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Trends in Investment in Agricultural R&D in Australia

and its Potential Contribution to Productivity

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Introduction

Within the Australian economy, productivity growth in agriculture, fisheries and forestry sector has been around 3 times that in the economy as a whole (ABS, 2007) and has markedly outpaced the decline in the terms of trade facing farmers over the past 15 years. International comparisons are difficult to make but the evidence available suggests that Australian agriculture has performed well against the agricultural sectors of most other counties (Mullen, 2007, Mullen and Crean, 2007, Mullen, 2009).

However since these earlier papers, ABARE has revised downwards its estimate of long term productivity growth in broadacre agriculture previously reported by Mullen in various papers to be 2.5% per year since 1953 to about 2% per year. But of greater interest, it is now clear that productivity growth in broadacre agriculture has declined in the ten years to 2007 (-1.4% per year).

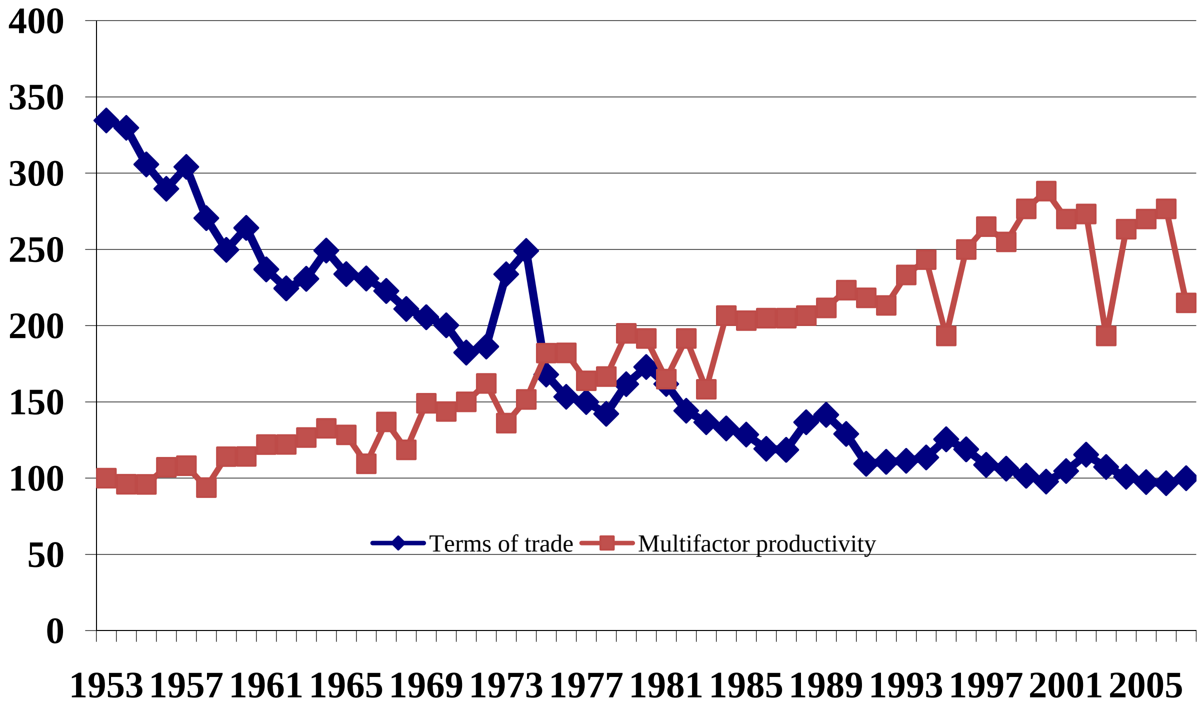
Clearly a run of poor seasons explains some of this slowdown in productivity growth but public investment in R&D in agriculture has been stagnant since the 70s and it seems likely that this stagnation is now being reflected in broadacre productivity growth.

The objectives of this paper are to briefly review trends in productivity growth and then examine recent trends in investment in R&D both in terms of total investment, how it is being funded and where it is being undertaken. Scenarios are developed which assess the potential contribution of domestic investment in R&D to productivity growth in agriculture. This paper updates a paper by Mullen and Orr (2007).

Trends in broadacre productivity in Australia

Multifactor productivity (MFP) in broadacre agriculture in Australia grew from 100 in 1953 to 288 in 2000, fell to 193 in 2003, rose to 277 in 2006 before finishing at 215 in 2007. Drought has been a feature of agriculture for the past decade but 2003 and 2007 were particularly severe years (Figure 1).[1] The terms of trade more than offset gains in MFP until the late 80s but since then there has been only a slow decline (1%) and hence farmers have been able to capture more of the gains from MFP growth.

Figure 1: Broadacre MFP and terms of trade in Australian agriculture: 1953 – 2007



Source: Terms of trade estimated as ratio of index of prices received by farmers to index of prices paid by farmers (ABARE, Australian Commodity Statistics, 2008) and MFP is gross output measure.

MFP growth varied across industries within broadacre agriculture and between States (Table 1). It has been much stronger for cropping specialists than for livestock specialists and it has been much stronger in Western Australia and South Australia than the eastern states. Of great concern is the apparent decline in MFP since 1998 (Table 2) particularly for cropping specialists, for whom MFP fell at the rate of 2.1% per year, a marked departure from growth of 4.8% per year for 1980 to 1989.

Australia has experienced a run of poor seasons since 2000. The rainfall anomaly chart for the Murray Darling Basin shows the deviation of annual rainfall from the average rainfall over the 30 years 1960 -1990 (Figure 2). The last eight years to 2008 have been below average and no doubt this has contributed to negative rates of MFP growth.

Recent econometric research confirms that there has been a structural break in the trend of MFP (Sheng et al., 2009). However this research also demonstrates that the slowdown cannot be explained by climate alone. The stagnation in public R&D investment has also contributed to the slowdown. The remainder of the paper focuses on trends in R&D investment and its potential contribution to MFP growth.

Table 1: Compound annual growth in MFP for broadacre industries and by State, 1978 to 2007

	Percentage Growth		
	MFP	Output	Input
Total Broadacre	1.5	0.8	-0.6
Cropping	2.1	3.1	1.0
Mixed crop/livestock	1.5	0.1	-1.5
Beef	1.5	1.7	0.1
Sheep	0.3	-1.4	-1.8
NSW	1.2	0.3	-0.9
VIC	1.4	0.6	-0.8
QLD	0.8	0.6	-0.2
SA	2.0	1.5	-0.5
WA	2.4	1.8	-0.6
TAS	0.8	-2.1	-2.9
NT(Beef)	1.7	1.6	-0.1

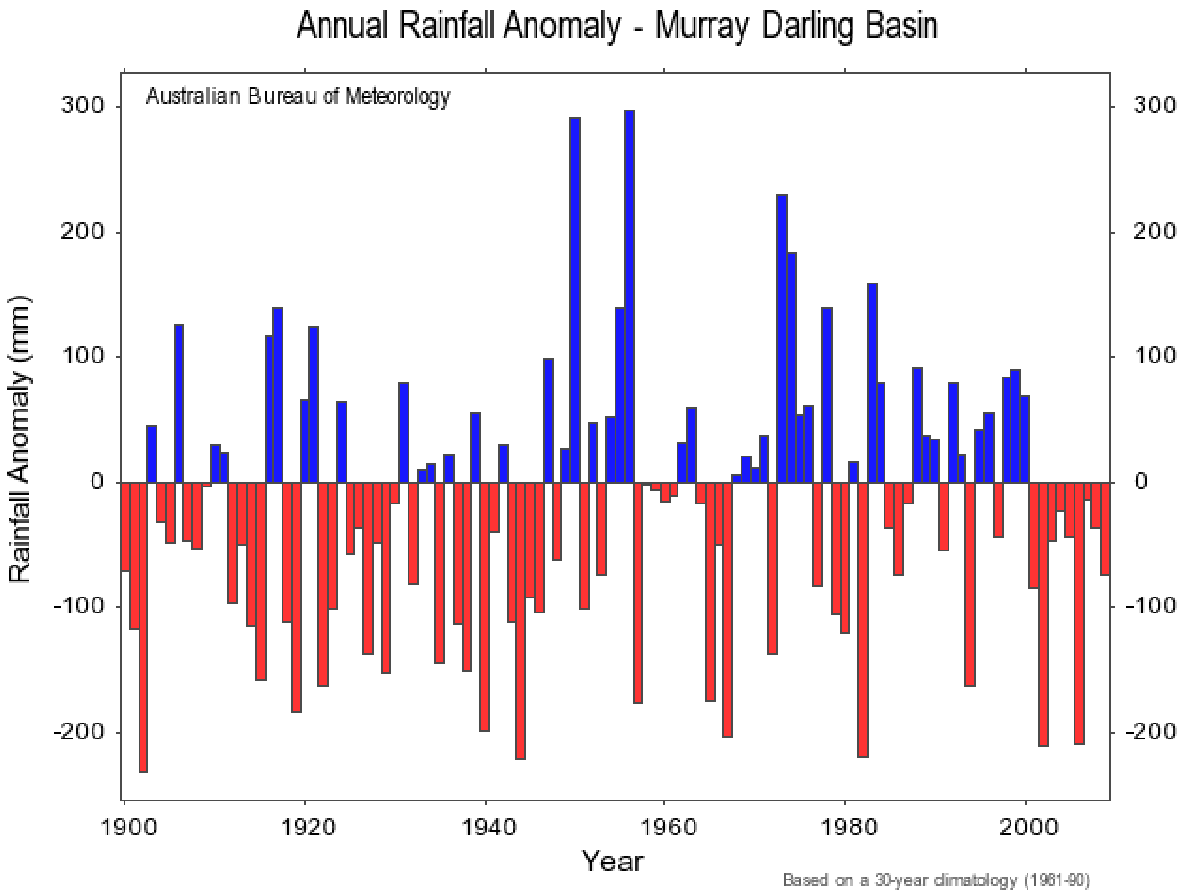
Source: Nossal et al. (2009) for the industry data. The state data come from the same database but were not published in Nossal et al. (2009).

Table 2: Trends in MFP for broadacre industries, 1978 to 2007

	All broadacre	Cropping	Mixed crop -livestock	Beef	Sheep
1979-80 to 1988-89	2.2%	4.8%	2.9%	-0.9%	0.4%
1984-85 to 1993-94	1.8%	4.7%	3.2%	3.1%	-1.7%
1988-89 to 1997-98	2.0%	1.9%	1.4%	1.6%	-1.2%
1993-94 to 2002-03	0.7%	-1.2%	0.0%	1.0%	3.4%
1997-98 to 2006-07	-1.4%	-2.1%	-1.9%	2.8%	0.5%
1977-78 to 2006-07	1.5%	2.1%	1.5%	1.5%	0.3%

Source: Nossal et al. (2009)

Figure 2: Annual Rainfall Anomaly – Murray Darling Basin, 1900 – 2008



Source: the Bureau of Meteorology. Available at: http://reg.bom.gov.au/cgi-bin/climate/change/timeseries.cgi?graph=rranom&area=mdb&season=0112&ave_yr=0

Trends in Public Investment in R&D

The way in which the data on R&D investment have been assembled from ABS sources and from a previous dataset developed by Mullen, Lee and Wrigley (1996) is described in Mullen (2007). Expenditure is attributed to research providers, rather than funders. As a result, expenditure by state departments of agriculture or universities, for example, includes funds obtained from rural RDCs. Attention is focussed on farm production research and investment in R&D in fisheries and forestry is not included.

Total public expenditure on agricultural R&D in Australia has grown from A$140 million in 1952-53 to almost A$830 million in 2006-07 (in 2008 dollars) (Table 3). Figure 3 shows that expenditure growth was strong to the mid-1970s. The trend in expenditure has essentially been static since that time although there was a spike in investment (nearly A$ 950 million) in 2000-01. Likewise, agricultural research intensity, which measures the investment in agricultural R&D as a percentage of GDP, grew strongly in the 1950s and 1960s, but has been drifting down from about 4.0 -5.0 per cent annually of agriculture GDP in the period between 1977-78 and 1985-86 to about 3.0 per cent per annum in recent years (as compared to 2.4 per cent per annum in developed countries).

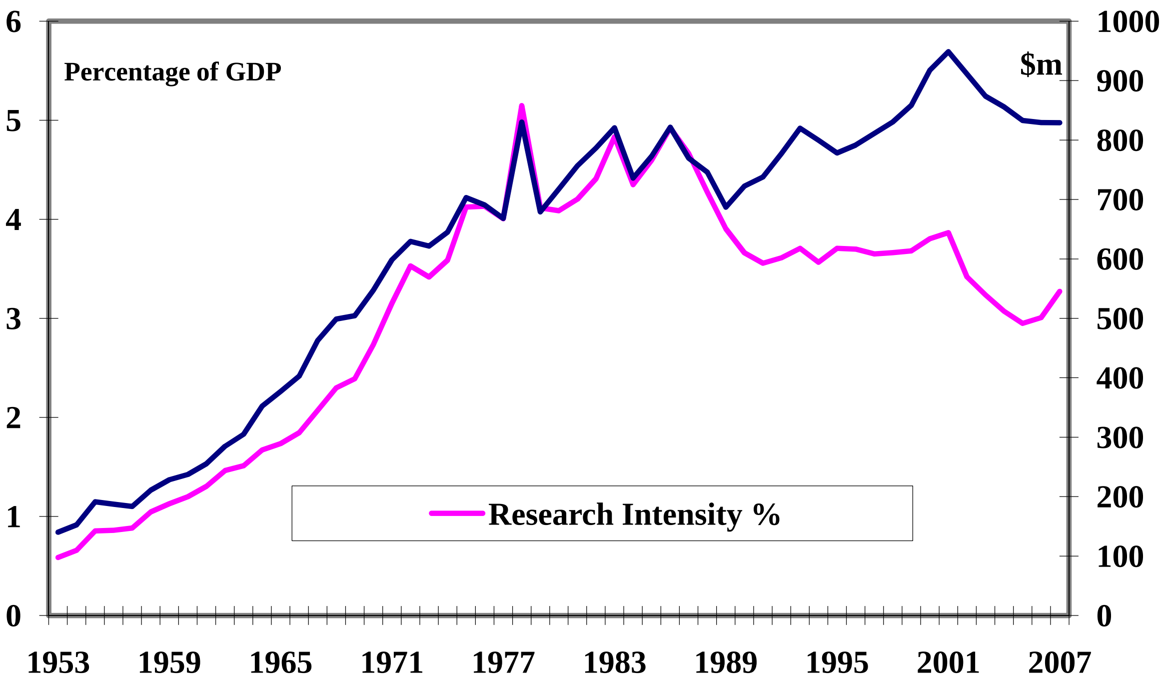
Table 3: Public investment in R&D in Australian agriculture

	Real Public Agric. R&D	GDP Deflator	GDP Agriculture	Research intensity	Terms of Trade
	$mill 2008		$mill 2008	%	
1953	140.1	6.4	23,936	0.6	334.5
1954	152.4	6.6	23,090	0.7	329.7
1955	191.3	6.7	21,278	0.9	305.7
1956	187.3	6.9	21,654	0.9	289.7
1957	183.5	7.4	22,601	0.9	304.1
1958	211.0	7.4	18,010	1.0	270.5
1959	228.4	7.4	21,134	1.1	249.7
1960	237.4	7.7	20,904	1.2	264.1
1961	255.4	8.0	20,805	1.3	236.9
1962	284.6	8.0	20,167	1.5	224.4
1963	305.0	8.2	21,961	1.5	230.7
1964	352.4	8.4	26,040	1.7	249.2
1965	377.2	8.7	25,013	1.7	233.8
1966	402.9	8.8	21,374	1.8	230.9
1967	462.8	9.3	25,074	2.1	222.7
1968	498.9	9.5	18,564	2.3	210.9
1969	504.3	10.0	23,635	2.4	205.5
1970	547.3	10.5	20,488	2.7	200.2
1971	598.5	11.1	17,373	3.2	182.4
1972	629.2	11.7	18,987	3.5	186.3
1973	621.6	12.8	23,433	3.4	233.7
1974	645.1	14.9	27,423	3.6	249.0
1975	703.0	17.4	20,616	4.1	167.9
1976	690.6	19.8	18,465	4.1	153.3
1977	668.2	22.0	18,400	4.0	149.9
1978	830.1	23.8	16,139	5.1	142.2
1979	679.2	25.9	24,104	4.1	161.6
1980	717.6	28.4	25,342	4.1	172.9
1981	756.6	31.2	21,655	4.2	161.7
1982	786.5	34.9	20,279	4.4	144.2
1983	820.6	38.4	13,921	4.8	136.7
1984	736.1	41.4	20,912	4.3	132.6
1985	772.7	43.5	20,031	4.6	128.6
1986	821.6	45.9	18,538	4.9	119.2
1987	769.4	49.0	18,870	4.7	118.6
1988	745.8	53.3	21,320	4.3	136.7
1989	687.0	58.3	23,164	3.9	141.6
1990	722.6	61.5	29,386	3.7	129.0
1991	737.9	63.7	21,889	3.6	109.5
1992	777.5	64.9	20,066	3.6	110.7
1993	819.9	65.8	21,618	3.7	111.4
1994	799.9	66.4	22,874	3.6	113.6
1995	778.2	67.2	21,027	3.7	125.5
1996	791.4	68.7	24,697	3.7	118.9
1997	810.9	69.7	24,236	3.6	108.7
1998	830.1	70.5	23,734	3.7	106.3

1999	858.1	70.6	24,923	3.7	101.6
2000	917.3	72.1	25,965	3.8	97.8
2001	948.6	75.5	30,134	3.9	104.7
2002	911.2	77.6	35,651	3.4	115.4
2003	873.8	80.0	26,574	3.2	107.3
2004	855.7	82.6	29,870	3.1	101.0
2005	832.8	85.9	29,055	2.9	97.4
2006	829.4	90.0	28,433	3.0	96.7
2007	829.2	93.8	23,858	3.3	100.0

Source: Derived by Mullen from public financial statements of research institutions and from ABS and ABARE statistics

Figure 3: Real Public Investment and Research Intensity in Australian Broadacre Agriculture: 1952-53 to 2006-07.

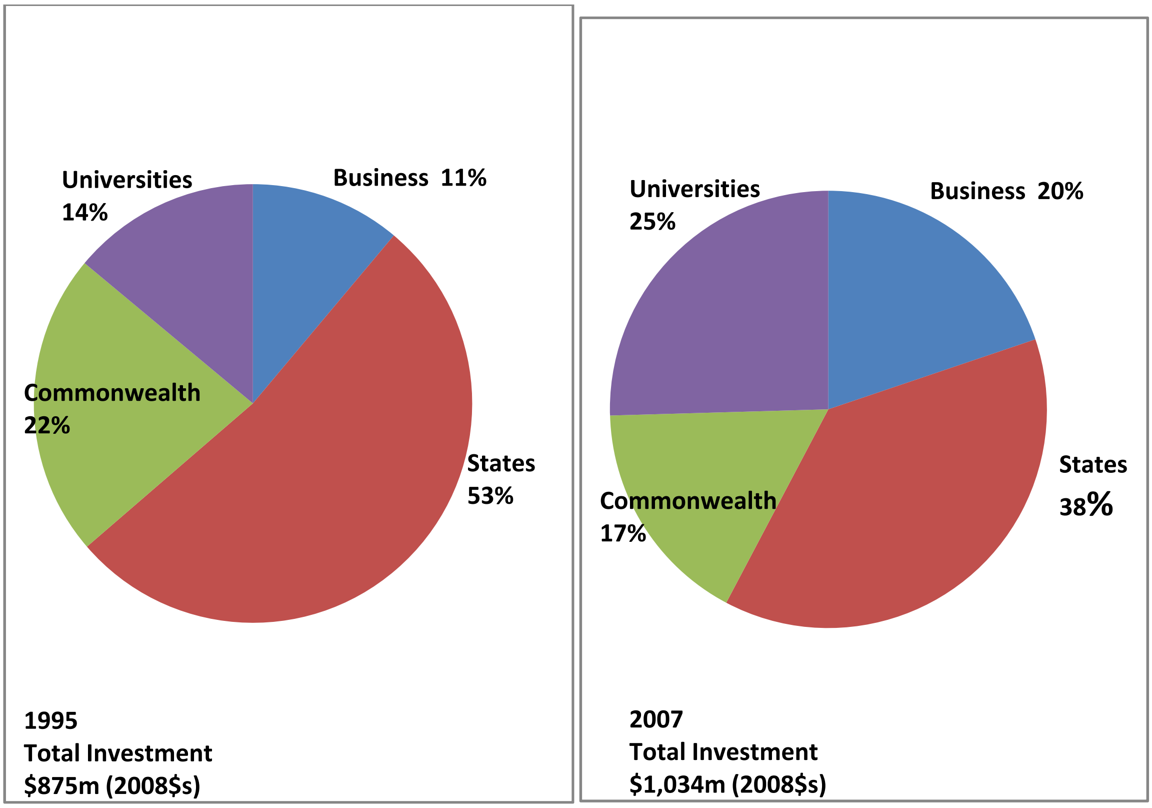


Source: Derived from public financial statements of public research institutions and the ABS

As a percentage of total expenditure on R&D in Australia, expenditure on agricultural R&D in 2007 was 5.6%. It has declined steadily from 20% in 1982. Expenditure on environmental research throughout the economy has never exceeded 10% of total expenditure and was 5.4% in 2007.

In Australia, the public sector has always been the dominant provider of research services to the agricultural sector (Figure 4). The private sector has generally been responsible for less than 10% of total agricultural R&D, although its share in 2007 was 20%. This contrasts sharply with other developed countries where agricultural R&D is roughly shared between public and private sectors (Pardey et al. 2006). From ABS data, state organisations, presumably dominated by the state departments of agriculture or their equivalents, had been responsible for about half of all agricultural R&D in Australia, with the Commonwealth responsible for 25% and universities, about 15%. However more recently the balance has shifted such that more research is being undertaken by universities and the private sector, and less by state and Australian government organisations. The share of agricultural R&D undertaken by states declined to 38% in 2007 and that by the Commonwealth was 17%.

Figure 4: Expenditure shares of agricultural R&D in Australia by providers of research services: 1995 and 2007



Source: Adapted from ABS sources (8112.0), various years

The state governments largely through Departments of Agriculture or Primary Industries have been major providers of agricultural research services. The decline in their importance as a group has already been noted. Additionally there have been significant shifts within the group (Figure 5). There have been minor real increases in investment by the WA and SA governments. Investment by Victoria is little changed from 1995 but down from 2001. Investment by both Queensland and NSW has declined from about $120m in 1995 to about $80m in 2007. In 2007 research intensity (investment in research/GVP) for the States was as follows – Victoria, 0.87%, QLD, 0.9%, NSW, 0.94%, SA, 1.18% and WA, 1.21%. NSW had been the leader in agricultural research investment. Research intensity there had been 1.9% in 1975 when investment in agricultural research had been $160m (2008 $s)[2]. Investment in research has now dropped to $80m, similar to other states. With due caution about implying causation, it is noticeable that the three States with the lowest research intensities are also the three States with the lowest rates of MFP growth.

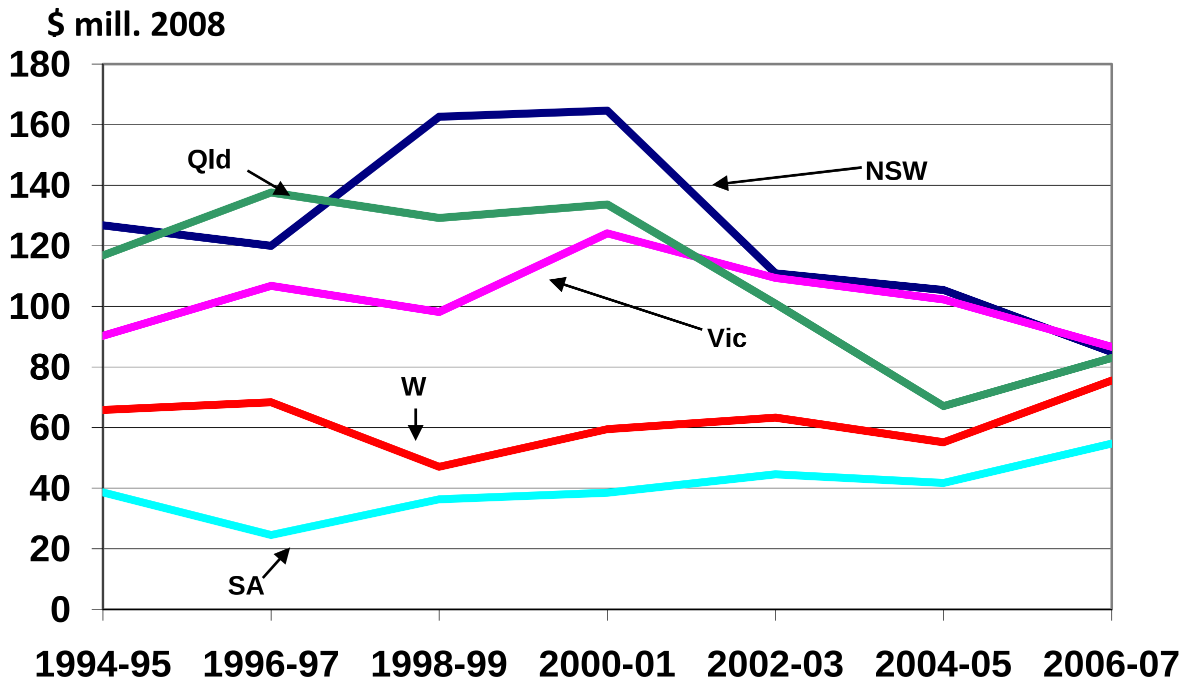
It would seem that these shifts in how agricultural R&D is funded and undertaken in Australia have evolved by default without any clear policy enunciation except a general trend towards less government involvement in agriculture.

For most of the 1990s, expenditure on plant and animal R&D was similar, but by 2007 expenditure on plant R&D was two thirds of total public investment in agricultural R&D. Perhaps this partly reflects the growing importance of the Grains Research and Development Corporation (GRDC) as a source of funds. During the 1980s, the share of total RDC funding from the GRDC was under 20%, but by 2001 it had risen to 30% before declining to 23% in 2005.

A feature of the agricultural research sector in Australia has been the prominent role played by what are now known as the RDCs. In approximate terms, RDCs commission agricultural research on a competitive basis amongst public and private research providers using funds from levies on production and matching Commonwealth grants (up to 0.5% of the value of production). The attraction of the RDC system is that it ameliorates the non-excludability characteristic of information generated by research, while preserving the benefits from its non-rival nature.

In 2007, total expenditure by the RDCs on traditional production agricultural research (excluding the fisheries, forestry and energy RDCs and LWA) was A$478 million ($2008), which is almost 60% of total public expenditure on agricultural R&D. Some of this investment by the RDCs is directed towards the processing sectors rather than production agriculture and some is directed to environmental outcomes. If these investments outside production agriculture amount to a third of the total then it seems likely that the RDCs are funding 40 – 50% of research into production agriculture in Australia. Recall also that about half of these RDC funds are raised from farmers. In the 1985, RDC funding amounted to less than 15% of total public expenditure on agricultural R&D.

Figure 5: Real Investment in agricultural research by State governments: 1995 – 2007



Source: Derived from ABS data

A recent international review of agricultural R&D by Pardey et al. (2006) found that public investment in agricultural R&D in real dollars (2000 international dollars) had only risen from A$15.2 billion in 1981 to about A$23 billion in 2000. Expenditure on agricultural R&D in 2000 in developing countries (55.7% share of total) exceeded that in developed countries – with China, India and Brazil emerging as major investors. Public research intensity in developed countries was 2.4% pa and total agricultural research intensity was about 5.2% pa. Research intensity in less developed countries was often very low, such that average public research intensity in developing countries was 0.53% pa. By 2000, about a third of all agricultural R&D was undertaken in the private sector, but little of this was in developing countries. The world's poorest countries are still dependent on technology spillovers from rich countries both individually and collectively, through the CGIAR system and through organisations such as Australia's ACIAR.

Returns from Investment in Research

Following Mullen (2007) (adapted from Alston et al. 1994), the real value of agricultural output since 1953 has been decomposed into components associated with traditional inputs, growth from investments in public infrastructure such as transport and communications and technical change from R&D both domestic and international. The long-term trend in productivity for broadacre agriculture in Australia has been in the vicinity of 2.0 percent per annum (revised down by 0.5% from Mullen 2007). Acknowledging its speculative nature, perhaps up to 0.4 percent per annum can be attributed to factors such as public infrastructure and the education levels of farms. Perhaps the remaining 1.6 percent can be attributed to technical change, arising from public and private investments in research and extension where a significant component of both activities is related to the adaptation of foreign knowledge spillins. Here it is assumed that domestic R&D activities may be directly responsible for productivity growth in the order of 1.0 percent per annum and foreign spillins for 0.6 percent per annum – a 60:40 split.

For this scenario the contribution of domestic research is particularly significant. Almost half the value of output in 2008 can be attributed to new technology generated since 1953. Were it not for domestic research the real value of output would have contracted from about $43.3b to less than $27.7b in 2008 which serves to highlight the importance of domestic R&D in maintaining output levels. At a real rate of interest of 4 percent, the compound value of the stream of benefits from domestic research (1.0 percent) from 1953–2003 is A$988 billion (in 2008 dollars).

The compound value of public investment in research between 1953 and 2007 was A$95.7 billion and the estimated total back to 1918 was A$117 billion (in 2008 dollars). Mullen (2002) estimated that private R&D in Australia and public extension expenditure might add a further 40 percent to domestic R&D investment, giving a total of A$129 billion since 1953 and A$159 billion since 1918 (in 2008 dollars).

Two scenarios for investment analysis relate Australian R&D investment first, to productivity growth at the rate of 1.6 percent per annum and second, to productivity growth at the rate of 1.0 percent per annum. These scenarios 'bracket' the potential benefits from domestic research. Under the first scenario, domestic research generates productivity gains of only 1.0 percent and some productivity gains, 0.6 percent, are picked up from foreign sources without any domestic mediation. It is more likely the case that some domestic research is required to capture the benefits from foreign spillovers. Hence under the second scenario, domestic research is required to capture any of these foreign benefits, and domestic R&D can lay claim to the whole 1.6 percent gain.

Note that for these benefit-cost scenarios, only benefits between 1953 and 2007 were recognised, a conservative approach particularly with respect to the flow of future benefits. Costs between 1918 and 2007 were recognised to allow the estimation of IRRs. Results are sensitive to this assumption.

Under the most optimistic scenario where all productivity gains at the rate of 1.6 percent are attributed to domestic research investments made since 1918, the internal rate of return (IRR) is 16.8 percent and the benefit-cost ratio (discount rate of 4 percent) is 15.1:1 (Table 4). If it is assumed that productivity gains from domestic public and private research and extension result in productivity gains of 1.0 percent then the IRR is 13.3 percent and the benefit-cost ratio is 6.2:1.

The financial measures are slightly lower than those presented in Mullen (2007) reflecting the influence of lower productivity growth from both a run of poor seasons and the long stagnation in public investment in agricultural R&D. The estimated IRRs are at the lower end of the range suggested by Mullen and Cox (1995).

Supporting Evidence

Although based on empirical estimates of productivity growth, the benefit cost scenarios are based on a somewhat subjective decomposition of this growth. The assessment that investment in R&D has earned returns of about 15 percent per annum is supported by econometric analysis at an aggregate level and by a multitude of project level benefit cost analyses. There has been no systematic review of these project level studies but Mullen (2004) and Raitzer and Lindner (2005) review a limited sample of Australian studies.

Mullen (2007) reviewed previous econometric analyses and reported recent research of his own. Extending earlier research (Mullen and Cox, 1995), the econometric model used by Mullen (2007) related growth in TFP to a stock of knowledge available to farmers, the level of education of farmers, the terms of trade, seasonal conditions and investment in extension. Research is likely to have an impact on TFP over many years. The two alternatives considered by Mullen were a knowledge stock based on the previous 16 years of research investment and one based on the previous 35 years of investment.

He concluded that the returns on investment are likely to have remained within the 15- 40 percent per annum range estimated by Mullen and Cox (1995). The lower returns are associated with a 35 year lag model and the higher returns with a 16 year lag model estimated for the period since 1969.

Table 4: Rates of return to research in Australian agriculture.

Scenario:	Benefit-Cost Ratio	IRR
Productivity growth @ 1.6%:		
(a) Public research only		
R&D from 1918-2007	15.1	16.8%
R&D from 1953-2007	18.5	
(b) Public + private research + extension		
R&D from 1918-2007	10.8	15.6%
R&D from 1953-2007	13.2	
Productivity growth @ 1.0%:		
(a) Public research only		
R&D from 1918-2007	8.5	14.5%
R&D from 1953-2007	10.3	
(b) Public + private research + extension		
R&D from 1918-2007	6.2	13.3%
R&D from 1953-2007	7.7	

Concluding Comments

Since 2000 Australia has suffered a run of poor seasons and public investment in agricultural research in Australia has been static ($830m in 2004 dollars) for two decades and research intensity has declined (to 3.0%). It is not surprising that productivity growth in broadacre agriculture has slowed. Meanwhile the research sector has continued to evolve both in terms of where investments are made and how they are managed. ABS statistics reveal a shift in research resources to plant industries from animal industries. The increasing importance of funding through RDCs and CRCs may well mean that a greater proportion of research investment is of an applied nature, boosting productivity growth in the short run but perhaps at the expense of growth in the longer term. The shift in where agricultural R&D is conducted from state and commonwealth institutions to universities and the private sector has continued

In my view investment in agricultural research, at least over the range in investment levels experienced from 1953 to 2007, has earned moderately high rates of return and there is little evidence the rates of return are likely to decline markedly either as investment increases or over time because of diminished research opportunities. Hence a safe policy option is to at least maintain current levels of investment in research by public and private sectors.

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[1] MFP estimates for broadacre agriculture most often are based on data from ABARE’s farm surveys. Recent literature includes Sheng et al. (2009), Mullen (2009), Nossal et al. (2008) and Zhao et al. (2008).

[2] Mullen et al. (1996) assembled a series on R&D investment for each of State Departments of Agriculture from published financial statements to 1994. The ABS data are for each State as a whole. Mullen et al. (1994) estimated that for NSW Agriculture, investment in R&D in 1994 was about $120m ($2008) in the mid 1990s. He has been unable to extend his series.

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