Grain Research Funding in Australia: Lessons from International Experience

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Financing Rural Research: Opportunities for Public-Private Partnerships
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ABSTRACT: The Australian grain research system has undergone a profound transformation over the past 25 years. This began with the creation of Grains Research Development Corporation, which gave producers a voice within a national research system. In the second phase of development, the GRDC tendered for the development of three for profit public corporations (AGT, HRZ and InterGrain) that would invest revenues from endpoint royalties (EPRs) to fund wheat breeding. This new funding for breeding allowed the GRDC to move upstream to focus on pre-breeding research efforts. As of 2012, these breeding firms had each acquired a multinational private partner and had collectively reached the point where end point royalties were sufficient to cover breeding costs. While this transformation has been successful at increasing private research investment, it has also created a toll good industry with inherent financial risk, economies of size, and barriers to entry with incentives for market concentration and monopoly pricing. The North American experience in hybrid crop sectors suggests that producers are likely to continue to see increasing prices for varieties, perhaps with only a small portion of end point royalties being reinvested in breeding activities.

Key words: toll goods, R&D funding models, research levies, seed pricing

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Introduction

Two very important pieces of legislation have enabled the transformation of the Australian agricultural Research Development and Extension (RD&E) system over the past 25 years. The 1989 Primary Industries and Energy Research Development Act (PIERD), established a number of national, government-matched, levy-funded, industry directed research corporations, which changed how agricultural RD&E was funded and organised. The introduction of the Plant Breeders Rights Act (1994) strengthened intellectual property rights that enabled crop breeders to charge End Point Royalties (EPRs) on their varieties. While many of implications of these two pieces of legislation were not apparent at the time, the economic incentives they created and the subsequent evolution that took place resulted in some remarkable changes to the Australian agricultural research, development and extension (RD&E) system.

Arguably, the largest economic impact from the resulting changes to RD&E have occurred in wheat sector, which is also the most economically important broad acre commodity. Funded by a 1% general grains research levy that is matched up to .5% by the Commonwealth government, the GRDC annually invests upward of $60M AUD on behalf of wheat producers. Since 2002, the GRDC has also partnered with both public institutions and private firms to create three wheat-breeding corporations, which are funded from the End Point Royalties. Other innovations in this dynamic industry include the creation of the Pre-Breeders Alliance and the development of National Strategic Plans.

The firms in wheat breeding industry have only recently reached point of commercial viability. As described in detail later in this paper, EPR rates for new varieties have been steadily increasing over time. As the adoption of newer varieties have increased, wheat breeding firms are able to support their breeding programs without assistance from the GRDC, which given the relatively short history of these firms is a remarkable accomplishment. The ability to increase EPR rates and revenue for wheat breeding over time is perhaps the most important dynamic in this fledgling wheat breeding industry.

Given speed of development in this youthful corporately governed breeding wheat breeding industry it is important to consider how it is likely evolve over the next two decades. With strong intellectual property rights, the sector produces excludable, non-rival *toll goods* --giving firms in the industry significant economies of scale and scope. This inherently non-competitive industry structure raises a number of important questions about the future of the wheat breeding industry. Will the four firms currently in the industry continue to be viable? How will future varieties be priced? If the firms become profitable, how will profits be distributed and reinvested? Are governments likely to continue to be shareholders? Is additional firm entry likely? What are the implications for producers? Given the significance of the wheat sector and large research investments being made, it is important to understand how this funding system evolved, where it is headed, and relevant policy choices for the future.

Objective

The objective of this paper is to explore the future of the Australian wheat breeding industry, and the implications this could have for variety pricing, firm entry, investment and profitability as the industry matures. An economic framework involving the production and use of toll goods, is used to examine some of the economic incentives faced by the firms wheat breeding industry and likely industry outcomes. These hypothetical outcomes are then compared to the outcomes in US Corn and Canadian Canola sector, where the private research industry is more mature. The inferences for Australian wheat breeding industry have implications for public policy in the design of wheat RD&E system and the design of RD&E systems in general.

Organisation of the Paper

The remainder of the paper begins with a description of the theory and regulation of the toll industries, which will underpin the framework to examine the incentives in the wheat breeding industry. This is followed by a brief description and analysis of the development of the Australian wheat-breeding sector to date, including the establishment of wheat breeding firms and the evolution of EPRs to date. As means, of exploring potential future developments, this is followed by a description of some of the salient features of Corn and Canola sectors in North America, where hybrid technologies and patented technologies have provided excludability for much longer periods of time. The development of these more mature breeding industries will be explored as plausible futures for the Australian wheat breeding industry. The paper concludes with a discussion of potential issues and the role of public policy in crop breeding.

Knowledge as a Toll Good

Knowledge, when protected by IPRs, becomes a “toll good”—a good that is non-rival but excludable (Lesser, 1998; Fulton, 1997). The non-rival nature of toll goods means that they are likely to result in significant market concentration if they are used as key inputs into a production process (e.g., new varieties protected by IPRs, used as inputs in production of seed). Because the toll good input is non-rival, it only has to be purchased or created once. This fixed cost is incurred only once for each such good—for example, a new variety of soybeans— and the same genetic material can be used again and again without reducing its availability to others and at no additional cost. This means that the average cost of producing the final output (i.e., seed using this genetic material) decreases with the quantity produced because the cost associated with purchasing, or creating, the non-rival input (the new variety) is spread over more units of output. The declining average cost implies that large firms will always have a cost advantage over smaller firms. The lowest industry average cost can be achieved if the good is supplied by a single monopoly. Toll good industries, for which fixed costs represent a large share of total costs, such as railways, software companies, or electrical distribution networks, are often referred to as natural monopolies.[1]

The toll good nature of knowledge can also create economies of scope, when the protected knowledge created for one product can be used in the production of other products. If knowledge generated for one crop can be used for other crops, then firms doing research in more than one crop will have economies of scope and general economies of size. For example, if a firm owns the patent for a "gene gun", this knowledge gives the firm a cost advantage in several transgenic crops. When a firm has owns a large pool of protected knowledge, this will tend to lower the average research costs across several crops. This is particularly evident in transgenic crops, where large multinational research firms are improving genetics for a wide portfolio of crops. Scope

[1] In some of these industries, governments have prevented competition and regulate a monopoly. In others, profits attract some entry resulting in oligopoly, or monopolistic competition.

economies are becoming increasingly true for most crops as genomic knowledge and genomic selection tools have wide, multi-crop applicability.

The toll-good nature of IP has profound implications for the cost structure of the crop research industry. Consider the case of breeding new wheat varieties. If one begins with a hypothetical situation where all research is organized in the most cost-effective manner and all the knowledge generated in wheat and other crops is shared globally without transaction cost, this would be the lower bound for the industry average cost curve, where the research costs are minimized. This average cost curve for any new wheat variety would be downward sloping, as the fixed costs of the research that generated the particular innovation are spread over more and more units of output that use that innovation. Deadweight loss arises because the monopolist sets the price too high and stifles adoption, compared with a scenario where the technology was free (i.e., the price is zero) or to a scenario where the monopolists could price discriminate perfectly, and charge each farmer his willingness to pay for each unit technology on each unit of the land.[2]

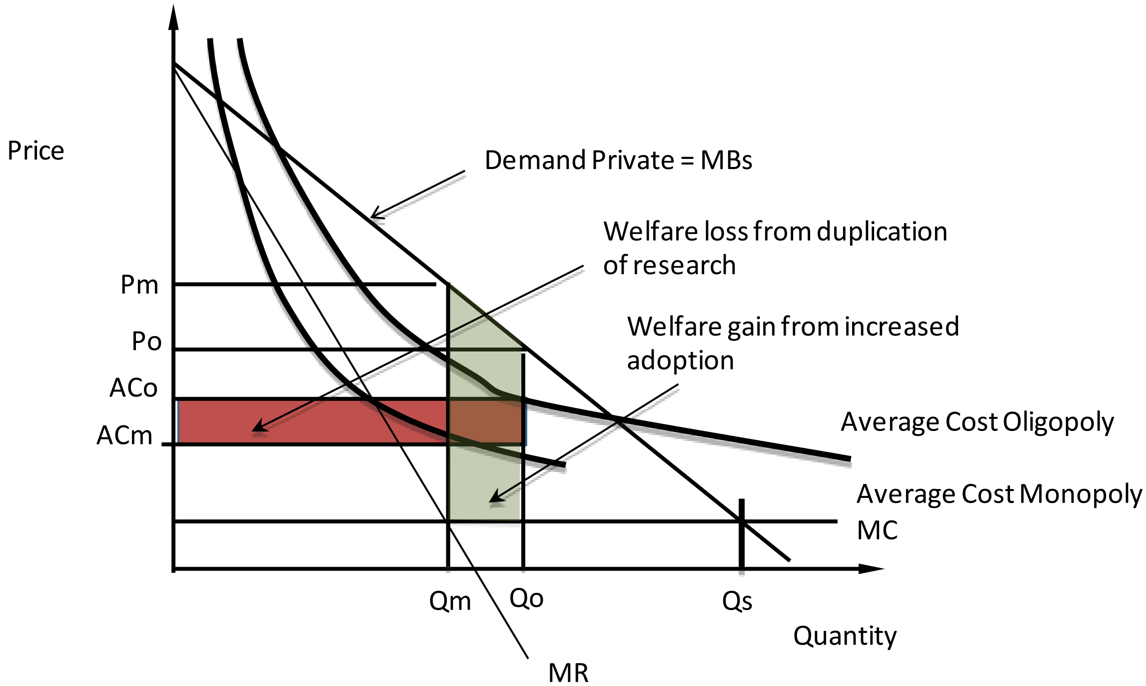
Given this cost structure, the prospect of other firms entering the market creates conditions of monopolistic competition. If the industry is profitable it will attract entry by other firms. Typically, research-intensive industries have more than one R&D firm. If two firms or more firms were engaged in any form of price competition, this would decrease the price charged for seed and reduce the efficiency loss associated with the over-pricing of the research output. However, this increased competition also comes at a cost. If two identical firms were engaged in research, and each produced effectively

[2] The near impossibility of perfect price discrimination is apparent when one considers the transaction costs associated with designing and enforcing contracts that could reflect producer and land heterogeneity and seasonal weather variation in the willingness to pay for each marginal unit of production.

identical varieties that were sold to one half of the market, each would incur the fixed cost of research. This duplication of effort would double the research cost, which would shift the industry average cost upward, imposing a loss on society. The net effect on social welfare is difficult to assess. On one hand competition reduces seed prices toward marginal cost, encouraging adoption. On the other hand, the duplication of effort increases the cost of producing seed. This effect is illustrated in Figure 1. The entry of additional firms reduces the "oligopoly" price *Po* below the monopoly price, *Pm*, which encourages more adoption. However, firm entry also increases the average cost of research for a given research outcome, from *ACm* to *ACo* because of the duplication of research effort. While the optimal amount of entry is difficult to assess, the toll-good nature of the research makes this dilemma nearly impossible to avoid in an unregulated private market. As shown in Figure 1, the net effect of firm entry will be the gain in surplus from additional adoption minus the additional research costs associated with the duplication of effort.

This dilemma of market power versus production inefficiency in toll good industries has led policy makers to develop a range of policies to govern the production and pricing. Many toll goods such as roads and bridges are built by government and financed by general revenues, fuel taxes, and in some cases with user tolls. Other toll good industries, such as electrical utilities, are often allowed to exist as a monopoly but are subjected to regulated prices. Governments can also mandate competitive access to enhance competition. With the aim of applying this toll framework to the Australian wheat breeding industry, the next section describes the developments in Australia.

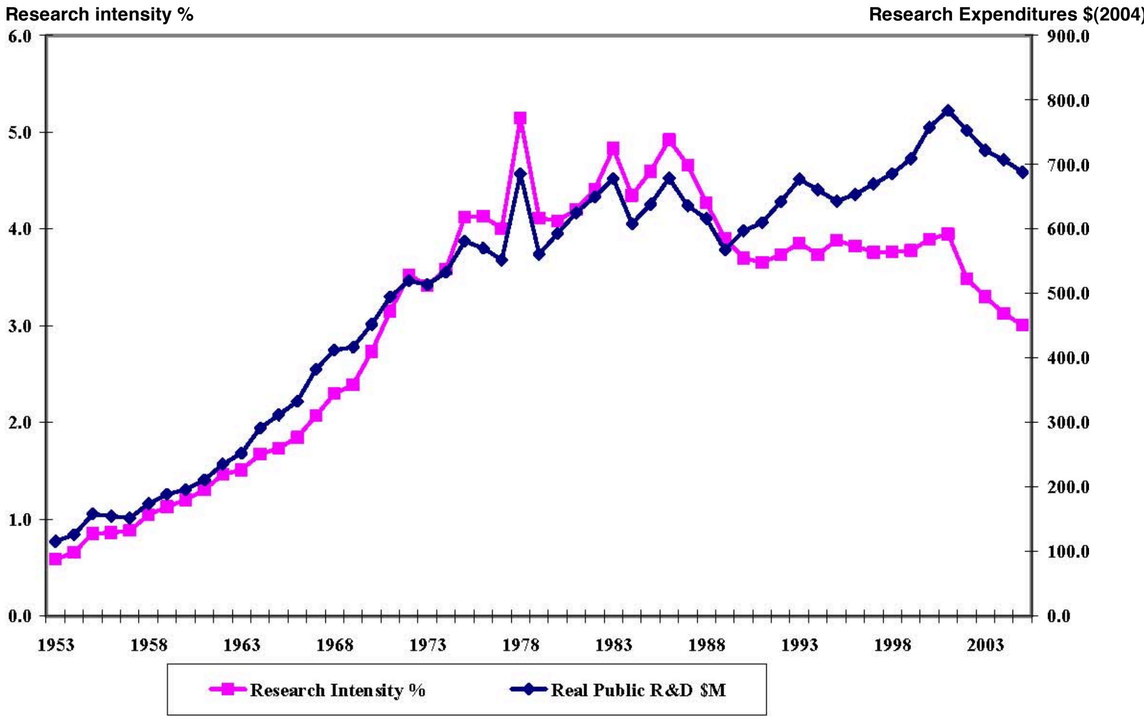
Figure 1: The welfare impact of entry in a toll-good industry



The Australian Experience --The Transition to Producer Control

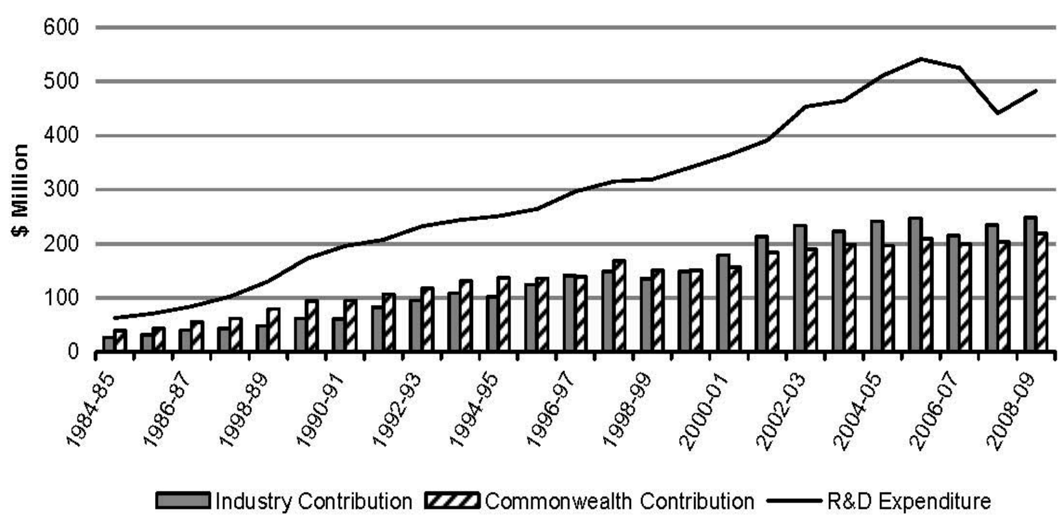
Public agricultural research went through a period of rapid growth increasing over five hundred per cent between 1953 and 1978. As shown in Figure 2, after 1978 public spending became more erratic and the rate of growth slowed, resulting in a decline in research intensity. During the growth period Australian agricultural research system predominately relied on publicly administered research funding (Brennen and Mullen, 1999) and most agricultural RD&E was funded by national and state governments (Kingwell, 2003; Brennen and Mullen, 1999). The resources were used to fund research at universities, state departments and few other organizations. Established during the 1950's farmers and consumers were also financing research through 14 rural industry trust funds that were by paying levies based on output or value of production matched Commonwealth Government.

Figure 2: Public Research Agricultural Expenditure and Research Intensity in Australia



Source: (Mullen and Orr, 2007)

Figure 3: RDC contributions and Expenditures 1984/85- 2008/09



Source: Figure 2.4 Productivity Commission (2011)

In the mid 1980s financial pressure on public plant breeding organizations began to increase as part of a general government policy move toward market deregulation and export competitiveness in the economy. The publicly funded plant breeding organizations and all their activities were facing increased scrutiny and funding pressures (Productivity Commission, 1998; Lazenby et al., 1994). Consequently, the plant breeding organizations had to look for alternative methods of funding and breeding organizations and were successful in replacing at least part of their funding from grower levies (Lazenby et al., 1994).

The Rural Industries Research Act 1985 (Cwlth) reformed the funding for industry-focused R&D by creating the precursor for the current model. The Act, for each of the 14 industries replaced individual research committees with industry directed research councils, which started to administer the trust funds. The Act also created uniform funding arrangements across most industries (Productivity Commission, 2011). Notably, under this Act, the Australian Meat and Livestock R&D Corporation was established in 1985. This important innovation in governance led to the 1989 Primary Industries and Energy Research and Development Act (the PIERD Act) that created the current statutory model for Research Development Corporations (RDCs), which replaced the industry councils.

The Key features of PIERD Act are:

- *It sets out a procedure for establishing an RDCs;*
- *Skills based selected Board;*
- *Industry consultation process leading to recommendation to Government for introduction of compulsory levy;*
- *Levy varies between industries – grains is 1% net farm gate value of grain;*
- *Government committed to matching industry levy $ for $ up to 0.5% GVP of the industry;*

- *Governance – Legislation makes RDC Boards subject to law similar to a public company;*
- *Reporting – 5 year strategic p; annual operating plan, annual report, stakeholder report to industry;*
- *National research priorities;*
- *Corporations do not conduct research: they co-ordinate a research investment plan;*

Source: Enright, 2007

Under this legislation, the RDC board of directors have strong industry representation and have a mandate to invest the matched levy funds in R&D with the goals of increasing industry profitability and competitiveness (Brennen and Mullen, 1999). As shown in Figure 3, RDC investment increased from $67m to $541m between 1984/85 and 2005/06 (industry $27m to $325m; government $39.9m to $216m) (Productivity Commission, 2011).

The Grain Research and Development Corporation

The GRDC is one of 14 RDCs in Australia, was established in 1990, and operates under PIERD Act collecting research levy on twenty-five grain crops.[3] The GRDC manages the investment of the grower levies and also controls the agenda in many of the crucial areas of applied breeding and breeding infrastructure. The GRDC does not directly undertake research but rather funds RD&E activities at various research organisations including, universities, State Governments, research institutes and grower groups. Historically, crop breeding has been the major research focus of the GRDC. With the recent establishment of a private wheat breeding industry, the GRDC has shifted more

[3] *Wheat , barley, oats, sorghum, maize, triticale, millets/panicums, cereal rye, canary seed, lupins, field peas, chickpeas, faba beans, vetch, peanuts, mung beans, navy beans, pigeon peas, cowpeas, lentils, canola, sunflower, soybean, safflower, linseed*

resources into pre-breeding activities, agronomic research and small crop research where the private industry is less able to invest. The GRDC funds currently make up about 30% of total grain research expenditures (Budd, 2011).

The GRDC has been very proactive in creating industry goods and in the development institutional arrangements for accelerating innovation in the sector. For instance, the GRDC funds the *National Variety Trials* program to help growers identify and adopt the best varieties to grow. They have also helped to fund standardise contracts and coordinate End Point Royalty collection.

Institutions receiving support from the GRDC to undertake pre-breeding research must be agree to make their innovations generally available to the downstream breeding industry. The Australian Winter Cereals Pre-Breeding Alliance (AWCPA) was established to promote collaboration and cooperation among cereal pre-breeders. The Alliance's objective is to maximize the national pre-breeding effort and shorten the time frame between genetic enhancement and the development of new, improved crop varieties. The Alliance was established by a steering committee representing major pre-breeding organizations. The current composition of the Steering Committee includes CSIRO, MPBCRC, University of Adelaide, SARDI, ACPFG, NSWDPI, QDPI, DPIVic and DAFWA (Meyer, 2011).

Perhaps the most important initiative of the GRDC was the result of a 1999 decision to create three wheat breeding corporations, which has allowed the GRDC to get out of the business of directly funding wheat breeding. There were number of factors behind this decision to get out of wheat breeding operations and move upstream. With the Plant Breeders Rights Act -1994 private firms had gained the ability to charge the EPR's, creating strong, market based incentives to produce varieties desired by producers. By encouraging the development of a market based breeding industry the GRDC could shift its breeding resources toward investment in pre-breeding and other non-excludable forms of research. By soliciting partners to create companies and investing in these companies the GRDC would also retain some grower voice in the governance of wheat varieties.

Another important factor in the GRDC decision to create three breeding firms was the desire to rationalise the wheat breeding programs in Australia in order to capture some returns to scale by moving away from the historical basis of each state department and many universities having its own wheat-breeding program (Budd, 2011). In the early 90s there were nine wheat-breeding programs in Australia that were either university based or based with state departments of agriculture.

As direct result of the GRDC tender process there are currently four wheat-breeding companies in Australia. The largest breeding company in Australia is Australian Grain Technology Pty Ltd, second largest InterGrain Pty Ltd, followed by LongReach Plant Breeders and HRZ Wheats.

Australian Grain Technologies (AGT) was established in 2002. The original shareholders of the AGT were the GRDC, the South Australian Research and Development Institute (SARDI) and the University of Adelaide. AGT licensed the majority of the former Victorian Department of Primary Industries' wheat-breeding germplasm. In 2005, AGT merged with SunPrime Seeds Pty Ltd. to become a fully integrated wheat breeding and Commercialization Company. In 2007, AGT started partnership with the Council of Grain Grower Organizations. In July 2008, Vilmorin & Cie, which is a wholly owned subsidiary of Limagrain Holdings, purchased a 25 per cent shareholding in AGT (AGT, 2011). AGT is currently the largest breeding firm with 48 full time employees, breeding a wide range of crops with research operations in five states (AGT,2012;GRDC, 2012).

InterGrain Pty Ltd was formed in October 2007 with GRDC 30% owning of the shares the Government of Western Australia owning 70% of the shares. This new Corporation took over the wheat breeding activities of the Department of Agriculture and Food, Western Australia (DAFWA) transforming a government crop-breeding unit into a commercial company structure. InterGrain was assigned all DAFWA breeding material and associated Intellectual Property (IP) for current and future commercial wheat varieties. InterGrain's current wheat-breeding programs target Western Australia, South Australia, Victoria and New South Wales. InterGrain has developed an alliance with Nuseed, which is a subsidiary of Nufarm, for the production, sales and promotion of its varieties. InterGrain and Nuseed provide rapid access for growers to new varieties and have established the on-line trading site (www.seedpool.com.au) to facilitate farmer-to-farmer trading. As a result of Nuseed alliance, InterGrain has also obtained access to some of the former Victorian DPI wheat-breeding germplasm (InterGrain, 2012). On August 24, 2010, Monsanto joined DAFWA and GRDC as a minority shareholder owning 19.9% of the shares. At the moment Monsanto has 19.9% of the InterGrain shares but they have the option to increase it to 26%. As of 2011 InterGrain was the second largest breeding firm with 30 employees (GRDC, 2012).

The smallest breeding firm with GRDC shareholding is HRZ Wheats Pty Ltd, which was established in 2003. The firm specialized breeding company developing milling-quality wheats targeted to the high-rainfall zone (HRZ) of Australia. The shareholders of HRZ Wheats are CSIRO, New Zealand Plant and Food Research, the GRDC and Landmark Operations Ltd. In September 2011, Dow AgroSciences Australia Ltd announced an equity investment in HRZ Wheats Pty Ltd (CSIRO,2011). HRZ Wheats is a small firm with five full time employees (GRDC,2012)

The fourth wheat breeding firm in Australia is LongReach Plant Breeders, which was Australia's first commercial wheat breeder with multinational interests. LongReach Plant Breeders was formed in 2002, as a joint venture between Syngenta Seeds and AWB–Landmark. Syngenta Seeds purchased the Landmark share in 2006 and in late 2007 Pacific Seeds purchased a majority share in the company from Syngenta. As of 2011 Longreach was the third largest wheat breeding firm in Australian with 10 employees. (Longreach, 2012; GRDC, 2012).

End Point Royalties

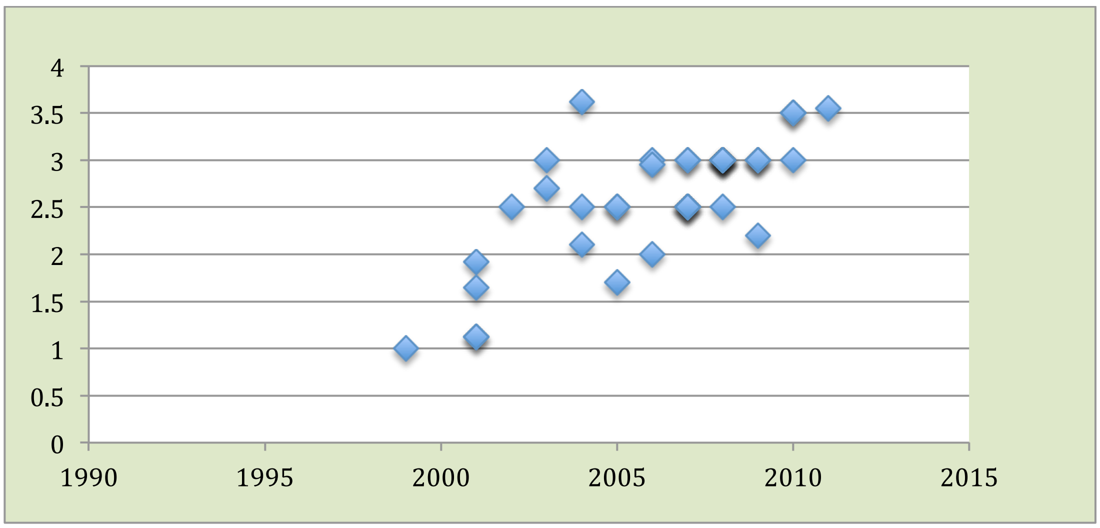
Intellectual Property Rights (IPRs), which give their owners the legal ability to exclude others from using the products their research, can provide strong incentives for private companies to invest in research and development (R&D). The IPRs for plant varieties in Australia, began with the Plant Variety Rights Act 1987 which was extended by the Plant Breeders Rights Act 1994 (Kingwell and Watson, 1998). The Plant Variety Rights Act 1987 had very little effect on breeding because intellectual property rights were only effective on the seed that was sold to farmers. There were no royalty payments on farm saved seed, and because farmers in Australia were using mostly saved seed, industry had very limited returns. This *farmers' privilege* only allows the breeder to capture a small fraction of the benefits from innovation Perrin and Fulginity (2008).

The Plant Breeding Rights Act 1994 extended breeders' rights to harvested material produced from seed. While the farmers maintained the ability to save seed these provisions gave the breeder right to collect royalties on harvested product each time their variety was grown for a period of 20 years. The royalties on harvested material became known as the End Point Royalties. Kingwell and Watson (1998) decribed EPR as*" An EPR is a levy imposed on the first sell on harvested material derived from varieties protected by plant breeders rights"*. At the time they were introduced, End Point Royalties were recognised as a very promising way of dealing with underinvestment, which for years was an issue in agricultural research (Lazenby et al. 1994).

The potential for EPRs to generate revenue to fund private research took many years to be realised. There were at least three important barriers for their implementation. First of all, an affordable enforceable system of levy collection had to be developed. This required the development of new licensing agreement, collection agreements and the education of industry participants. These processes required more than a decade to develop, but the industry has now developed a standardized set of contracts and the major breeders have agreed to use SeedVise as a single agent to negotiate and coordinate the EPR collection system (McGrath, 2011). Second, when EPRs were first introduced new EPR varieties, had to compete with royalty free varieties already used on farms. The availability of these free varieties made it difficult to charge a significant EPR on the new varieties until they had improved to the point where producers were willing to pay a significant amount of EPR to access these new varieties. Third, a private industry with the incentive to charge EPRs had to evolve. As long as there were some public breeders in the industry that were reluctant to charge EPRs the ability of the remaining firms to charge significant EPRs was limited. Over time these barriers were addressed and the use of EPRs has increased.

When EPR rates for new varieties increase over time and newer varieties are adopted over time, the revenue generated from EPRs can rapidly increase. Figure 4 is a *scattergram* of the per ton EPR rates for varieties versus their year of release. This shows a strong upward trend with the most recent varieties with EPR rates $3 per ton or higher.

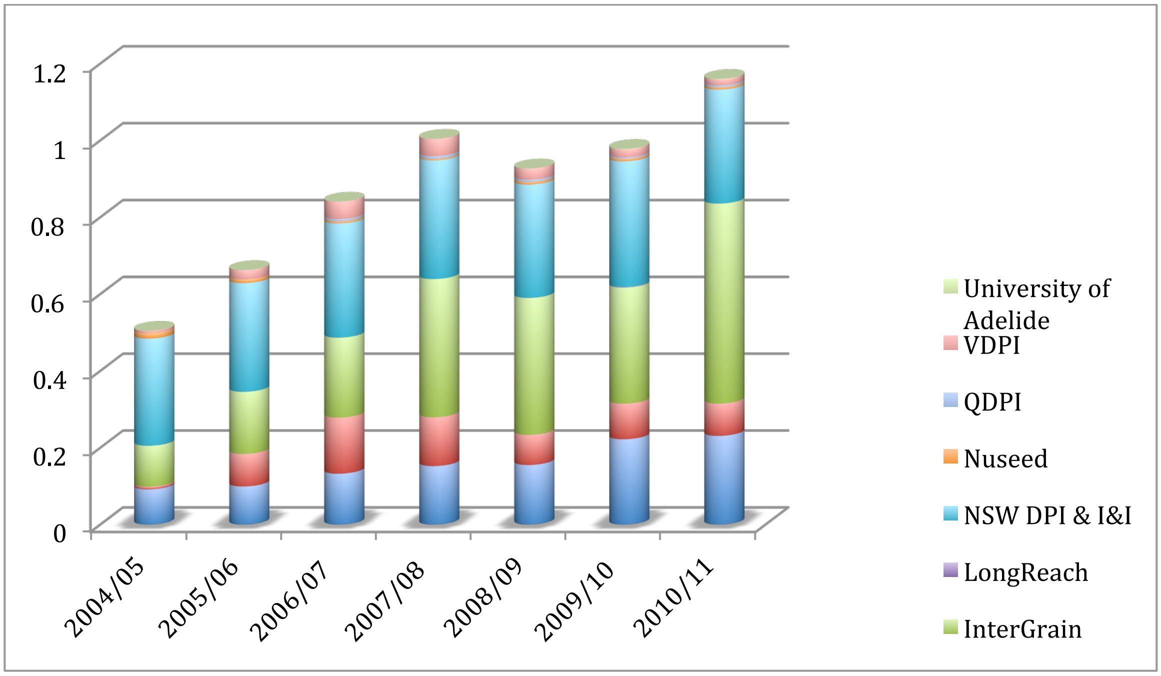
Figure 4: Average Wheat EPR Rates $ per ton by Year of Variety Release



Source: GRDC, DAFWA, SeedVise 2011

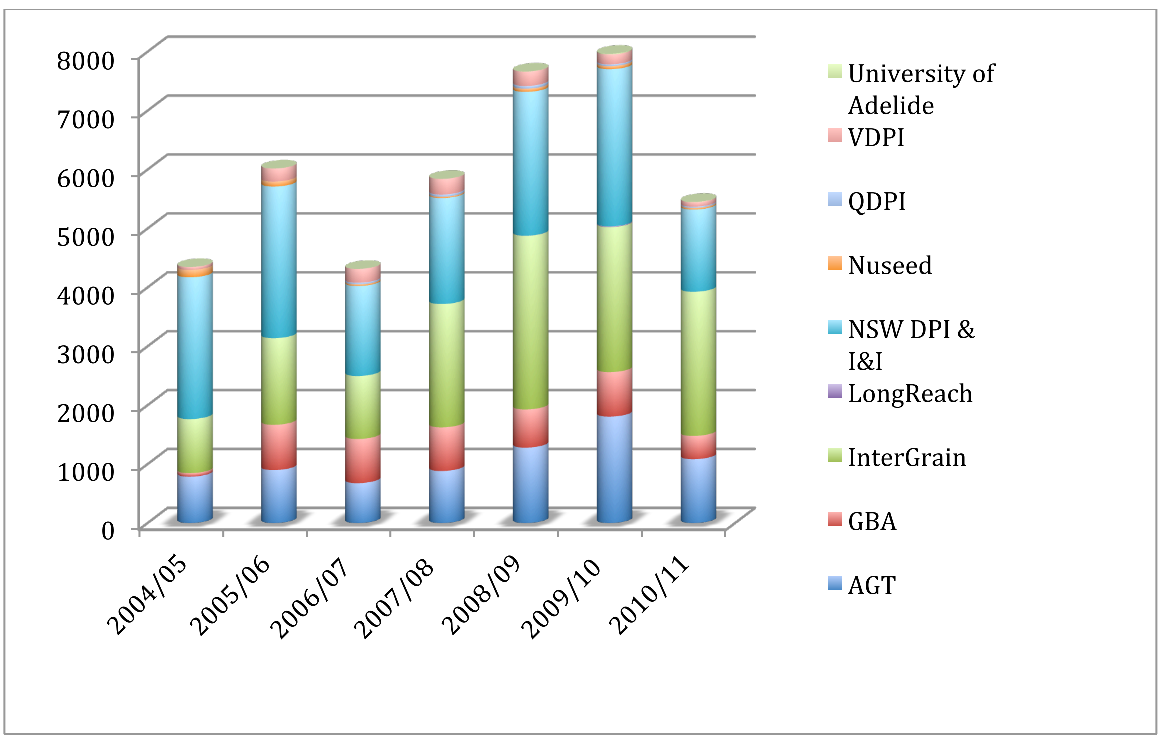
Figure 5 shows a cumulative column graph of the royalties collected by the variety owners per ton of wheat production in Western Australia (WA). This Figure shows that the industry EPRs have increased from an average of less than $0.5 /t to over $1 per tonne in year period. Finally, Figure 6 shows the total dollar amount collected by each firm, each year in WA. In this figure royalties peaked in 2009 at $8 million per year and were decreased by the severe drought in 2010. Given the recent EPR rates and much larger production estimates, EPR revenue for the 2011/12 crop year should easily exceed $15 million in WA.

Figure 5: EPR per ton of Wheat Produced in Western Australia by Owner



Source: Author's Calculations based on EPR rates and variety adoption

Figure 6: Wheat EPR revenue by owner in Western Australia



Source: Authors calculation based on ERP rates and variety adoption.

The North American Experience in IP protected crops

In North America, the protection of plant related intellectual property varies a great deal by crop. The most common form of protection for broad acre crops falls under the Plant Variety Protection or Plant Breeders Rights, which gives the breeder the exclusive right to market the seed for their varieties but also provides exemptions that allow farmers to save seed and allows other breeders to use registered varieties in their own breeding programs. These forms of protection that have formed the basis of the 1961 and 1978 international UPOV conventions have been too weak to stimulate significant private investment (Wright and Pardey 2005). There are other forms of IP protection that are much stronger but are not generally available. The 1930 US Plant Patent Act, which gives patent protection to vegetatively propagated plants (except tubers), has been important for vines, tree crops and horticultural crops and has attracted some private research investment. A strong form of intellectual property protection for broad acre crops has come in two forms. First, the development of hybrid seed, for corn, sorghum, canola and sunflowers has rendered seed saving uneconomic, and when combined with plant variety protection, also inhibits rival breeder use of the genetics. Second, the ability to use patents to protect biotechnology processes, gene traits and plants varieties created from transgenic processes has been very important in development of a private research industry. For the United States, the pivotal point occurred in 1980 when the Supreme Court confirmed in the landmark *Diamond v. Chakrabarty (1980)* decision that utility patents could be granted on eligible living organisms to protect novel, nonobvious and useful products or processes embodied in tangible forms. (Wright and Pardey, 2004). In Canada, patenting of rapeseed (Canola) based biotechnology processes began in 1977. In the famous ”Harvard Mouse” case (Harvard College vs. Canada 2002) the Supreme Court ruled that higher life forms could not be patented. Despite the Court’s negative ruling on higher life forms, the Courts continued to uphold the ability of firms to patent the functional characteristics of transgenic genes.[4] As a result of these rulings in Canada and the United States, a large private crop research industry has emerged in North America, funded from the sale of IP protected crop varieties.

The subsequent development of the North American agricultural biotechnology industry is characterised by industry concentration, vertical integration with the seed industry and significant private crop research investment. While early biotechnology patents were widespread and held by many small firms, the difficulty in writing contracts to license these technologies led to flurry of mergers and acquisitions which began to create large “life science” companies investing in both human and agricultural biotechnology (Fernandez-Cornejo, 2004). Recognising the need for elite, regionally-adapted germplasm to host the new transgenic traits, the companies purchased most of the existing seed companies by the late 1990s. By 2000 the mergers and acquisitions created an industry dominated by five large agri-chemical and biotechnology firms -- Bayer, Dow, DuPont, Monsanto, and Syngenta (Wilson and Dahl, 2010).

Each of these firms large firms continue to make significant investments in crop protection technology and seed and crop traits. As shown in Figure 7, Monsanto dramatically increased its investment in seed and crop trait R&D, increasing from about $100 million in 1991 to over $800 million in 2008 (Wilson and Dahl, 2010). As a result of these investments, Monsanto has become a dominant supplier of seed and seed traits.

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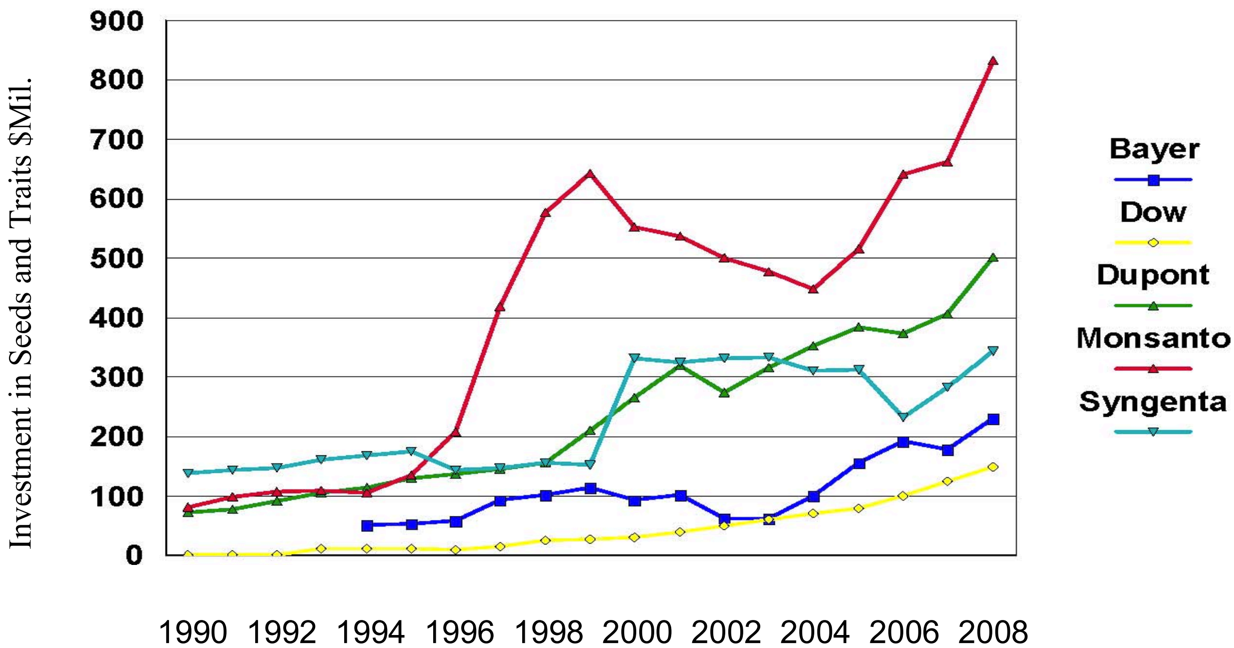
[4] . In Schmizer vs Monsanto, 1984, the court upheld Monsanto’s patent over the use of Round Up Ready technology.

Figure 7: Private Investment in Seeds and Traits by Selected Firm 1990-2008



Source: p.11, Wilson and Dahl (2010):

The large private research investments have been very successful in creating new varieties in demand by growers. Transgenic crops, with herbicide tolerant and or insect resistant traits have been very widely adopted by growers in most major field crops including Corn, soybeans, Canola, Sunflowers and cotton. So far, wheat and rice stand out as important exceptions where the transgenic technologies have not being approved due to concerns over consumer acceptance. In terms of particular companies, Monsanto stands out as the dominant firm field trials, less so in patents and seed sales. (See Moss, 2011, for more detail).

During the strong growth phase of biotechnology industry (1995-2004), firm relied on their recently acquired seed firms to facilitate the commercialisation of their technologies (Howard, 2009). Firms were also very reluctant to share knowledge through licensing and cross licensing agreements. This knowledge sharing situation changed significantly in the 2005 to 2007 period when many cross license agreements were signed (Smyth and Gray, 2011). Monsanto, has been active using its lead position in crop trait development to license these traits to rival seed firms. As result we now see far more double, triple, and even quadruple trait stacking occurring. A new set of corn varieties called *SmartStax* contains eight different traits for corn will be commercialized in the next year or two is billed as creating a 10 % yield advantage over existing varieties for corn producers. While these licencing agreements allow firms to pool knowledge, there could some negative implications as these agreements can restrict the behaviour of rival firms. (Shi et al.,2008; Moss, 2010; Wilson and Dahl, 2010).

The Implications for seed pricing

While the success of the privately based biotech and hybrid seed industries has received a great deal of attention, a natural outcome to strong IP and industry consolidation is higher seed prices. These price impacts have been considerable. Seed costs have risen much faster that general farm input prices. Firms offering improved genetics have increased seed prices over time. In the 1980's seed costs made up 3.5% of farm input costs (Fernandez-Cornejo, 2004). As shown in Table 1, for crops protected strong forms of IP seed costs are about 10% of gross income.

According to USDA, between 1999 and 2008, the US average "prices paid for seeds" rose 146 percent, with 64 percent of that rise occurring during 2006-09, and seed expenses increased $8.3 billion (115 percent). They point out that during the 2006-08 period alone, seed expenses jumped $4.1 billion (37 percent). The upward movement in seed costs slowed considerably in 2009 and 2010, with seed expenses rising only 8%

Table 1: Estimated Revenue, Rents and Research Expenditures for IP Protected Crops 2010

2010 Estimates	US Corn	US Soybeans	Canadian Canola
Farm seed costs per acre ($)	75[a]	52[a]	46[b]
Acres (M)	88[c]	79[c]	17[d]
Total seed expenditure ($M)	6,593	4,100	773
Gross value of crop at farm ($M)	66,700[e]	38,280[e]	5,074[f]
seed cost/ farm gross income	**10%**	**11%**	**15%**
Seed production costs ($/bu.)	24.00[g]	13.50[h]	56.00[g]
Seed rate bu./ac	0.25[i]	1.20[j]	0.10[k]
Seed production costs $/seeded acre	6.0	16.2	5.6
Total seed production costs ($M)	527	1,280	94
Gross seed margin ($M)[5]	6,065	2,820	578
Total private research expenditures ($M)	2,000	2,000	87
% of total US private age. research	34%	17%	75%
Estimated crop research exp. ($M)	680	340	65
private investment/gross seed margin	**11.2%**	**12.7%**	**9.6%**
Gross seed margin/farm gross	**9.1%**	**7.4%**	**11.3%**
private research/farm gross	**1.02%**	**0.89%**	**1.29%**

[a] NASS, USDA Farm Prices Paid 2011, USDA

[b] Author's estimate based on $8 per pound paid in 2010 plus a $15 TUA fee for Roundup Ready Canola on 40% of area.

[c] USDA final seeded acre estimate

[d] Statistics Canada 22-007 final estimate

e. NASS, USDA Crop Values Annual Survey

f. Statistics Canada 001-0010

[g] Hybrid seed production cost estimated as four times the cost of non-hybrid commercial price of $6/bushel

[h] Estimated as 1.5 times the cost of commercial production

[g] Gross seed margin calculated as gross revenue minus seed production costs

[i] 30,000 seeds per acre at 2000 seeds/ per pound

[j] 72 pounds per acre

[k] 5 pounds per acre

[l] gross value on seed purchases – seed production costs

[m] Wilson and Dahl 2011.

[n] private research expenditure estimate 2007, Canadian Seed trade Association.

[o] based on corn share research in 1996 reported in Fernandez-Cornejo 2004.

[p] corn research estimate x soybeans/corn sales

[q] author's estimate

Source: Adapted from Table 13.1 (Gray, 2012) percent over the two year. In the same article they were predicting seed purchases to rise almost $1.1 billion year between 2010 and 2011 (ERS, 2011).

While the sector-wide general increases in seed costs are striking, the impact on Corn and Soybean seed cost is even more evident. As shown in Table 1, US farmers paid approximately $6.6 billion and $4.0 billion for corn and soybean seed respectively. This seed cost represents approximately 10 percent of the gross revenue from the sale of these crops, and even a greater share of expenses. To calculate the gross margin for variety owners the cost of seed production need to be netted out. In the case of hybrid corn, if hybrid corn seed production can be contracted at four times the cost of commercial corn production of $6US per bushel this implied that at a quarter per bushel per acre seeding rate, the corn seed production costs are in the neighbourhood of $6 per seeded acre. Subtracting the seed reproduction costs, the gross margin of variety owners is still just over $6 billion US in 2010. For non-hybrid soybeans the contracted seed reproduction costs are estimated to be 1.5 times the price of commercial soybeans. The gross seed margin for soybean seed companies was just over $2.8 billion US.

These large surpluses from seed sales are used to fund breeding activities. The figures from Wilson and Dahl (2011) indicate that the major seed firms spent about $ 2.0 billion US in crop breeding related activities. If corn makes up 34% of this spend (Fernandez-Cornejo, 2004), and soybeans have the same research intensity, the private research investment is $680 million and $340 million respectively. These research expenditures are 11.2% and 12.7% of the gross seed margin for these crops, which is somewhat higher than the average research intensity of the crop life industry which averages 7.5% across the entire crop protection and agricultural biotechnology investments (Croplife Canada 2011). While these are clearly research intensive firms, these private research activities amount to approximately 1% of the gross value of corn and soybeans produced, which is a modest industry investment rate.

The figures for Canadian Canola reveal a very similar situation. The crop is small seeded and well protected by hybrid technology. Growers spend 15% gross Canola income on seed and the industry re-invests just under 10% of this revenue in research, creating an Canola industry research intensity of 1.3%. It is worth noting that the $65 million in private Canola research (plus $20 million public) compares very favourably to Canadian wheat industry, which is a similar size at the farm level, with about $20 million (mainly public) breeding research.

Policy Implications and Conclusions

The Australian crop research sector has undergone a major transformation. The establishment of the RDC system, has increased grower involvement in crop research, in terms of both increased funding levels and increased governance. Working with the Commonwealth and State governments they have been able to create a national grain research system. This nationally coordinated sectorial approach to research has addressed some of the industry underfunding for broad acre crops. While State governments have reduced their funding for agricultural research this could have occurred even if RDC funding did not exist. In the grains sector the GRDC has played a key role in providing some of the industry club goods and has motivation and the resources to speed innovation in the grain sector. As an outsider that has examined other RD&E systems I would have to concur with the Productivity Commission's (2011) perception that the RDC system of crop research funding is envied beyond Australia's borders.

Australia's 1994 amendments to Plant Breeders Rights Act, which created the legal framework for the breeder collection of EPRs, and the subsequent industry-led EPR collection system, has also been key to the development of a private breeding sector of broad acre crops. EPRs not only increased domestic breeding investment, it has attracted investment and share purchases by several multinational breeding firms, which will give breeders in Australia access to the much larger pools of breeding tools and germplasm. In Canada, where the wheat breeders do not have EPRs, the industry continues to be unattractive for breeding firms except where hybrids and crops with patented transgenic traits are predominant.[5]

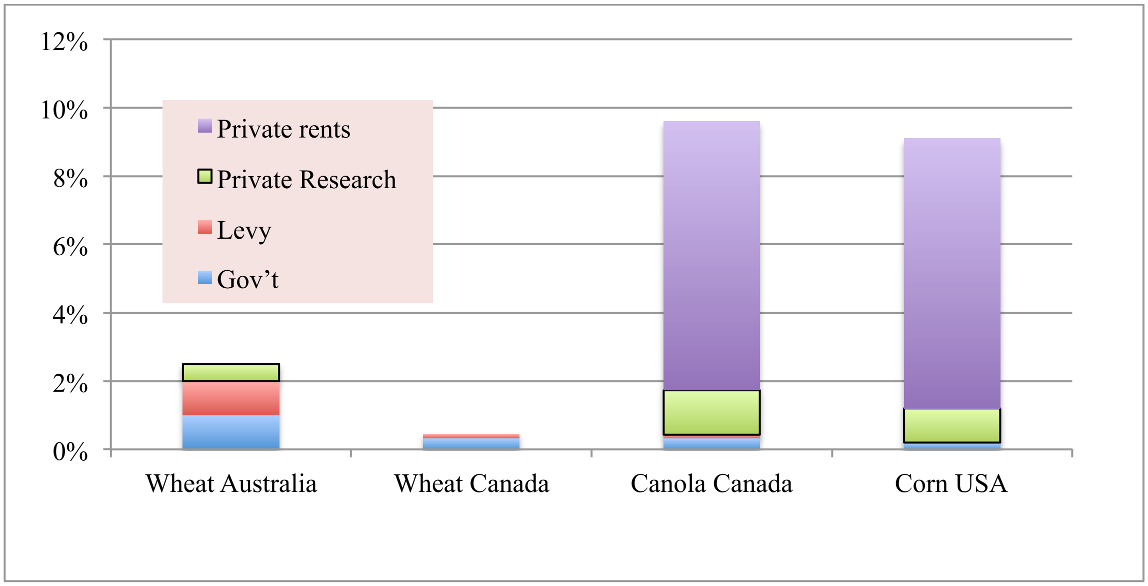
The GRDC decision to stop supporting public wheat breeding programs and to tender for the development of three wheat breeding firms, where the GRDC would be a minority share holder, was a very interesting move that will have implications for wheat research and grower returns for decades to come. Collectively these firms have already reached the point where EPR revenues are sufficient to support their current wheat breeding programs.

If EPR rates continue to increase, firms that are able to create varieties demanded by growers could eventually have large revenue streams. The stochastic nature breeding success could also create highly variable revenue streams for these firms, as one firm could quickly come to dominate the industry if they had a run of successful varieties. Finally, with the toll good nature of knowledge ---creating with economies of size and scope--- pressure could develop for mergers in the industry.

[5] Monsanto abandoned a wheat-breeding program in North America after several years of attempting to license transgenic wheat varieties had failed. Late in 2011, Bayer Crop Science announced it would initiate develop a wheat breeding program in Canada.

The Australia wheat breeding industry began only a decade ago. As a means of exploring how this private industry could develop, some of the developments in North American private crop research industry were explored. This longer period of private industry development has created some striking outcomes. The hybrid and the biotech related crop research industries have become concentrated dominated by a few firms. Monsanto's was the first shift its research resources from crop protection to biotechnology. They now are the largest seed firm and dominate seed sales in some crops. Cross licensing and trait stacking have resulted in producers buying high performance seed with stacked traits. Grower seed costs have exceeded 10 % of gross crop revenue, with seed firms earning a very large gross margin on seed sales. In turn, these research-intensive firms spend 10% of their gross returns on breeding research, which is somewhat higher than 7.5% research intensity in crop protection industry. Table 2 and Figure 8 compare research funding and research rents in the Australian wheat industry, the Canadian wheat industry, the US corn industry, and the Canadian canola industry. In the absence of the GRDC and EPRs the wheat, research intensity in Canada is much lower than the current intensity in Australia. However, even the more mature IP protected crops in North America have research intensity somewhat lower than those found in the Australian wheat industry, while grower costs, which include the research rents flowing to private industry shareholders, is much higher in North America.

Figure 9: Crop Research Intensity by Funding Source and Private Rents 2010



Source: Authors calculations see Table 2.

Table 2: Approximate Research Intensity By Funder and Research Rents by Crop 2010

	Government	Levy	Private	Total Intensity	Grower Royalty Paid
Wheat Australia	1%	1%	.5%	2.5%	.5%
Wheat Canada	.33%	.12%	0	.45	
Canola Canada	.33%	.1%	1.3%	1.73%	9.6%
Corn USA	.2%	0	1.0%	1.2%	9.1%

Source: Authors estimates based on funding levels, levy rates and seed costs

Is the situation in the corn and canola industry a possible future for the Australian wheat industry? EPR rates have increased quite quickly over time but still are just over 1% of gross income. As free and low royalty varieties depreciate, and new varieties continue to sequentially improve, the revenue maximizing firms will increase EPR rates overtime, in part to signal to their growers that they are selling a superior variety that is better than "last year's" model. If ERP escalation were to continue to rise to much higher levels, as seed pries have they have done in North America, the seed companies could become very profitable.

High and profitable seed prices would create new challenges and opportunities for these companies. How would growers and government policy makers react to the notion that wheat producers are paying high prices for seeds thereby generating share revenue for the GRDC, private firms, and for government shareholders? If this in turn creates a political problem for government, will governments retain their shares or sell them?

How would higher prices affect producer support for the GRDC? Could producer reaction to higher EPRs change their attitude toward the GRCD and the behaviour of the GRDC as a shareholder? At this point, these important questions remain unanswered.

Rather than seeing escalating EPR rates over time the GRDC and State shareholders could move away for profit maximization, and rather choose to heavily reinvest in research and curtail EPR rate increases. How would this sit with the private shareholders? While these future developments have not occurred and decisions have yet to be taken, it is clear that if the Australian wheat breeding industry follows the course set by the older North American research industries, at some point it will become a political challenge and a governance issue for this toll good.

Policy Implications

The 1994 amendment for the Plant Breeders Rights has created strong IP rights for wheat breeders in Australia. The GRDC initiative to create three new wheat breeding companies has created a private toll good industry for wheat breeding. Yet the best policies this industry is not straightforward. What is the appropriate public policy to maximise the national benefits from this industry? Is some form of price regulation or entry regulation desirable? What are the efficiency losses of a uniform EPR? If EPR rates are regulated, what are the principles or objectives that should govern the rate setting process? If industry representatives are involved in EPR rate setting will they set rates too low? What are the efficiency and social welfare implications of alternative policies?

From a grower perspective, are there actions they should take to ensure their interests are protected? If governments could eventually sell off of these firms is there a need to more effectively vertically integrate into these seed companies through grower share purchase?

Perhaps doing more economic research to understand economics of these issues and potential solutions will help find the most appropriate path forward. At this point the discussion around public and private policy deals with only a future hypothetical set of conditions. The wheat breeding is still very young faced with potentially complex problems without obvious answers. Understanding how these industries evolve can help to foresee issues and understand how outcomes can be affected by policy.

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