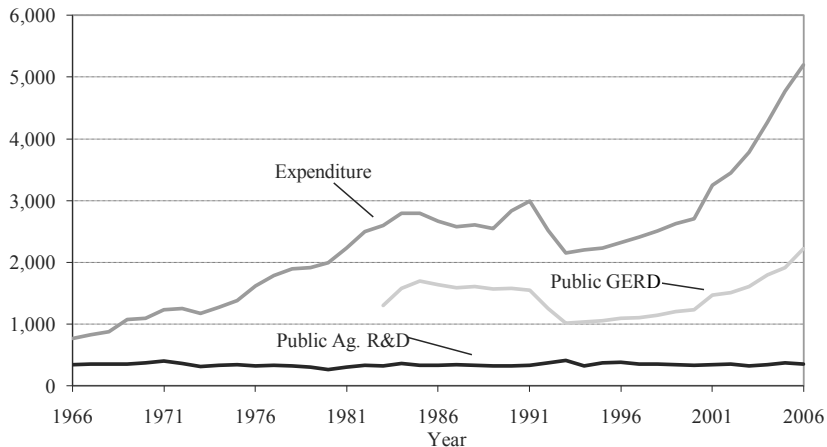
These sizable structural shifts have important implications for – and in turn have no doubt been affected by – the amount and nature of R&D and the accompanying technical changes.<sup>3</sup> Liebenberg and Pardey (2011) provide a chronological history of the policy and institutional changes that characterised South African agricultural R&D over the past one hundred years. As a sequel to and complement of that article, here we use an entirely new set of long-run agricultural R&D indicators to examine changes in the amount, orientation and sources of support for public agricultural R&D in South Africa since 1910/11.<sup>4</sup> Given the increasing international interconnectedness of the South African agricultural production and science sectors we also place selected South African science spending indicators in a comparative international setting. In particular we include some comparative R&D indicators for sub-Saharan Africa, the US and Australia. We begin by situating agricultural R&D in a broader science policy perspective, cognisant of the increasingly blurred policy and practical boundaries that denote the sciences in general and the agricultural sciences in particular.

## 2 OVERALL VS AGRICULTURAL SCIENCE SPENDING

In the fiscal year (FY) 1966, South Africa's gross expenditure on research and development (GERD) measuring total public and private R&D spending in all fields of science, was \$769.5 million (R36.5 million), representing 0.43 per cent of gross domestic product (GDP) (HSRC, 2007).<sup>5</sup> After growing at an annual average rate of 5.2 per cent per year in inflation-adjusted terms during the period 1966 to 2006, GERD totalled \$5.2 billion (R16.5 billion) in FY 2006, around 0.95 per cent of GDP (figure 1, panel a).<sup>6</sup> The rate of growth in GERD spending picked up in recent years, averaging 7.2 per cent per year from 1993 to 2006, reflecting, in part, the higher priority placed on overall public R&D spending during this period. In contrast, real agricultural R&D spending decreased by 0.83 per cent per year over the same period.

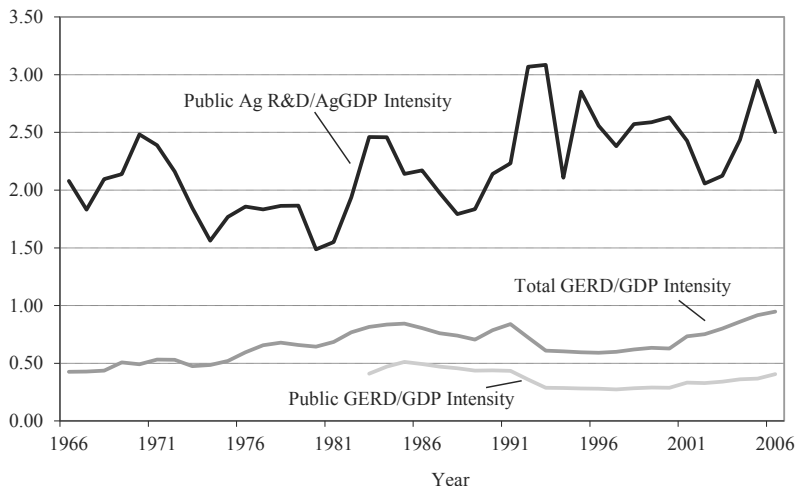
### Panel a: Spending trends

Expenditures (millions,  
2000 international dollars)



### Panel b: Research Intensities

Percentage



**Figure 1:** GERD and agricultural R&D spending, 1966–2006

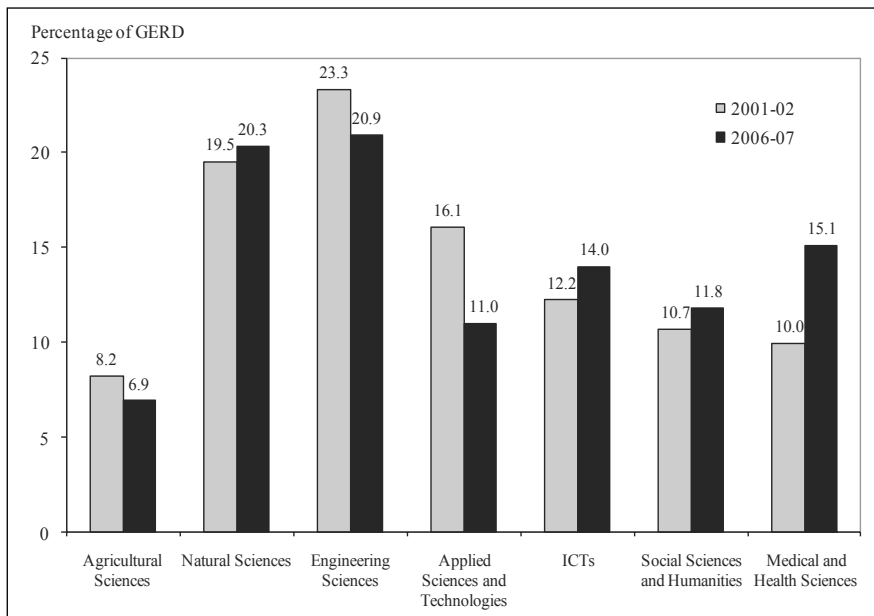
Source: CeSTII (various years), SARB (2009), and Liebenberg (2010)

Note: GERD data were reported bi-annually from 1966 to 1993, thereafter, in 1997, 2001 and from 2003 on an annual basis. The intervening years were derived by linear interpolation. Data were deflated using the GDP deflator from SARB (2009).

Figure 1, panel b shows a range of research intensity ratios, including total and public GERD relative to GDP and public agricultural R&D spending relative to agricultural GDP. Overall GERD as a share of GDP grew from just 0.43 per cent in 1966 to 0.95 per cent in 2006, with a generally increasing intensity of R&D spending aside from the sizable drop in FY 1993.<sup>7</sup> An imputed public-only GERD series is also shown. The pattern of change over time in the intensity of public research mirrors that of total GERD, with the combined share of private for-profit and not-for-profit research changing gradually during this period. In 1983, private research accounted for 49.9 per cent of all research, compared with 57.2 per cent in 2006.

In 2006, the ratio of public investment in agricultural R&D relative to the value of agricultural output (AgGDP) was 2.5 per cent, considerably higher than the 0.4 per cent intensity of public investment in all areas of research relative to the overall size of the South African economy (figure 1, panel b). However, both the agricultural R&D intensity ratio and the GERD intensity ratio have changed little since the early 1980s. These stagnant intensity ratios belie the substantial differences that underlie these investment relativities. As figure 1, panel a reveals, growth in real public agricultural R&D spending stalled over the past 30 years or so (albeit with significant fluctuations around this stagnant trend), whereas public GERD spending increased substantially during the past decade and a half. However, the substantive real growth in public GERD spending (2.21% per year from 1983–2006) was almost matched by the corresponding rate of real GDP growth (2.26% per year), and so the intensity of R&D investment in the overall economy barely deepened during this period. Likewise, public agricultural R&D growth of 0.30 per cent per year more or less matched the growth in real agricultural GDP (0.37% per year from 1985–2006), so investments in agricultural R&D also failed to intensify; but in the case of agriculture, the total amount of annual investment failed to grow, whereas overall public investments in science grew quite rapidly.

These public sector R&D trends in conjunction with a gradual (and, more recently, accelerating) increase in the overall intensity of public and private R&D investment in the South African economy since 1966 signal a shift in the orientation of South African R&D. Figure 2 shows a significant drop in the share of GERD directed to the applied sciences and technologies (often referred to as problem-solving research), as well as the engineering and agricultural sciences. The natural sciences, information and communication technologies, and social sciences have all increased their respective shares of total science spending. The medical and health sciences saw the greatest gains, jumping from 10 per cent of GERD in FY 2002 to 15.1 per cent just five years later, more than double the total spending directed towards agricultural R&D in that year.



**Figure 2:** GERD spending by field of science, FY 2002 and FY 2006

Source: CeSTII (2002 and 2009).

## 3 AGRICULTURAL R&D SPENDING

### 3.1 Long-run trends

Measured in inflation adjusted, year 2000 prices, South Africa invested just R68.9 (\$32.2) million in public agricultural R&D in 1910. Real public agricultural R&D spending grew steadily by an average of 5.1 per cent per year until 1952 (figure 3). The pace of growth accelerated to 7 per cent over the subsequent 19 years to total R866.4 (\$404.7) million by 1971. Spending on public agricultural R&D then declined by an average of 2.9 per cent per year in inflation adjusted terms from 1971 to R574 (\$268) million in 1980 and thereafter recovered somewhat to reach R752 (\$351) million in 2007. Notably, real public spending on agricultural R&D failed to grow significantly after 1972 – except for a brief jump to R890 (\$415) million in 1993 brought about by structural adjustment payments during the establishment of the Agricultural Research Council (ARC). In fact, if external income generated by ARC is excluded, public agricultural R&D spending for every year in the entire 1971–2007 period was less than the inflation-adjusted 1971 amount of R866 million.<sup>8</sup> In 2007, with the external income generated by ARC excluded, direct public investment in agricultural R&D was equal to just

70 per cent of the corresponding 1971 figure. Several of the switching points in the growth of public agricultural R&D spending coincide with changes in the administrative structure of public agricultural research agencies (Liebenberg & Pardey, 2011), while others relate to changes in science policy more generally.



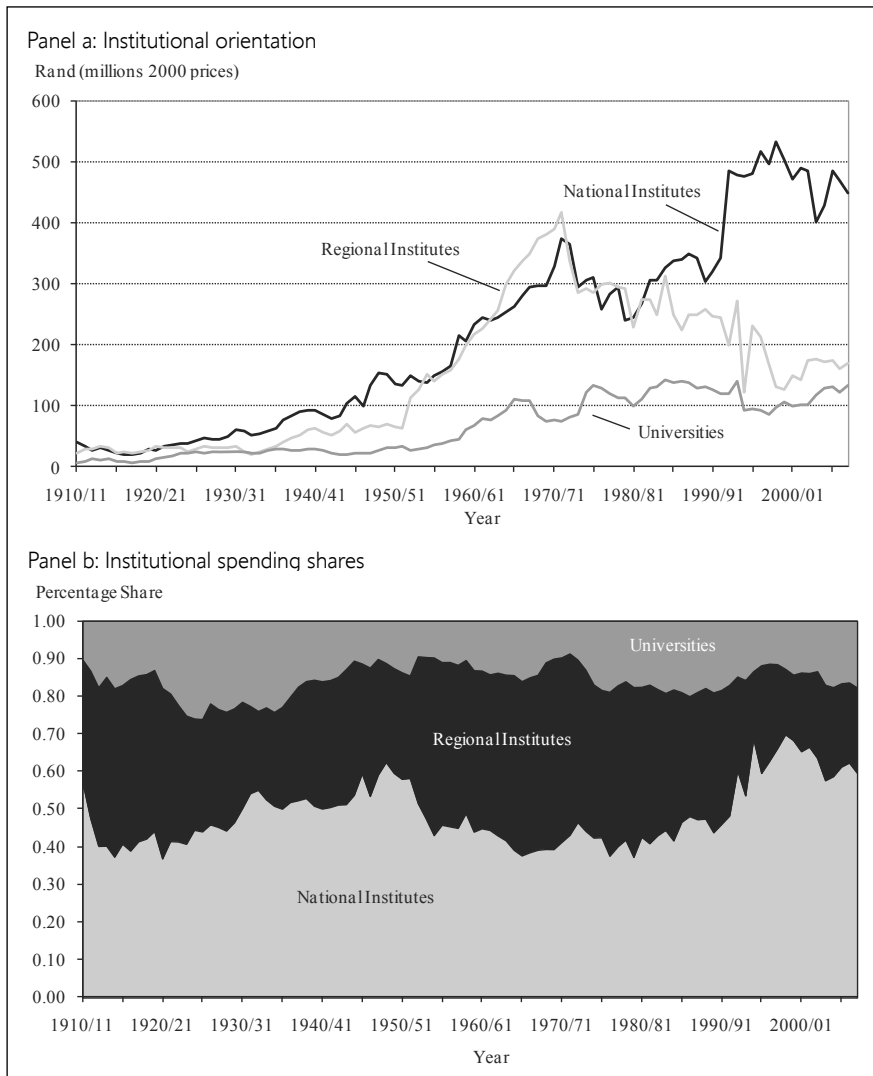
**Figure 3:** Public agricultural R&D spending trends, 1910–2008

Source: Union of South Africa (1910–1959), RSA (1960–2009), ARC (1993–2009), and SARB (2009)

Note: A nominal agricultural R&D series was deflated using a GDP deflator derived from data provided by SARB (2009).

The institutional implications of these policy changes are revealed in figure 4, panels a and b. The shares attributable to the national (i.e., ARC and its precursor agencies) and higher-education institutions have waxed and waned over the years, but there has been no sustained shift in the share of public agricultural research conducted by national agencies. ARC and its predecessor agencies accounted for 57 per cent of the total in 1910, growing to 63 per cent in 1948, and 70 per cent in 1998, but in more recent years fluctuating around 60 per cent. A counterpoint to the generally flat but fluctuating share accounted for by national agencies was an increase in the higher-education share (from 10.3% in 1910 to 20% in 1986, and

18 per cent in 2007). The share of public agricultural R&D conducted by regional (now provincial government) agencies has been especially volatile. From 1910 to 1952, regional agencies performed about 33 per cent of total public agricultural R&D. This increased dramatically in 1952/53 when the Agricultural Education



**Figure 4:** Institutional structure of public agricultural R&D spending, 1910–2008  
 Source: Union of South Africa (1910–1959), RSA (1960–2009), and ARC (1993–2009)

and Experiment Stations were reconfigured as regional services institutions with a dramatic increase in the estimated research-related budget allocation to these services. The regional share of total public agricultural R&D expanded over the subsequent 19 years (to average 45% from 1952/53 to 1973/74). Since 1992/93 they have averaged just 22 per cent.

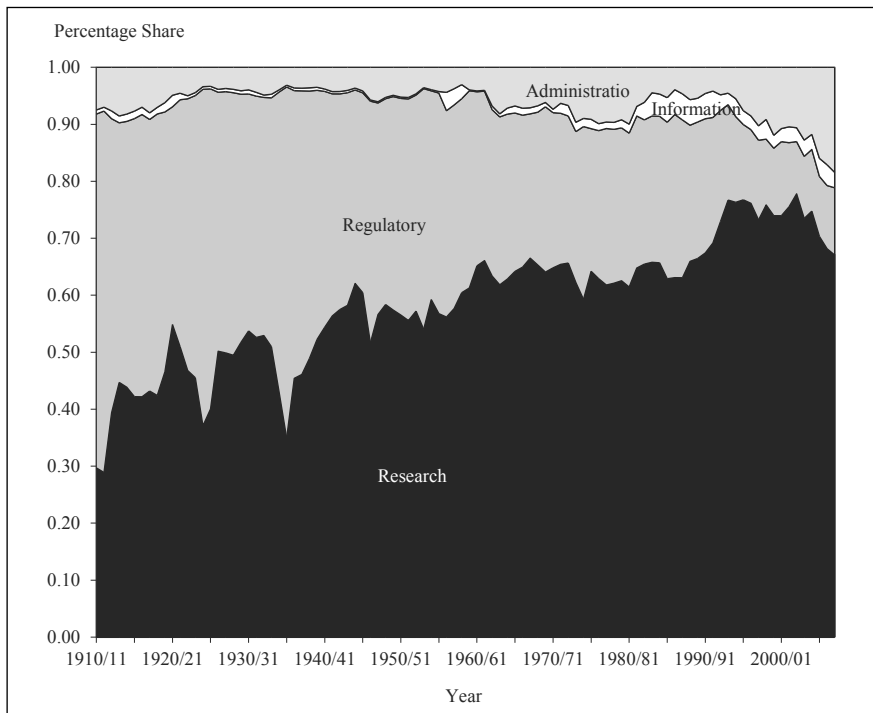
Beginning in 1971, the administrative oversight of the faculties of agriculture was moved from the Department of Agriculture (DoA) to the Department of Education (DoE). Inflation-adjusted spending on agricultural research conducted at the universities increased slightly until 1975 and thereafter stalled at around R118 (\$55) million. From 1967 to 1973, university funding for agricultural research declined, then increased erratically until 1993, followed by a relatively drastic decline in 1994 in the aftermath of the establishment of ARC. University-performed agricultural research inched upward from 1994 until 2003, then grew at a faster pace to reach R133.7 (\$62.8) million in FY 2007, returning these agencies to the amount they collectively spent on agricultural research throughout the 1980s.

Spending on regionally performed R&D experienced a marked downturn during 1971 to 1975 (declining from R393.4 to R266.8 million, or \$183.8 to \$124.6 million) in the immediate wake of the transfer of the faculties of agriculture to the DoA. It continued to contract at a slower rate until 1993, followed by a jump in 1995 when the provincial dispensation came into effect. Its current level is still well below that of its peak in FY 1971.<sup>9</sup> Spending on national and regionally performed agricultural R&D grew in parallel from 1951 through to the mid-1970s, and then also declined until 1979. For the subsequent 15 years, spending on R&D by national agencies fluctuated around a slowly declining trend, while spending by regional institutes contracted sharply. From a localised peak in FY 1989, spending at both the national and regional institutes contracted sharply in inflation-adjusted terms with wide fluctuations during the past three years, but began increasing again in FY 2001 for regional agencies and in FY 2003 for national institutes. Overall the spending patterns in the post-1970 period point to a good deal of institutional instability, with a marginally negative rate of growth of agricultural R&D spending (-0.04% per year) compared with the decades that preceded 1970.<sup>10</sup>

The spending relativities among public agricultural R&D and the supporting technology transfer and regulation cum inspection services has also shifted, in some cases substantially, over the years. Figure 5 shows that R&D accounted for a fluctuating but generally slowly growing share of agricultural R&D and regulatory services spending from 1911 (28.8%) until 1998 (74%). Thereafter, it declined precipitously to a 57.8 per cent spending share by 2005 occasioned by a dramatic decline in both the nominal and inflation-adjusted commitment to agricultural research during this period as well as an increase in spending on administrative



and regulatory services.<sup>11</sup> Not shown in this graph are the farmer support subsidies and general assistance payments to agriculture that for many decades were of orders of magnitude larger than the funds directed to research and technically related services.

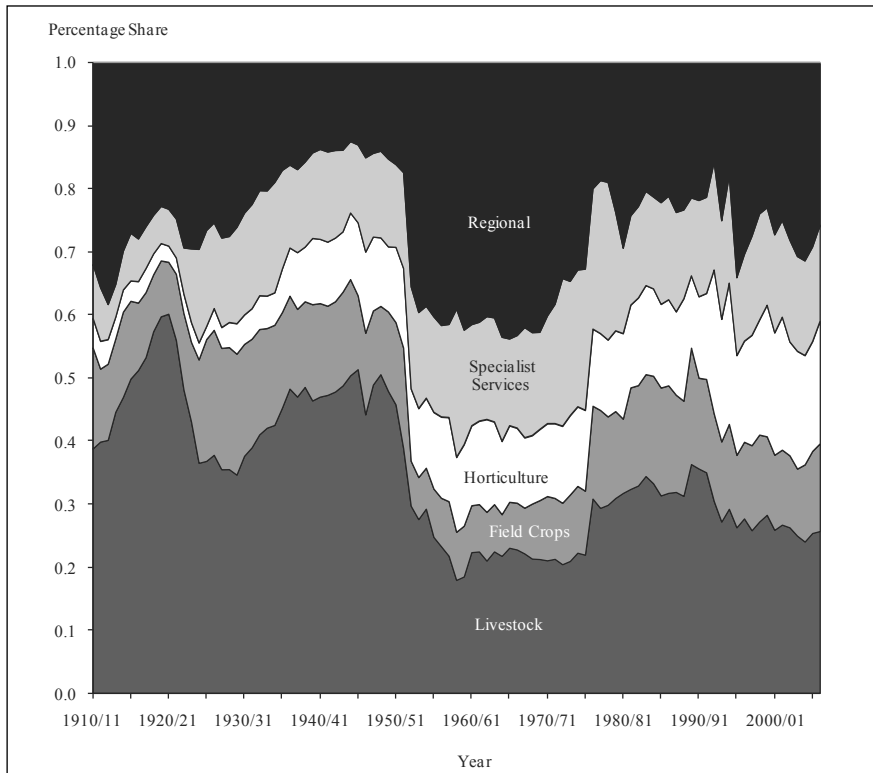


**Figure 5:** Public funding of agricultural R&D and technology related services, 1910–2008  
Sources: Union of South Africa (1910–1959), RSA (1960–2009), and ARC (1993–2009)

Notes: Administration includes only central or corporate administration and overhead costs, as institute specific administration and overhead costs are embedded in the institute-specific expenditures that constitute the corresponding research, regulatory and information totals. Regulatory services refers to all functions and services performed by various entities within the Department of Agriculture that relate to setting and enforcing all production and marketing standards and quality controls, including on-site inspection services. Information includes expenditures on publications and computer services.

During the period 1910 to 1953, the DoA struggled to settle on an institutional structure that best met its perceived service delivery demands. This period saw the transfer of the colleges and faculties of agriculture to the control of the DoA under the Research and Extension Division and the creation of a formal Extension

Service within this division from 1921 onwards. A separate division for extension was formally inaugurated in 1925 (Van Vuren, 1952). It was also an era when racial policies on land segregation and farmer settlement programmes to address the so-called “poor-white” issue dominated the R&D agenda. Combating livestock disease epidemics (such as East Coast Fever) dominated budget allocations toward regulatory services and affected the focus of research (figure 6).



**Figure 6:** Research focus of public agricultural R&D spending, 1910–2008

Source: Union of South Africa (1910–1959), RSA (1960–2009) and ARC (1993–2009)

Notes: 1. “Specialist Services” refer to spending by the Institutes for Soil, Climate and Water; Plant Protection, and Agricultural Engineering. “Regional” refers in large part to R&D conducted by the provincial Departments of Agriculture and the former Agricultural Development Institutes or regional research stations.

2. The evident downward blip in many of the share series reflects the ramping up of funding for regional activities during the 1954–1971 period, after which responsibility for the faculties of agriculture was transferred from the Department of Agricultural Technical Services to the Department of Education and the process of establishing national commodity research institutes began.

Beginning in the early 1950s, the agricultural development agenda increasingly began to emphasise the modernisation of agriculture and regional research gained significant policy and financial support. These funding and institutional shifts accelerated some trends that had already been in place. The livestock emphasis of public agricultural R&D declined, while specialist services (addressing soil, climate, water, plant protection and engineering concerns) gained a greater share, as did horticulture (figure 6). Farming systems research (often the emphasis of the revitalised regional institutes) markedly increased its share of R&D spending totals, especially during the 1960s and 1970s.

The formulation and implementation of a policy of “optimal agricultural development” during a 15-year period from 1968 to 1983 (Roseboom *et al.*, 1995), combined with the transfer of the universities to the DoE and the termination of the farmer settlement programme of the DoA Credit and Land Tenure, resulted in a marked change in the relative importance of the various research service providers. The higher-education sector marginally increased its share of the agricultural research spending total due to the country becoming increasingly reliant on training its own scientists as international isolation increased in reaction to the apartheid regime. The synergy between the regional and national institutes became less pronounced with strongly diverging trends in spending toward the early 1990s.

The national budget allocations at the time were also dominated by expenditures on the national defence and security forces in response to growing domestic unrest. Spending on agricultural R&D in the early 1990s was influenced by the establishment of the ARC, restructuring of the regional institutes to form the provincial departments of agriculture inclusive of the agricultural administrations of the former homelands, and demands for farmer support spurred by a severe drought during 1991/92. Research services at the provincial departments were hard hit by this given the enormity of the budgetary demands faced by provincial legislatures in meeting the demands of restructuring provincial governments to incorporate the homeland administrations and to take control over certain formerly national functions in education, welfare and security. In the midst of this came the closure of the Agricultural Credit Board and the Control Boards which, in the case of the Credit Board, saw a spike in investments as commitments for farmer assistance under some of its programmes was wound up. ARC was protected from these developments to some extent through its core funding being determined by a base-line (or cost-based) formula arrangement overseen by the Public Service Commission and Department of Finance, but this was soon to change (Liebenberg & Kirsten, 2006).

From 1997, the research investment trends of ARC, the provincial departments and universities followed distinctly different paths. Each agency now falls under different accounting authorities or line departments, with no effective overarching

coordinating mechanisms within government to guide investments in R&D across these institutions. The more recent increases in agricultural R&D spending by provincial agencies have been largely driven by the farmer settlement and land restitution and reform needs of the Land Redistribution for Agricultural Development and the Comprehensive Agricultural Support programmes. Moreover, the agricultural research activities of the provincial departments of agriculture lie outside the purview of the National Advisory Council on Innovation that oversees and evaluates the Science Councils such as ARC. Under the new national R&D strategy the provincial departments do, however, have access to funding from competitively bided funds and funding from the Department of Science and Technology (DST) for Centres of Excellence.

### 3.2 Research intensities

To place agricultural research expenditures in a more meaningful context, it is common practice to scale such data according to the size of the agricultural sector and various other criteria. Table 1 shows selected agricultural research and extension intensity ratios for selected decades from 1910 to 1990 and for each year since 2003, revealing wide fluctuations in expenditure intensity over the course of the century. In all cases there was a marked increase in investment intensities from 1910 to the 1930s reflecting the shift in the priorities of rural development policies. The growth in most of these research and extension intensities stalled in 1990, with the exception of investment per farm, which continued to increase from an inflation adjusted R9 675.9 (\$1 394.3) in 1990 to R16 968.8 (\$2 445.1) in 2007. This reflects a substantial reduction in farm numbers, evident since the 1993 *Census of Agriculture*, which is also accompanied by an increase in average farm size. After an initial period of growth during the early half of the twentieth century, extension intensities declined during the 1990s. Another notable feature of these trends is the divergent pattern of research and extension intensities. From the 1930s to the 1970s, the growth in extension intensities outpaced the growth in R&D intensities. Thereafter, extension intensities shrank to levels typically around a tenth or less of the corresponding agricultural research intensities that prevailed in more recent years.

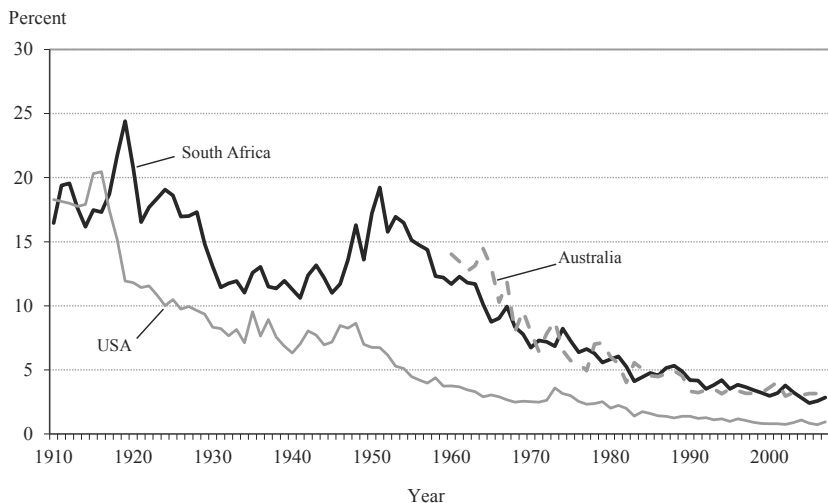
**Table 1: Alternative agricultural research intensity ratios, 1910–2007**

	1910	1930	1950	1970	1990	2000	2003	2004	2005	2006	2007
Relative to farm value added (per cent)											
Research	0.88	1.23	1.21	2.14	1.74	3.61	2.51	2.70	3.27	3.62	2.31
Extension	0.00	0.12	0.08	0.13	0.22	0.29	0.17	0.26	0.39	0.40	0.33
Relative to Ag. GDP (per cent)											
Research	0.71	1.26	0.77	2.25	1.86	2.44	2.21	2.2	2.58	2.45	1.97
Extension	0.01	0.13	0.05	0.13	0.23	0.20	0.15	0.21	0.30	0.40	0.33
Relative to farm numbers (real \$2000 per farm)											
Research	89.5	163.8	286.1	1,140.8	1,394.3	1894.4	2,341.1	2,192.2	2,362.4	2,586.8	2,483.8
Extension	0.2	16.3	18.9	67.4	174.7	154.6	156.3	209.0	278.5	426.9	421.8
Relative to total population (real \$2000 per capita)											
Research	1.61	1.85	2.69	4.65	2.45	2.21	2.25	2.05	2.13	2.25	2.08
Extension	0.03	0.18	0.18	0.27	0.31	0.18	0.15	0.20	0.25	0.37	0.35
Relative to farm worker population (real \$2000 per capita)											
Research	17.37	21.20	37.89	80.04	7307	70.74	116.93	123.32	142.41	127.79	128.97
Extension	0.28	2.11	2.50	4.73	9.16	5.77	7.81	11.75	16.79	21.09	21.90
Relative to total farm area (real \$2000 per ha)											
Research	0.08	0.19	0.38	1.17	1.04	1.16	1.24	1.13	1.19	1.27	1.18
Extension	0.00	0.02	0.03	0.07	0.13	0.09	0.08	0.11	0.11	0.14	0.21

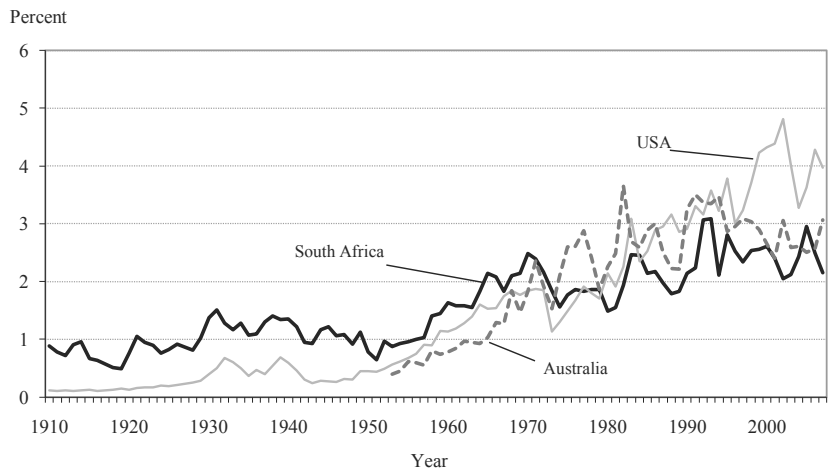
Source: BCS (1960), SARb (2009), DAS (1957–2009), Union of South Africa (1910–1959), RSA (1960–2009), and ARC (1993–2009)

Note: The establishment of an extension function within the Division for Education and Extension in 1925 was followed by a substantial increase in investments in agricultural extension services for the subsequent three decades, during which time the extension services were responsible for some research-related functions, such as the oversight and conduct of co-operative experiments. These arrangements and associated funding allocations changed when the Department of Agriculture was restructured in 1952–1954 with the intent of giving a greater regional focus to the provision of agricultural R&D services.

Panel a: Agriculture as a share of GDP



Panel b: Public agricultural R&D spending as a share of agricultural GDP



**Figure 7:** Comparative intensity trends in the US, Australia and South Africa, 1910–2007  
Source: Union of South Africa (1910–1959), RSA (1960–2009), ARC (1993–2009), Alston et al. (2010), Mullen (2010), US-BEA (2009), USDA (2009), and Australian Bureau of Statistics (2009)

### 3.3 International intensity relativities

Placing South African developments in an international context, figure 7, panel a shows that agricultural GDP shrank as a share of overall GDP for Australia and the US as well as South Africa throughout the twentieth century. The trend (and value) of the agricultural GDP to GDP ratio in South Africa and Australia were similar, but the corresponding ratio for the US declined at a faster rate than (and was generally considerably below) the South African figure. Notwithstanding the Australian and South African similarities in the agricultural shares of their respective economies, figure 8, panel b reveals that South Africa invested more intensively in agricultural research than Australia (and the US) for the first three quarters of the twentieth century. In the early 1970s, the relativities changed, with South Africa generally falling below Australia (and well below the US) in terms of public agricultural R&D intensity as the pace of investment in agricultural R&D faltered as did the growth of the South African agricultural economy.

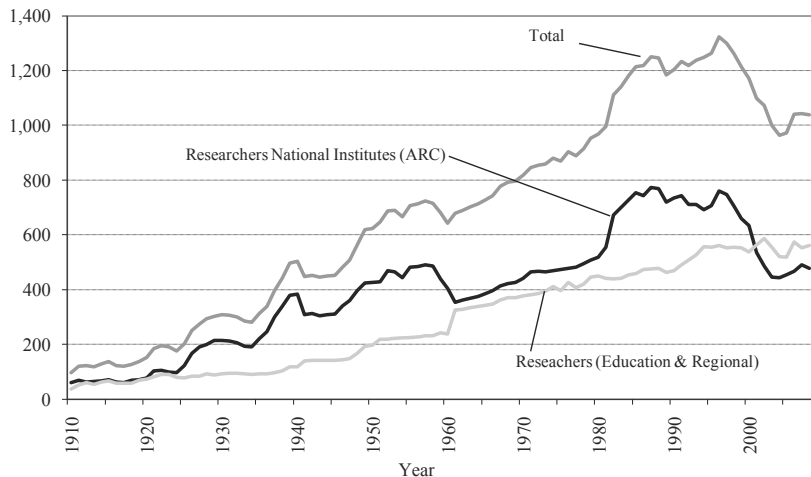
Notwithstanding South Africa's recent poor intensity performance relative to Australia and the US, in 2000, South Africa's intensity of commitment to agricultural R&D per unit of agricultural GDP (\$2.50 of research spending per \$100 of agricultural output) was on a par with the corresponding high-income average of \$2.36 reported by Pardey *et al.* (2006). However, South Africa had about half the spending on agricultural R&D per capita of the general population and about a fifth of the spending per capita of the economically active agricultural population compared with the corresponding average intensity ratios of the high-income countries.

## 4 SCIENTIST TRENDS

Figure 8, panel a, summarises trends in the number of researchers at the national and regional institutes (including universities) since 1910. The significant jump in the number of research staff at the regional institutes in the early 1960s coincided with the increase in the number of regional institutes from six to seven and implementation of the amended Soil Conservation Act (Act 37 of 1960), which involved an almost threefold increase in the nominal agricultural R&D budget in 1960/61. There was a run up in the total number of researchers during the 1980s when the national institutes received greater autonomy and the status of some was raised from a research centre to that of an institute headed by a director. A decline in the number of researchers at regional and national institutes began in 1996, initially in response to voluntary retrenchment initiatives introduced to reduce the size of government. During the initial years of this decline, the contraction was much faster among the regional institutes. The decline in the number of researchers at national institutes picked up pace after 1998/99 and bottomed out at levels equal to those that prevailed in the pre-1980 period. Figure 9, panel b indicates that the

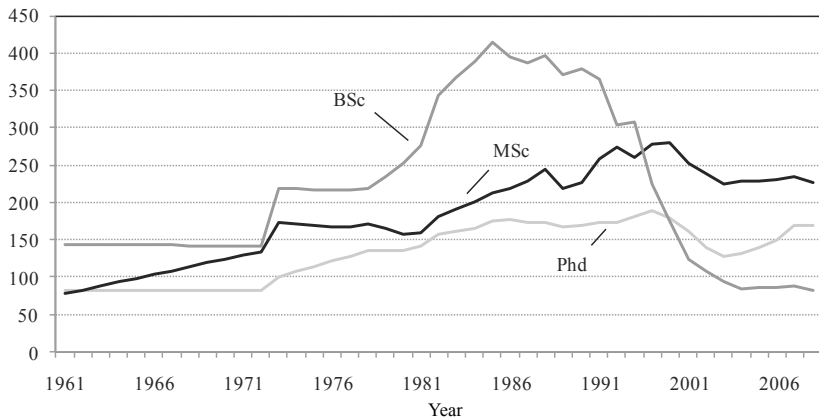
Panel a: National, regional and education researcher trends, 1961–2008

Number of Agricultural Researchers



Panel b: Staff qualification of ARC researchers, 1961–2008

Number



**Figure 8:** Public sector agricultural researcher trends, 1910–2008

Source: Union of South Africa (1911–1959), RSA (1960–1976), Roseboom et al. (1995), Liebenberg et al (2004), ARC (various reports), and CeSTII (various reports).

Note: Data for educational and regional researchers represent full time equivalents of time spent on research.



decline in the number of ARC researchers from 1997 to 2008 has disproportionately affected those holding BSc degrees (which decreased by 9.8 per cent per year), while those holding PhD and MSc degrees contracted at a slower but still substantial rate (i.e., they declined by 2.46 and 2.94 per cent per year, respectively).

## 5 FUNDING PUBLIC RESEARCH

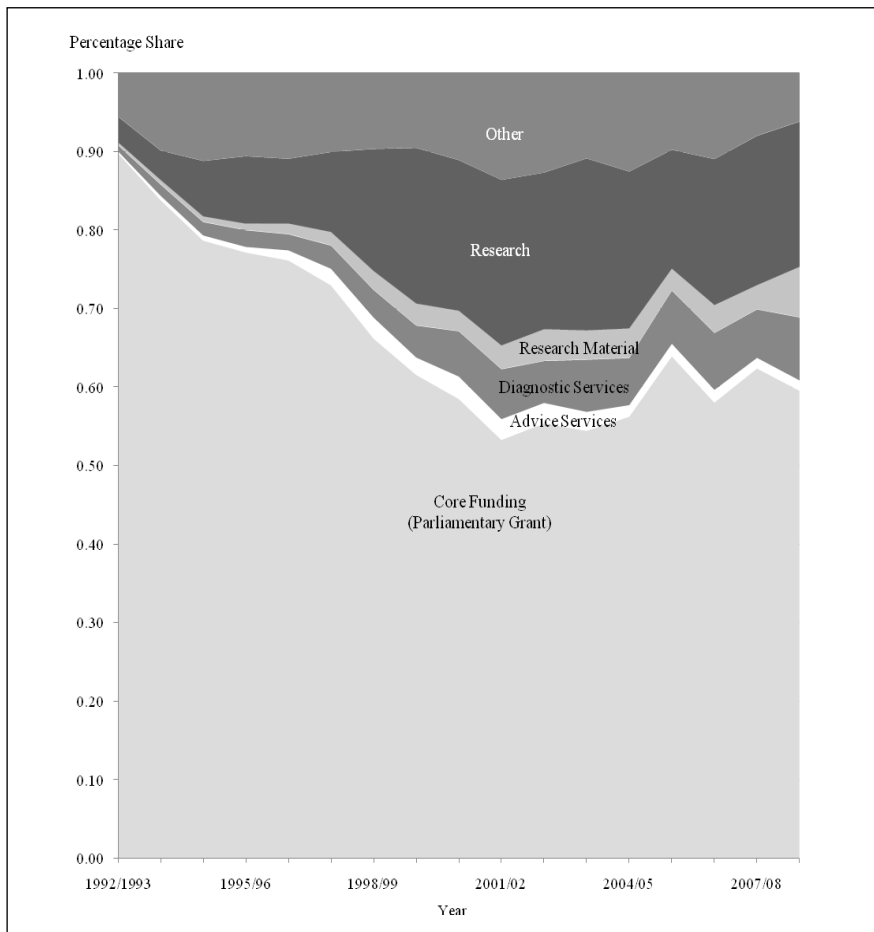
The sources and forms of funding for publicly performed research not only influence the amount of research conducted, but also the types of research undertaken, including the balance between strategic (or longer-term R&D) versus more applied (shorter-term research), or between crops versus livestock research, or between research on particular crops and particular livestock commodities, or specific problems confronting agriculture. The balance between research oriented to maintaining and enhancing farm productivity versus research directed to other aspects, such as the environmental dimension of agriculture, food safety, biodiversity, and human health and nutrition, can also be influenced by the way in which funds are forthcoming. Here we provide some indications of contemporary changes in the structure of funding of publicly performed agricultural research in South Africa using data on the various sources of funding for research conducted by the ARC institutes

### 5.1 Overview

Until 1992, research by the DoA relied heavily on block grant funding from the national government.<sup>12</sup> The commodity oriented Control Boards (such as the Wheat Board, Tobacco Board, Maize Board, etc.), which operated under the statutory marketing structures for agriculture that existed under various guises from 1937 to 1992, were an additional source of support. Allocations to agricultural research were made from levy income generated by way of the marketing schemes promulgated under the Agricultural Marketing Act (Act 59 of 1968).

In 1992, ARC institutes began to diversify their sources of funding (figure 9). The reported share of government core-funding for ARC dropped from 89.8 per cent in 1992/93, to 76.2 per cent in 1995/96. The target was to reduce the share of government funding to 70 per cent by 2000 in line with a general understanding reached with organised agriculture prior to the establishment of ARC. ARC exceeded this target by about 11 per cent. By 2001/02 the share of ARC funding from government in the form of block grants had fallen to 53 per cent of total revenue. Since then core funding has crept up to 62 per cent of total funding by 2007/08, mostly driven by increases in funding from the DoA and DST in an effort to redress shortfalls in funding for government commissioned diagnostic and research services provided by ARC. In addition, the DST now provides funding earmarked for the maintenance of national assets (gene bank, reference collections of fungi,

insects and pathogens), while the DoA provides additional funds directed towards the maintenance of the country's physical research infrastructure (RSA, 2009).



**Figure 9:** Funding sources for ARC, 1992–2008

Source: ARC (2009)

Income generated by providing diagnostic services and selling research materials, including the sale of plant and livestock products, breeder seed, and revenues from royalties and technology licence fees accounted for roughly 11 per cent of ARC's non-core income in 1992/93. These forms of funding began to increase from 1997, reaching a combined 24.7 per cent share of total funding by 2007/08.

The source of funds varies markedly among ARC institutes. Table 2 shows the relative share of the various non-core sources of support for each of the 12 ARC institutes (including headquarters) for FY 1995/96 and 2007/08. For most of the institutes the major source of non-core income was from research services, except for veterinary research, citrus and subtropical crops and agricultural engineering, where a range of other sources predominated. Most institutes have quite diversified sources of support, although in the case of livestock, deciduous fruit, plant protection and soil, climate and water, there has been a sustained increase in the share of income generated from research services. The crop-related institutes (specifically the grain crops, industrial crops, and small grains institutes) have long sourced a large share of their non-core income from the provision of research services, whereas agricultural engineering has received none of its funding from this source, but has relied heavily on the sale of advice services to secure non-core sources of support.

## 5.2 Non-government sources of support

The policy governing the activities of Science Councils in South Africa classifies all sources of funding other than the parliamentary grant as private and is commonly referred to as external funding (DACST, 1996). For the purpose of this analysis private funding is redefined as funding originating from non-government sources, including commodity trust funds and levies from producer organisations along with research funding from private firms. ARC's formal policy is to charge full cost for all research and other services performed on behalf of external clients. Many clients however, balk at this pricing policy and as a practical matter the common practice currently is to undertake contracted research on a 50:50 cost sharing basis. Typically only operational costs (i.e., scientists' salaries and the cost of materials used in carrying out the research) are included. Some ARC institutes include overhead costs to recoup some of the costs of the physical and administrative support costs of the institutes, but this practice varies among clients and institutes and rarely if ever includes the full cost of the central or corporate expenses incurred by ARC.

The year 1997 was an important transition year with significant implications for industry support for ARC research. In that year the commodity Control Boards overseeing managed marketing schemes ceased to exist, as did the producer levy schemes that underwrote the commodity stabilisation funds and other costs incurred by these Control Boards. It took several years before a new set of statutory levy schemes were in place under the legislative authority of the Marketing of Agricultural Products Act (Act 47 of 1996). In 1998, just seven industries agreed to a levy scheme, but by 2007, the number had grown to 11 industries. Levy income is used to provide collective goods to farmers in each

**Table 2: Non-core sources of support for ARC institutes, various fiscal years**

Source	Institute												
	Corpo- rate	Grain Crops	Industrial Crops	Small Grains	Tropical & Sub- tropical	Infrui- tech	Vegetables & Ornamental Plants	Animal Products	Veteri- nary	Plant Protec- tion	Soil, Climate & Water	Agricultural Engineering	ARC Total
Percentage													
Share of external income 1995/96													
Advice services	0.0	0.4	0.0	0.5	5.3	1.5	3.6	4.3	2.0	1.3	3.1	78.1	3.4
Diagnostic services	0.0	1.2	9.4	5.0	11.2	3.2	1.8	31.2	65.2	5.0	8.2	0.0	18.1
Farm products	0.0	1.2	5.5	2.1	49.7	8.1	1.0	14.0	0.0	0.0	0.0	0.0	5.4
Personnel services	4.0	0.0	22.3	0.7	14.6	7.6	11.8	3.7	6.4	0.4	0.0	20.3	5.1
Research materials	60.1	15.7	4.3	27.1	4.4	10.9	29.8	7.5	5.2	1.7	0.1	0.1	13.7
Research services	14.5	79.5	58.5	63.3	13.2	67.0	52.5	33.5	19.9	91.0	87.7	0.0	45.6
Supporting services	2.0	0.5	0.0	0.0	2.0	0.0	0.0	1.2	0.4	0.0	0.0	0.3	0.7
Other income	19.3	1.3	0.0	1.3	-0.4	1.6	-0.6	4.5	1.0	0.6	0.9	1.2	8.1
Share of external income 2007/08													
Advice services	0.0	0.4	0.0	0.5	5.1	1.5	3.2	4.3	1.7	1.2	2.9	73.4	3.4
Diagnostic services	0.0	1.1	8.7	4.8	10.7	3.1	1.6	29.3	65.6	4.7	7.6	0.0	18.1
Farm products	0.0	1.1	5.1	2.0	47.3	6.4	0.9	13.2	0.0	0.0	0.0	0.0	5.4
Personnel services	4.8	0.0	20.6	0.7	13.9	7.5	10.5	3.5	7.6	0.4	0.0	15.4	5.1
Research materials	52.6	15.2	3.9	26.3	4.2	10.7	26.4	7.0	4.5	1.6	0.1	0.1	13.7
Research services	16.7	74.6	54.0	61.3	12.6	65.5	46.5	31.9	16.6	86.2	84.7	0.0	45.6
Supporting services	2.4	0.5	0.0	0.0	1.9	0.0	0.0	1.1	0.4	0.0	0.0	0.3	0.7
Other income	23.5	7.0	7.7	4.4	4.4	5.3	10.8	9.7	3.5	6.0	4.7	10.9	8.1

Source: ARC (2009)

of the respective industries, including promotional services for local and export markets, product development, quality control, sectoral transformation activities, plant improvement and research. The National Agricultural Marketing Board oversees the collection and disposition of these levy funds. For ARC, another significant source of industry support comes by way of the commodity trust funds that developed as a redeployment of the closing balances of the pre-1997 commodity stabilisation reserves that are now overseen by their respective boards of trustees, which includes industry and ministerially appointed representatives.

The share of levy income directed to agricultural R&D varies markedly across industries and among years within an industry (table 3). For example, in 2007 the Citrus Levy directed 64 per cent of its levy income to R&D, whereas the Dairy Levy and Red Meat Levy each spent only 3 per cent of their income on research. The types of research supported by levy funds also vary. For example, in 2007 around 79 per cent of the levy income collected by the winter cereal industry was directed to projects addressing the response of crops to changes in external factors affecting them, such as diseases and pests (NAMC, 2007). Notably, the share of statutory levy income earmarked for agricultural research projects has declined over the past three years, from 42 per cent of the total levy income in 2006 to 32 per cent in 2008 (NAMC, 2009). ARC's share of the levy income allocated to research has also declined from 42 per cent in 2007 to 37 per cent in 2008 (NAMC, 2008, 2009).

Another concern is that even if funding from the commodity trusts to ARC was increased so that all the levy income collected was allocated to research, this would represent only 23 per cent of total ARC external income. Moreover, if all the income generated through research services was assumed to come from private clients, only two thirds of the crops institutes would be deemed to be earning more than half their external (non-core) income from private sources.

As a share of non-core funding, contract research executed by ARC increased from an average of about 30 per cent during the first three years of its establishment to 38 per cent in 1995/96. By 2007/08 this had increased to 49 per cent. However, many of these contracts are with public agencies and often government parastatals, such as Onderstepoort Biological Products Ltd and other Science Councils. Thus, the increase in the share of contract research performed by ARC overstates the degree to which government has reduced its share of funding for publicly performed agricultural R&D. But at a minimum this contract-client arrangement has laid the basis for a market for R&D goods and services that, in principle at least, can increase the degree to which this public system is responsive to the demands placed upon it.

**Table 3:** Annual contribution by commodity organizations to agricultural research, 1999–2008

Source	Contribution						
	1999	2000	2001	2002	2006	2007	2008
	Rands in millions						
Trust contributions							
Crops	13.06	18.73	21.34	n.a.	n.a.	n.a.	n.a.
Horticulture	5.28	4.20	3.68	n.a.	n.a.	n.a.	n.a.
Livestock	3.58	3.47	7.22	n.a.	n.a.	n.a.	n.a.
Subtotal	21.92	26.40	32.25	n.a.	n.a.	n.a.	n.a.
Levy income							
Crops	11.19	11.49	12.34	n.a.	19.47	n.a.	23.20
Horticulture	19.16	25.67	27.52	n.a.	40.16	n.a.	46.22
Livestock	n.a.	n.a.	n.a.	n.a.	0.46	n.a.	1.26
Subtotal	30.35	37.16	39.86	38.41	60.09	74.42	70.68
Total contribution by commodity organisations							
Crops	24.25	30.22	33.68	n.a.	n.a.	n.a.	n.a.
Horticulture	24.44	29.87	31.21	n.a.	n.a.	n.a.	n.a.
Livestock	3.58	3.47	7.22	n.a.	n.a.	n.a.	n.a.
Total	52.27	63.56	72.10	n.a.	n.a.	n.a.	n.a.

Source: Unpublished information provided by various trusts and commodity organisations (1999–2001) and NAMC (2007–2009)

## 6 CONCLUSION

Government sponsored agricultural research in South Africa stretches back more than a century. In 1911, public agencies employed a total of 120 scientists and spent a total of R68.9 million (or \$32.2 million, both in 2000 prices) on agricultural research. By 2007, there were 1 279 scientists and the investment had grown to R753.8 (\$352.1) million. Agricultural research spending grew unevenly over time: real spending grew by an average of 5.1 per cent per year from 1911 to 1950 increasing to 7 per cent per year from 1950 to 1971, at which point spending effectively ceased growing. During the rapid growth phase of the 1950s and 1970s, spending on agricultural research grew faster than agricultural output so that the intensity of investment in public agricultural research (i.e., agricultural R&D spending as a share of agricultural GDP) increased from 0.8 per cent in 1911 to 2.46 per cent in 1983, but barely budged over the subsequent two and a half decades reaching only 2.5 per cent by 2007.

The early 1970s were a turning point in another notable sense. During the six previous decades, South African agriculture maintained a higher intensity of investment in public agricultural research than two of its main global competitors, the US and Australia. South Africa gradually fell behind after the early 1970s, and now trails the US and Australia in terms of its public agricultural research intensity. Perhaps not surprisingly, South Africa appears to have sustained a competitive edge during the decades prior to 1970, with a strong growth in agricultural exports and more muted but still pronounced growth in its net agricultural trade surplus. However, agricultural exports and net trade balances have declined precipitously in more recent decades.

The balance of public agencies conducting agricultural R&D has also changed over the past century. National and regional agencies performed the lion's share of the research for the first half of the twentieth century. The regional institutes reached their zenith by the early 1970s, at which time they performed around 48 per cent of the public agricultural R&D compared with 42 per cent conducted by national institutes and 10 per cent by universities. By 2007, the balance among research performers had changed markedly. The regional share had fallen to 23 per cent, not much in excess of the university share, which stood at 18 per cent, while the national share had grown to 60 per cent.

For a good part of the past 50 years, industry has financed some of the research conducted by public agencies. The share of funding from industry sources has fluctuated over time and varies among commodities and types of research. Most of it is now directed to research conducted in national institutes, and in recent years accounted for about 20 per cent of the funds flowing to ARC.

From a long-term perspective these developments are generally positive. From small beginnings at the turn of the last century, South Africa grew its capacity to educate agricultural scientists and developed the institutional capacity to self finance and conduct the R&D required to develop its agricultural sector. From a more recent perspective, the picture is less rosy. The amount of real funding for public agricultural R&D failed to grow since 1992; the intensity of investment in agricultural R&D also stagnated; and the country lost a substantial number of well-trained and experienced agricultural scientists. These more recent developments are cause for concern and suggest it is time to carefully and creatively rethink and revitalise South African agricultural R&D. The policy decisions and institutional actions taken over the next few years will help determine the destiny of the country's agricultural sector for the century that lies ahead.

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## NOTES

- 1 AgGDP excludes output from the (processed) food sector. The combined output of the farm and agribusiness sectors (including food and fibre 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 primary agricultural and food processing industries combined would constitute at least one-fifth of total GDP.
- 2 The long-run trends reported here draw on data collected from various reports and internal ledger files of the Directorate of Agricultural Statistics (DAS), and Census reports of Statssa and its predecessor agencies. Much of the data from these sources was adjusted to deal with changes in measurement practices, variable definitions and aggregation procedures over time. For a complete reference on this see Liebenberg (2011).
- 3 The emphasis in this study is on publicly conducted R&D. Mention is made of the private sector only in so far as it has provided financial support to publicly performed research. The private sector has long been engaged in agricultural R&D in South Africa. See, for example, the R&D conducted by the South African Sugar Research Institute (Nieuwoudt & Nieuwoudt, 2004a, 2004b).
- 4 Parts of this paper draw on Liebenberg (2011), which builds on and extends earlier work by Roseboom et al. (1995), Liebenberg et al. (2004) and Liebenberg and Kirsten (2006).
- 5 Unless otherwise stated, all dollar denominated values in the text were converted to international dollars using the relevant purchasing power parity indexes. Values denominated in U.S. dollars were converted from their respective local currency units using average annual market exchange rates. See Kahn and Blankley (2008) for more details regarding contemporary developments in the overall R&D system in South Africa.
- 6 The text amounts are denominated in international dollars (as per footnote 5). Using market exchange rates, the FY1966 GERD total in U.S. dollars was \$237.1 million and \$1,599.9 million in FY2006 (both figures in 2000 prices).
- 7 Blankley and Kahn (2005) discuss the details of the survey structure and responses that underpin these GERD estimates, thus helping to calibrate the precision, coverage and consistency of these data.
- 8 By way of comparison, in 2007, the US spent \$3.77 billion on public agricultural R&D, equivalent to \$1.45 billion (2000 prices) more than it did in 1971 despite a slowdown in the average annual rate of growth during the 1970-2007 period compared with the rate of growth during the previous 50 years (Alston et al. 2010).
- 9 The changeover to the new constitutional dispensation, and with it the incorporation of the administrations of the former homelands and self governing territories, saw a marked increase in the overall public expenditure on agriculture by these regional centres, mostly driven by spending on farmer settlement support and land restitution administration. Their expenditure on R&D, however, remained fairly stable.



- 10 By comparison, spending grew at an average rate of 7.04 per cent per year during the period 1952 to 1971, and 5.1 per cent per year from 1911 to 1952.
- 11 The reported increase in the share of administrative costs may in part reflect changed accounting practices, wherein some costs previously charged directly to R&D programs are now treated as a central overhead cost.
- 12 Government budget reports since 1910 show that the DoA has typically generated some income through the sale of farm products and research materials, as well as the fees charged for diagnostic services. The share of total income derived from fees (inclusive of non-research service income) to total expenditure by the departments varied between 29 and 17 per cent from 1915 to 1933. Thereafter, it fluctuated around 10 per cent until 2005, after which it declined to around 5 per cent of total departmental expenditure. An interesting aspect of the pre-depression years was that research stations often produced a surplus above costs. In addition, during these early years of the twentieth century, expenditure on agriculturally related operations by non-agriculturally related departments, such as post and telecommunication, police and prisons, was equivalent to upwards of 20 per cent of the total expenditures incurred by the DoA (Union of South Africa 1910–1959).

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