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Institutional Change and Plant Variety Provision in Australia

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Abstract

The science, funding and organisation of plant breeding in Australia has changed greatly since the 1980s. This paper explores the institutional change in plant variety provision in Australia. The roles of key economic and political agents are emphasized, along with the impact of changes in biotechnology and intellectual property rights. Their joint interaction has produced a set of complex agribusiness arrangements that underpin the current funding and supply of plant varieties. The pace of institutional change has been rapid and is uncovering a further set of agribusiness issues such as access to enabling biotechnologies, funder capture, contestability in pricing of varieties and access to royalty collection facilities.

1. Introduction

Since the 1980s the science, funding and organisation of plant breeding in Australia has experienced great change. The breeding of major broadacre species has shifted from utilising simple crossing techniques to sophisticated biotechnologies that accelerate the generation of superior varieties. A handful of publicly funded R&D organisations responsible for varietal provision has become a more disparate group of varietal providers funded from a greater variety of sources.

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When examining changes in provision of plant breeding services, most authors have emphasized its increased privatisation (Thirtle *et al*., 1998; Blakeney *et al*., 1999; Kesan, 2000; Heisey *et al*., 2002) that in turn is underpinned by intellectual property protection (Maredia *et al*., 1999; Klotz-Ingram and Day-Rubenstein, 1999) and fuelled by new biotechnologies (Evenson *et al*., 2002; Lindner, 2003; Kalaitzandonakes, 2003; Pardey *et al*., 2004).

This paper reviews the changes in provision of broadacre plant breeding services in Australia. The rationale for change and the pace and extent of change are described. The roles of economic and political agents are discussed and emerging issues requiring further examination or resolution are touched upon.

The process of institutional change in the provision of broadacre plant breeding services is seen to arise from transactions between economic and political agents (North, 1990). These transactions are driven by the goals and perceptions of key economic and political agents and are conditional upon transaction costs and the nature of a country's customs, laws and bureaucratic and political processes (Challen, 2000). This paper highlights the roles of economic and political agents in responding to and creating institutional change that has affected the provision of broadacre plant breeding services in Australia.

Section 2 of this paper describes the institutional setting of broadacre plant breeding in Australia in the early 1980s. In some detail the institutional change that has unfolded since then is explored. This description of change forms the bulk of the paper. In Section 3 are some reflections on firstly, why certain institutional changes and not others have arisen; and secondly, what economic issues and problems surround the current institutional arrangements for the provision of broadacre plant breeding services.

2. Institutions and Institutional Change in Australian Broadacre Plant Breeding

The Early 1980s

Around 20 years ago plant breeding for broadacre crops in Australia was funded mainly by federal and state governments (Jarrett, 1990). They channelled funds to universities, state departments of agriculture and a few research institutes who, through cooperation and competition, undertook varietal development for farmers. State departments of agriculture, CSIRO[1] and universities were responsible for over 90 percent of all expenditure on agricultural research in Australia (Jarrett, 1990, p. 84).

In the field of broadacre plant breeding, these same organisations dominated the supply of new plant varieties. In 1980, 88 per cent of all broadacre crop plant breeders were employed in the public sector (SCA, 1984). Five years later, as shown in Table 1, these same organisations continued to dominate broadacre plant breeding.

Table 1: The distribution of broadacre plant breeders in Australia in 1985[a]

	---------Number of plant breeders---------		

	State departments	Universities	CSIRO	Total	Public breeding share of breeding effort in this crop	Share of total breeding effort in all crops
Wheat	20.9	13.9	3.3	38.1	95%	43.2%
Barley	8.4	3.8	0.5	12.7	98%	13.8%
Oats	4.25	0	0	4.25	100%	4.6%
Triticale	0.45	3.15	0.3	3.9	100%	4.2%
Sorghum	3	0	0	3	39%	8.3%
Canola	2.8	0.8	0	3.6	78%	4.9%
Soybean	1.5	4.35	2.5	8.35	100%	8.9%
Grain legumes	4.45	0.4	1.35	6.2	100%	6.6%
Cotton	1	1.1	3	5.1	100%	5.5%
Total	46.75	27.5	10.95	85.2		
Share of public breeding effort	55%	32%	13%			

[a] Compiled from data contained in various tables in Lazenby (1986)

Plant breeding focused mainly on wheat, resulting in cereals accounting for almost two-thirds of breeder effort and state departments and universities in combination employed 87 per cent of the plant breeder workforce of public organisations. The goals of plant breeding were to increase the yield and range of adaptation of major crop species, particularly cereals, as well as widening the portfolio of crop species from which farmers could profit. Traditional breeding techniques such as simple crossing of parental lines were the norm. Funding for broadacre plant breeding came mostly from the public purse with some supplementation from growers (Lazenby, 1986). Most farmers appeared satisfied with the system of provision of crop varieties from public agencies and considered it a main role of these agencies.

The institutional property right setting of broadacre plant breeding in Australia around 20 years ago is outlined in the top half of Table 2. The provision of new varieties was underpinned by a hierarchy of property rights whereby genetic resources that commenced as state property in germplasm collections (e. g. the winter wheat collection at Tamworth) were transformed through publicly-funded breeding programmes to become private property in the form of grain produced from new crop varieties.

Table 2: Institutional schema of property rights for broadacre plant breeding in Australia in the early 1980s and early 2000s[c]

Early 1980s			
Scope of allocation	Key parties involved in decision-making	Conceptual property-right regime	Allocation decision

Seed in Australian germplasm collections allocated to Australian public sector agencies or overseas plant breeders	Germplasm curator, plant breeders, plant or seed collector	State property (Federal government)	Define criteria for release of seed to enquirers
Bulk-up of acquired seed for field testing and/or allocated as parental material in crossing programmes for developing a new variety	Crop program managers, plant breeders	State property (State governments)	Crop breeding programme investment decisions
Seed of new variety allocated to particular growers for seed bulk-up and subsequent sale to other farmers	Crop program managers, plant breeders, marketers, farmer representatives	Common property	Define criteria for release of seed; some farmers given exclusive bulk-up access to new variety
Purchase seed and trial new variety to assess its performance; adopt if variety is perceived as superior	Farmers, seed merchants	Private property	Farmers' varietal investment and crop production decisions
Early 2000s			
Seed in Australian germplasm collections allocated to Australian public sector agencies, *private firms* or overseas plant breeders *Licensed or joint venture access by Australian breeders to gene sequences, plant varieties and/or biotechnologies*	Germplasm curator, plant breeders, plant or seed collector. Plant breeders, *biotechnologists, lawyers, intellectual property officers, senior managers, OGTR*[a].	State property (Federal government) *Private property*	Define criteria for release of seed to enquirers *Patent and PBR*[b] *owners' and patent and PBR users' investment decisions*
Bulk-up of acquired seed for field testing and/or allocated as parental material in crossing or genetic modification programmes for developing a new variety	Crop program managers, plant breeders, *OGTR*	State property (State governments) or *private property (private firms, joint ventures*)	Crop breeding programme investment decisions
Seed of new variety allocated to *commercial firms* for seed bulk-up and subsequent sale to farmers	Crop program managers, plant breeders, *lawyers, intellectual property officers*, marketers, *OGTR*	*Private property*	Define criteria for release of seed

Purchase seed and trial new variety to assess its performance; adopt if variety is perceived as superior	Farmers, seed merchants	Private property	Farmers' varietal investment and crop production decisions

[a] Office of Gene Technology Regulator [b] Plant Breeder's Rights [c] Text in *italics* identifies the main changes between the early 1980s and early 2000s.

Institutional Change

Since the 1980s a series of institutional changes has altered the provision of services for broadacre plant breeding. These institutional changes and their causes are described in the following sub-sections.

Changing perceptions of key political agents

During the 1980s and for much of the 1990s, in many developed countries including Australia, key economic and political agents accepted a revision of the role of government such that its priorities became delivering micro-economic reform, deregulation, greater environmental protection and more support for privatisation (Productivity Commission, 1998). In agriculture this meant movement away from government market interventions by removing subsidies, reducing tariffs and removing price guarantees. Direct government involvement in commodity marketing lessened. In Australia the guaranteed minimum price scheme for wheat, the reserve price scheme for wool and market milk pricing arrangements were all removed. Fuelling the withdrawal of direct government involvement in state and federal agricultural marketing was the Council of Australian Governments' (COAG) endorsement in 1995 of the Competition Principles Agreement drawing on Hilmer *et al.* (1993). Resources in the public sector agricultural agencies shifted to accommodate emerging environmental, social and post-farm gate issues (Briggs and Vernon, 1993).

The fiscal focus of many of these reforms was to reduce federal and state government expenditure and allow an increasing array of services to be provided by the private rather than public sector (e.g. McCarrey, 1993). Publicly funded agencies such as universities and state departments of agriculture were included in the reform process. Public funding of broadacre plant breeding tightened and some breeders began to feel their activities were suffering. Lazenby (1986) commented that "With increasing budgetary constraints every activity funded from the public purse is undergoing more and more scrutiny and financial pressure. Plant breeding because of its long-term and costly nature, is receiving more critical attention than most." (p.86).

The widening portfolio of activities in most state agricultural agencies further restricted state public funds for plant breeding, especially as most of these agencies had declining or very slowly growing real public funding throughout the 1980s and for much of the 1990s (Mullen *et al*., 1996 & 2000). Also, various internal and external reviews of public R&D organisations (e.g. DFA, 1992; QDPI, 1990; SADPI, 1992; Bell, 1993; Hussey, 1994; Watson, 1996) tended to generate uncertainty over their R&D directions, structures and funding, adding to the complications of plant breeding which required stable, long-term funding.

The political weakening of the rural vote initially assisted the implementation of these policies. In Queensland and Western Australia major electoral redistributions reduced malapportionment and gerrymandering, and lessened the lobbying leverage of rural groups. Also assisting the reform agenda for

universities and state departments of agriculture was the emergence of funds, other than consolidated revenues, to support these organisations and so lessen adverse political costs of reform. For example, political agents were aware that R&D funds were increasing from national bodies such as the Grains Research and Development Corporation (GRDC). There was a perception that these 'external funds' could maintain some traditional activity such as plant breeding, allowing some increasingly scarce consolidated revenues to be transferred to other activities of greater priority to government.

Changing plant breeding technologies and biotechnologies

During the past 15 years biotechnology advances have been rapid. The new biotechnologies that apply to plant breeding include genomics, proteomics and bioinformatics. Genomics involves the mapping and sequencing of all the genes of an organism and studying their structure, function and interaction. From genomics comes knowledge about which parts of a plant's genome is responsible for growth, development, physiological activities and reproduction. Proteomics is a tool of functional genomics used for the large-scale identification of proteins. It allows researchers to determine the patterns in which proteins are expressed in various states of growth, development, health, stress, disease, and natural decline. Bioinformatics is part of the larger discipline of computational biology. It deals with the large-scale storage, retrieval and assessment of data from genomic and proteomic studies.

Genomic mapping studies are well-advanced for several agriculturally important crops such as corn, barley, wheat, and soybean. The rice genome has already been published. Genomic research identifies important traits such as disease and stress resistance, and yield • enabling improvements in agricultural productivity and environmental quality. Genes associated with these traits can be used as molecular or genetic markers, allowing laboratory rather than glasshouse or field testing of progeny and accelerating both the efficiency and timeliness of release of new plant varieties. Genomics leads to what is known as smart breeding where parents and progeny with desired traits are rapidly and unambiguously identified.

To utilise these new technologies requires significant investment in technical capability, staff and facilities. A pre-condition for applying these technologies is often legal approvals or agreements to use other enabling technologies. Hence, the design and management of biotechnology research often is crucial to ensure marketable outcomes are possible.

Changing property rights in plants

An institutional change that has affected all funders and providers of plant breeding services in Australia since the 1980s has been changes in intellectual property rights concerning plant varieties and plant genetics (Godden, 1998). Firstly, the Plant Variety Rights Act (1987) established an intellectual property right in plant varieties in Australia. There was vigorous debate about the consequences for plant breeding of the passing of this Act, similar to the debate surrounding the draft Plant Variety Rights Bill 1982 (Godden, 1982; SCA, 1984).

The transactions cost of establishing the Plant Variety Rights Act (1987) were large, especially given the degree of opposition it faced and the uncertainty of its beneficial effects. It signalled a turning point for the formation of property rights in plant varieties in Australia. It established a property right that rewarded the development of plant varieties by providing limited monopoly power over certain uses of plant varieties. In the case of grain crops the duration of the property right was for a maximum of 20 years. Most

importantly, the right did not extend to seed saved on-farm for sowing subsequent crops.

For many broadacre crops, the common practice of farmers saving seed at harvest greatly restricted the effective appropriation of varietal value by plant breeders (Alston and Pardey, 1998). The effectiveness of a plant variety right as a property right was further limited by costs of monitoring and litigating infringement of a plant variety right (Loch, 1998), plus plant breeding rivals could relatively quickly produce similar varieties.

In part because of this limited appropriation available to plant breeders, the Plant Variety Rights Act (1987) was revised and replaced by the Plant Breeder's Rights Act (1994). The 1994 Act strengthened the commercial power of plant breeders in their dealings with seed multipliers, distributors and farmers by extending the breeder's right to harvested material. The view of Godden (1998) was that the 1994 amendments, ostensibly introduced to ensure consistency with the international plant variety rights convention, in reality reflected the plant industry's desire to strengthen commercial private plant breeding.

Although the 1987 and 1994 Acts supported change in the provision of plant varieties in Australia, the more important trigger for change came from funding pressures and opportunities. Restrained growth in funds from state governments combined with growth in GRDC funds stimulated change, as discussed in a later sub-section.

A further strengthening of the commercial power of plant breeders occurred with passage of the Plant Breeder's Rights Amendment Bill (2002). This bill altered the 1994 Act in several ways: including:

1. clarifying the circumstances in which the breeder's right was exhausted;
2. further protecting commercially sensitive information;
3. making explicit the right of the owner of the plant breeder's right to initiate infringement actions and
4. altering section 18 to enhance the opportunity of the plant breeder's right owner to gain a commercial reward.

However, even before passage of the Bill in December 2002, the increase in breeder's right registrations under the previous 1994 Act was notable. In 2000/01 317 new applications were recorded (up 21% on 1998/99) with up to 100 new breeders entering the scheme each year, mostly from private sector firms. At least 20 new varieties of major export crops were being registered each year. In 2003-04, a record year for plant breeder's right applications, 414 new applications were received, bringing the total to more than 4,400 varieties in the breeder's right scheme. Also in 2003-04 32 major crop varieties were registered.

Accompanying these legislative changes for plant variety and breeder's rights during the past 15 years have been biotechnology advances in patentable products and innovations, particularly emanating from the United States and Europe (Jefferson, 2001; Kingwell, 2002; Pardey *et al*., 2004). Scientific progress in gene sequencing and manipulation, combined with various court rulings that often clarified intellectual property rights, confirmed that gene technologies, gene sequences and tissue culture techniques were patentable. The extension of intellectual property rights to plant material meant that plant germplasm,

along with certain genes and gene technologies, generally were no longer freely available. Access to them was gained by means such as outright acquisition, becoming a partner or licensee, signing a material transfer agreement, accepting a bag-label contract or signing a technology use agreement. The rapid advances in biotechnologies applicable to agricultural plants, combined with the enlargement of property rights, has stimulated interest in plant breeding among private firms and relevant public sector agencies.

The impact of the increased role of intellectual property rights upon plant breeding has been pervasive. Komen *et al*. (2002) observe: "..national research organisations using agricultural biotechnology are caught in a complex environment, reflecting a transition from earlier periods where products and processes for research resided in the public domain." (p. 200). There are difficult legal issues in both the use of proprietary technologies and in their generation, involving contract law, intellectual property law, biodiversity and biosafety law and commercial and consumer law. Komen *et al*. suggest that in many publicly-funded research organisations there is a pressing need to establish competent legal expertise in issues of proprietary rights (p. 199). Gaining access to appropriate proprietary technologies is a difficult task for private firms and public organisations (Lindner, 1999 & 2002). Nottenburg *et al*. (2001) comment on the latter that "Maintenance of adequate freedom to operate in important technologies will require management well informed about the international IP environment, and well aware of the need to collaborate creatively on many fronts with other public and nonprofit institutions facing similar problems." (p. 29).

The alteration in the scope of property rights in plants and gene sequences, in combination with the advent of patentable biotechnologies, has fostered change in the provision of plant breeding services in Australia. The hierarchy of property rights that has emerged is outlined in the bottom half of Table 2. As shown in Table 2, in the early 1980s in Australia most plant breeding techniques were not subject to patents or licenses. Rather, collaborative and free exchange of genetic material was common. State or common property plant material was transformed through publicly funded breeding programmes to become private property in the form of seed initially available from certified seed growers. However, as shown by the italicised text in Table 2, the hierarchy of property rights has become dominated by private property considerations. This has fuelled the greater privatisation of the supply chain of plant variety provision, although it has allowed some publicly funded variety suppliers greater access to market-based revenue streams. The emergence of royalty or intellectual property payments by farmers for use of new varieties is an illustration that the market-place, rather than the public purse, began to offer a further revenue-raising opportunity to support plant breeding activity. These royalties have been introduced in several Australian States. For example, in 2001/02 the Western Australian Department of Agriculture (DAWA) had 15 varieties that were subject to royalty rates that varied from $0.70/t to $1.00/t. DAWA has an agreement with the statutory marketing authorities (AWB and GPWA) and with GrainCo for royalty collection on DAWA/ GRDC varieties grown outside Western Australia. By 2004 DAWA had 24 varieties subject to royalty rates varying from $0.45/t to $4.17/t.

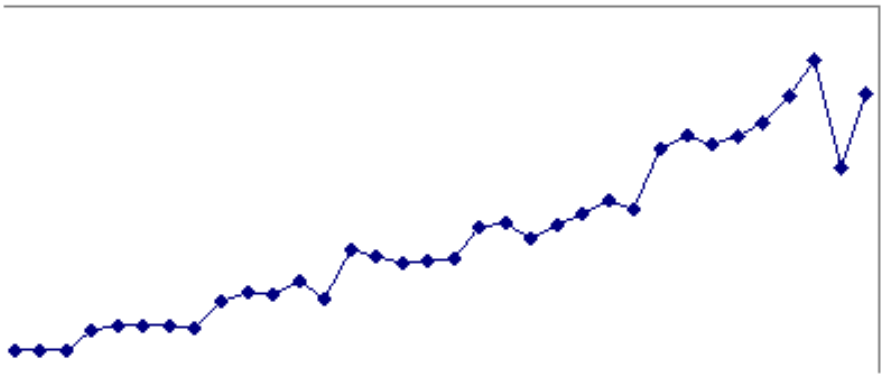
Variety providers that rely on public and GRDC funds, often in response to political concerns, have set royalty rates less than their commercial counterparts. Also, the implementation of the royalty schemes has suffered from high transaction costs that have lessened net revenues flowing back to varietal providers (Kingwell and Watson, 1998). However, the Plant Breeder's Rights Amendment Bill (2002) has facilitated the introduction of these royalty payments, as the Bill's amendments addressed a range of legal uncertainties. The regulation impact statement for the Bill stated that "Growers, and agencies that represent growers, will be clear that a royalty payment is necessary for the use of the plant breeder's

innovation.". It also states that "Agricultural industry is anticipating the introduction of the amendments positively as they will facilitate commercial arrangements based on the PBRA, including through a system of end point royalties.".

Changing perceptions of key economic agents

Enhanced property rights in plants, combined with advances in gene technologies and growth in the value of crop production in Australia (see Figure 1) have stimulated interest in the provision of plant varieties by economic agents in the private and public sectors. In an increasingly privatised supply chain for grains, these agents have adopted a suite of offensive and defensive tactics to ensure their organisations benefit from plant breeding activity.

Figure 1: Value of crop production in Australia (A$m)



Source: ABARE (2003,2004)

In the public sector, economic agents have identified the need to protect their botanical and human plant breeding assets from poaching by rivals. Most public sector organisations have employed intellectual property officers or have established accounts with legal firms with specialist patent and intellectual property attorneys. Some Australian universities have followed the lead of major universities in the United States where offices of technology transfer were established to commercialise R&D from which the universities and individual researchers could benefit. Among universities in the United States in 1980 there were only 25 offices of technology transfer, yet by 1990 there were 200 (Mowery *et al*., 2001). In the United States passage of the Bayh-Dole Act in 1980 greatly encouraged the formation of technology transfer programmes in universities (Graff *et al*., 2002) from which the universities and some individual researchers benefited.

The need to protect existing and emerging intellectual property is seen as both a defensive and offensive tactic. It prevents free-riding by competitors on the intellectual property developed within the plant breeding and biotechnology programmes of the publicly supported organisation(s). Also it provides a bargaining chip in joint venture or biotechnology access discussions with other commercial or public parties. Finally, it is a potential source of revenue that provides flexibility in management decisions for these public sector organisations.

Graff *et al*. (2002) comment that the "private objectives of all scientists can be summed up as a pursuit of some combination of the three 'F's — *fame*, *fortune* and *freedom*." (p. 113). In the public sector, where funding from consolidated revenues for plant breeding is uncertain and restricted, and accountability requirements are increasing, economic agents in these organisations have secured other sources of funds, including revenue streams from intellectual property, to make the work environment of plant breeders more attractive. For plant breeders, sole reliance on limited public funds usually translates into limited freedom to operate and a limited capacity to derive personal gain from plant breeding activity, so other funds and rewards need to be made available.

A corollary of the diversification of funding for plant breeding in public sector organisations is that it is potentially privatisation by stealth. As plant breeding in these organisations becomes increasingly dependent on revenue sources apart from government funds then firstly there is the risk of funder capture (Banks, 1996) where private funds leverage additional government funds and secondly commercial concerns increasingly dictate plant breeding choices. Ultimately, the need to generate or receive revenue, apart from consolidated funds, becomes the main focus of plant breeding activity; a need shared by privately funded plant breeders.

A tactic employed by several economic agents in the public and private sectors has been to form vertical and, less frequently, horizontal relationships. Several partnerships linking private and public sector organisations have emerged. The Australian Wheat Board Ltd combined with the CSIRO and GRDC to form a joint venture called Grain-gene. The University of Sydney, GrainCorp Operations Ltd and the GRDC established a wheat breeding joint venture with SunPrime Seeds Pty Ltd. Commercial alliances, such as Nugrain and Graintrust, formed to capitalise on crop variety intellectual property rights and associated production inputs and services. Australian Grain Technology was formed as a joint venture between SARDI, the University of Adelaide and GRDC.

Figure 2 shows the main publicly-announced commercial relationships, as at June 2003, for the provision of wheat breeding services within Australia; wheat being Australia's main grain crop. The figure shows the various arrangements between public and private organisations as funders and providers of the wheat breeding services. Arrows show the direction of linkages culminating in the eight main wheat breeding programs. Most breeding programs involve several players. The multiplicity of arrangements is evidence of the extent to which the interests of key economic agents have been kindled by changes in crop variety intellectual property rights and plant breeding technologies.

As shown in Figure 2, the GRDC funds collaborative cross-border and cross-institution activity in plant breeding. The federal government has also encouraged similar collaboration through its support of the cooperative research centres for quality wheat, value added wheat, molecular plant breeding, tropical plant

proteins and legumes in Mediterranean agriculture. These cooperative research centres have commercial partners such as Bayer Crop Science, GrainCorp and Goodman Fielder Milling and Baking. Various state governments have also funded cross-institution activity in biotechnology R&D from which the breeding of various crops benefits.

Some multi-national biotechnology companies (e.g. Bayer CropScience, Syngenta, Monsanto) have also invested in plant breeding partnerships in Australia. However, consumer and, in some cases, grower resistance to genetically modified crops and foods in Australia limit the returns to much of the current proprietary technology of these companies. In fact, in May 2004 Monsanto announced its withdrawal from providing GM canola varieties to Australian farmers due to bans placed by state governments and restrictive trial conditions. In the same month Monsanto also announced it was pulling out of GM wheat trials in the United States and Canada.

Figure 2: Main commercial linkages for wheat breeding in Australia in mid-2003

Source: Keith Alcock, WA Dept of Agriculture, pers.comm.Note:not all linkages are shown, particularly those regarding Cooperative Research Centre (CRC) partners

In Australia, multi-national companies are not, at present, a major source of new varieties for many broadacre crop species (apart from cotton). Their role in strengthening intellectual property rights inplants in Australia has been minor; in contrast to the situation in North America. As Alker and Heidhues (2002) observe; "...it is questionable whether strong IPRs attract additional investments or whether powerful and knowledge intensive industries, such as the modern, highly integrated breeding companies, lobby and push for strong IPRs." (p. 64, 65). The views of Fowler (1994) and Alston and Venner (2000) are that strong intellectual property rights in plants, rather than clearly encouraging additional investment in plant breeding, could just be an instrument of marketing, advocated and employed by powerful seed companies.

The trend toward private and collaborative investment in plant breeding has occurred in many other countries besides Australia and private investment in plant breeding, in general, has accelerated (McGuire, 1997; Smith *et al.*, 1999; Heisey *et al*., 2002). For example, Fuglie and Walker (2001) outline how and why in the United States large increases in private investment in plant breeding have occurred while investment in public plant breeding has stagnated or declined. Table 3 shows how private institutions in the United States dominate the provision of plant breeding services, being clearly the main source of plant variety protection certificate applications. Bijman and Joly (2001) similarly outline the main changes that have occurred in the 1990s in Europe, concentrating on structural and merger activity within the seed and pesticide industries.

Table 3: Number of plant variety protection certificate applications in the United States by type of institution

Type of Institution	1971-80	1981-90	1991-00	2001-02	Total
Private	1,027	1,900	2,941	436	6,304
University	138	229	358	84	809

Foundation	43	19	96	18	176
Public	6	14	53	24	97
Total	*1,214*	*2,162*	*3,448*	*562*	*7,386*

Source: part of Table 6 in Pardey et al. (2004)

Farmers in parts of Australia have reacted to the investment opportunities in plant breeding, as well as the restricted availability of public funds, by directly supporting plant breeding. Farmers in South Australia and Queensland have paid voluntary levies to support plant breeding (Lazenby, 1986). In Western Australia, in the late 1990s a company called the Council of Grain Growers Organisations Ltd was formed to receive and invest farmers' voluntary levy payments with the levy being based on 0.5% of farm-gate crop value. This company has invested in a private company Grain Biotechnology Australia and another joint venture company Canola Breeders WA in which the University of Western Australia is a partner.

Apart from enhanced property rights in plants, advances in gene technologies and growth in crop production in Australia, another stimulus to the provision of plant varieties by economic agents in the private and public sectors has been the trend towards de-regulation of statutory grain marketing, handling and freight. Reviews of several State-based statutory grain marketing, handling and freight authorities have led to a withdrawal or lessening of their statutory support, exposing them to greater competition. To defend their economic power several of these authorities have formed vertical linkages. For example, partners in NuGrain Limited include GrainCorp Limited, Vicgrain Limited, the South Australian Cooperative Bulk Handling and Cooperative Bulk Handling Western Australia and Nufarm Limited. Also Co-operative Bulk handling Western Australia has amalgamated with the Grain Pool of Western Australia. Also the Australian Wheat Board has commercial ties with CSIRO through Graingene. The organisational strategy of the grain marketers has been to secure and widen their roles in the grain supply chain by amalgamation and joint venture arrangements. Their greater participation in the provision of new plant varieties is part of their strategy.

Grain marketers, by building commercial linkages with varietal providers and grain handlers, believe they will be more able to ensure plant breeding outcomes are consistent with trait requirements in the various markets that they service. In some cases they will have greater control over the portfolio of varieties they market, especially if closed loop marketing arrangements are invoked. The vertical linkage strategy also acts as an income diversification strategy where profits are derived not only through marketing margins but also through intellectual property payments. Finally, the strategy also ensures that access issues up and down the supply chain are less problematic.

A major economic player in the organisation and function of plant breeding in Australia is GRDC. Founded in 1990 the GRDC is a statutory corporation [2] responsible for planning, investing and overseeing R&D for the Australian grains industry. Its mission is to invest in R&D for the greatest benefit to its funders: graingrowers and the federal government. The GRDC's research portfolio covers 25 crops and its funding is based on a levy applied to each of those crops, with the rate set by the Grains Council of Australia. The federal government matches this funding, up to an agreed ceiling.

During the 1990s larger and more valuable harvests of broadacre crops (see Figure 2) meant that the

GRDC had more R&D levy receipts and matching federal government funds to disburse for plant breeding. Since the early 1990s, as shown in Figure 3, annual R&D funding from the GRDC trebled to be currently around $120 million.

Figure 3: Grains R&D Corporation R&D expenditure since 1992.

The GRDC has emerged as a major stakeholder in plant breeding and at various times has identified R&D strategic initiatives (e.g. GRDC, 1997) or reforms for plant breeding (e.g. Clements *et al*., 1992; Lazenby *et al.*, 1994). The reaction of many publicly-funded plant breeding organisations, in light of the restricted availability of funds from their state government treasuries, has been to rely increasingly on GRDC as a funder and equity partner (Wright, 1996; Watson, 1997) and, in very recent years, to rely more on sharing of revenue streams from intellectual property rights in varieties. Through its funds the GRDC has motivated co-operation and, at times, rationalisation of plant breeding activity across and within States.

Funding for plant breeding from the GRDC during the 1990s has become increasingly important as funding pressures upon plant breeding from state governments have increased and crop diversification increased, fuelling the demand for new plant varieties. GRDC has formed commercial linkages with a range of national and international R&D providers of biotechnologies and plant breeding services.

The need for an organisation such as GRDC, supported by commodity levies and matching government funding, has also been identified in Canada, a grain export competitor to Australia. When Canadian federal government funding support for wheat breeding declined and there were difficulties in recouping research investment from seed sales, then policies for commodity check-off programs were initiated (Carew, 2001). The intention of these programs was to ensure a higher level of investment in plant breeding by grain producers through imposition of commodity levies.

3. Some Reflections

Alternative Institutional Change

Institutional change can arise from the actions of political entrepreneurs who initiate institutional innovations in response to demands from private or economic or other political entrepreneurs (Hayami and Ruttan, 1985; Challen, 2000). The type and extent of institutional change depends on the relative power and perceptions of gain for the political entrepreneurs, as well as the costs of transactions and transition (Easter, 2000; Dorward, 2001). As Challen (2000) says, “Alternative institutional arrangements will differ with respect to (i) the transaction costs of decision making and exchange to achieve a particular objective with respect to resource allocation; and (ii) the costs of institutional establishment and maintenance.” (p. 29).

In the case of provision of plant breeding services in Australia, several alternative pathways of institutional change have not been followed or adopted (Watson, 1998); or they represent only a minor component of the institutional change that has unfolded. A few examples are discussed in the following paragraphs and explanations are offered for their failure to be adopted or their limited adoption.

More grower voluntary levies

Since the 1980s voluntary levies to fund plant breeding have applied at various times in Queensland, South Australia and Western Australia. However, as an economic instrument they suffer from 'free-riding' and need high profile, prolonged championing to maintain grower commitment. Typically they become short-term minor sources of support for plant breeding. Their voluntary nature often means that in economic downturns farmers opt to not contribute funds, and so they are an unreliable and therefore potentially ineffective method of funding long-term, on-going demands of plant breeding. Their establishment costs can be high as widespread publicity and grower interest must be generated to fuel voluntary payments. Also, rapid success from breeding investment tends to be required to ensure growers continue their voluntary contributions, yet such opportunities for almost immediate breeding success are rare. To be maintained they need coordinated promotion by political and economic entrepreneurs.

Higher GRDC levies

The GRDC's levy receipts come from a levy applied on 25 crops, with the rate set by the Grains Council of Australia and the federal government matching this funding, up to an agreed ceiling. Raising the levy rate could increase funding for plant breeding. However, the transaction costs of accomplishing this could be high. Agreement from members of the Grain Council of Australia is required. This would involve gaining cross-State and cross-industry consent. Growers paying the increased levy, and the council, would need to be convinced that the additional funds flowing to the GRDC would be allocated to plant breeding and not to

some other research priority of GRDC and its government stakeholder. Growers would need assurance that the additional funds allocated to plant breeding would not simply trigger an offsetting decline in federal and state treasury support for plant breeding. Growers would also need to be convinced that their levy payments would fund plant breeding activity relevant to their region, crop or main grain markets. Few political entrepreneurs would see their advantage in advocating raising the levy, knowing that it is money out of growers' pockets with little likelihood of a matching contribution from the federal government and with an uncertain, distant return on offer to growers.

Privatisation of "public breeding institutes"

In a few developed countries some publicly funded plant breeding institutes have been fully privatised (McGuire, 1997; Heisey *et al*., 2002). This is yet to occur in Australia. However, as discussed earlier, plant breeding in most publicly funded organisations in Australia is already being subject to a form of privatisation by their need to rely increasingly on funds other than consolidated revenues. The net effect of the actions of economic and political agents within these organisations and their political counterparts in farmer organisations is that governments have not abruptly ceased to invest in plant breeding, rather they have either gradually reduced real funding or re-directed it to less applied biotechnology and pre-breeding R&D.

The partial or complete sell-off of some public assets (e.g. Telstra) can offer large cash injections for some governments with all their associated political advantages. However, a sell-off of plant breeding assets in Australia is unlikely to generate substantial revenue and therefore is not particularly attractive to many political and economic entrepreneurs. Most plant traits on offer from publicly funded varietal providers already exist in the public domain. Further, much of the value of future varieties will come from the technology (i.e. novel gene sequences) embedded in the new varieties. Accessing the public domain varieties that will form the parental lineage to new varieties will be relatively inexpensive. Hence, a sell-off of public sector plant breeding assets or its privatisation is unlikely to generate substantial additions to treasury coffers.

Higher crop improvement royalties

Crop improvement royalties in Australian agriculture are low compared to royalty rates in other sectors (see Table 4). For example, AgSeed has a royalty of $8/t (less than 2 per cent of the farm-gate canola price) for its canola variety AG-Castle, AWB-Seeds has royalty rates up to $3/t and DAWA/GRDC royalty rates are mostly less than 1 per cent of the farm-gate price of grains. Rates set by public sector plant breeding organisations in general are less than those set by private companies and perceptions of political tolerance appear to influence the setting of these rates. Although economic agents in the private and public sectors recommend higher rates, political concerns usually dictate a lesser rate.

Yet higher rates may be more consistent with the Competitive Principles Agreement that states:

> "The objective of competitive neutrality is the elimination of resource allocation distortion arising out of the public ownership of entities engaged *in significant business activities*: Government businesses should not enjoy any net competitive advantage simply as a result of their public sector ownership".

Table 4: Average royalty as a percentage of sales

Type of product	Average royalty as a percentage of sales
Agricultural	3.9
Engineering	6.3
Medical (therapeutics)	6.3
Medical (diagnostics)	6.6
Medical (materials & reagents)	9.4
Other (includes chemicals)	7.6
All fields	6.6

Source: Castillo et al. (2000)

For most publicly funded organisations the selling of plant varieties would qualify as a *significant business activity* and thus full cost accounting would need to apply to developing and pricing new grain varieties. Exceptions apply where a government directs the organisation to charge below competitively neutral full output recovery in order to achieve a policy goal or where the product or service generates spin off benefits for the community or positive externalities. However, for this exception, the CPGO (2001) states:

> "where an agency is selling a commercial output at a price less than its avoidable cost of production because the Government believes there are spin-off benefits to the community, then where there are commercial competitors selling the same type of output the Government should consider *uniformly subsidising the production of the output by all suppliers*." (section 5.5.4.3)

Hence, if publicly funded organisations are found to charge royalties substantially less than competitively neutral pricing then State and Federal Treasuries are potentially exposed to anti-competitive claims from private providers.

Currently, it appears that political agents have successfully argued that during the transition phase of introducing crop improvement royalties the rates needed to be set low. As growers come to accept these payments, and as the Plant Breeder's Rights Amendment Bill (2002) further facilitates their continuance, then political perceptions may alter and the rates increase.

Future Economic Issues in Plant Breeding

Property Right Protection

The large private and public investments occurring worldwide in biotechnology are likely to be accompanied by a proportional rise in expenditure on property right protection. Hence, investment in securing, maintaining and policing intellectual property rights could become an important component of investment in plant breeding. Multi-national biotechnology companies devote substantial funds to establishing and enforcing their proprietary rights. For example in July 2002, Syngenta filed a lawsuit against Monsanto, DeKalb Genetics, Pioneer Hi-Bred, Delta and Pine Land, Dow AgroSciences and Mycogen Seeds to stop the alleged unlawful infringement of Syngenta's US biotechnology patents covering transgenic corn and

cotton. Syngenta also sought damage payments from these other companies.

The increasing privatisation of plant breeding services in Australia necessarily means that property right protection will become increasingly important to many providers of varieties. The high costs of biotechnology R&D and the transaction costs associated with establishing and enforcing property rights over that R&D may mean that eventually smaller firms or joint ventures providing varieties will disappear. Already in Australia some of the smaller organisations are seeking offshore providers of the biotechnology R&D due to the greater expense of conducting the same R&D in Australia and the higher regulatory costs in Australia, particularly for transgenic R&D.

In Australia gene technology R&D has become subject to greater regulation. The Gene Technology Act 2000 was passed and became operational in June 2001. This federal Act and its accompanying State legislation establish a national regulatory system to protect public health and the environment from risks associated with gene technology. The legislation revolves around a system of prohibitions and approvals. Each dealing with a genetically modified organism, apart from statutorily exempt dealings, needs to be licensed by the Office of the Gene Technology Regulator.

While Australian consumers and farmers continue to express concern about the merits of transgenic crops, it is likely that the supply of transgenic varieties will continue to be highly regulated. This will limit, at least in the medium term, several commercial opportunities for biotechnology firms and joint ventures. It will delay the spread of privatisation of plant breeding and ensure that traditional plant breeding methods persist longer than might otherwise have occurred.

Property Right Access

The greater emphasis on property right formation and protection, and the greater privatisation of the grain supply chain, will inexorably lead to issues of access to enabling biotechnologies and facilities for royalty collection (Lindner, 1999; Nottenburg *et al.*, 2001). A major unfolding issue will be determining appropriate access regimes across the supply chain (Lindner, 2003), including access to biotechnologies. A major challenge is how to enable markets to operate across the grain supply chain so that supply chain efficiency is achieved at low transaction cost (Lindner, 2004).

As patenting becomes prevalent in underpinning variety provision, the number of rights to produce a new variety is likely to increase. For example, Kryder *et al*. (2000) and Gillis (2000) comment that the prototypic transgenic vitamin A rice incorporated technology based on 70 patents with, at the time, 32 owners. Where ownership of these rights is poorly defined then the transaction cost of gaining access is potentially large leading to the problem of the "tragedy of the anticommons" (Heller and Eisenberg, 1998). Hence, patent gridlock can stifle varietal development and limit the incentive to invest in plant breeding. A study by Marco and Rausser (2002) of merger activity among 111 biotechnology firms in the United States supports this view. They found many mergers were fuelled by real or potential conflicts over mutually blocking patents.

Even where the problem of access to intellectual property rights is overcome • through merger, access arrangements or regulation; a remaining problem is the difficulty of enforcing an intellectual property right. Fulton and Giannakas (2001) examined horizontal and vertical merger and acquisition activity and

found that product complementarities between seeds and chemicals encouraged vertical linkages as did the related need to overcome difficulties in enforcing intellectual property rights.

Funder Capture

Largely publicly funded R&D institutions, such as universities, CSIRO and state departments of agriculture, risk what is known as funder capture (Banks, 1996). This occurs when private or external funds are provided to these R&D institutions on the condition that existing or additional resources within these institutions complement the external funding. The external funder can leverage substantial resources within the host R&D institution to support their projects. In the field of plant breeding this can mean switching funds away from other priority areas, such as environment or health, towards agricultural production.

The Industry Commission (1995) argued that largely publicly funded R&D institutions should ensure that their research contracts with external funders are based on full cost recovery. Their rationale was that dependence on external funds should not drive out research with net public benefits that had no private sponsor. However, many publicly funded institutions involved in broadacre plant breeding face a decline in real funding from the public purse and so rely increasingly on funds other than those from government. Even when external funders such as the GRDC are charged full-costs, it may be in the strategic or even short-term interests of the publicly funded organisation to switch other funds or resources to maintain the organisation's attractiveness to the external funder. Hence, even with full-cost recovery, funder capture may remain a problem.

Varietal Assessment

New varieties are experience goods. Only by growing a new variety and directly comparing its performance to the existing variety over a few seasons will a farmer have assurance of the superiority of the new variety. Yet a variety can attract a plant breeder's right if it has a breeder and is distinct, uniform, stable and novel (Blakeney *et al*., 1999; Australian Government, 1994). In short, it is possible to gain a plant breeder's right (PBR) for a broadacre variety even where the variety offers no commercial advantage to the end-user. As Dawson *et al*. (2002) comment:

> "PBR registration of a plant is not a guarantee of performance/value, it simply warns against infringement of the innovator's rights. The expertise of the PBR Office does not extend to balancing the evidence of competing claims involving issues of economic impairment and/or aesthetic consideration." (p. 23)

Although the PBR Act requires that an approved person (Section 8 of the 1994 Act) acts as a PBR applicant's technical consultant, there is no requirement for that expert to offer any economic assessment of worth. Historically, in each Australian state there were so few competing suppliers of varieties that often all potentially suitable varieties were compared in field trials, well attended by grain growers. However, with an increased number of potential suppliers of new varieties, combined with the drive for marketing returns from varietal adoption, there is enhanced commercial pressure to promote each new variety. To confer advantage for a variety, field comparisons may be manipulated through site selection, time of sowing, agronomy treatments or selection of the varietal portfolio in the trial. To lessen the likelihood of inappropriate varietal comparisons or cosmetic breeding there is a role for government to ensure

information about a variety's performance facilitates farmers' assessment of its likely true worth on their farms (Lazenby *et al*., 1994).

Competition and Co-operation

Greater privatisation of plant breeding services in Australia has attracted new entrants, unleashed more competition and tested the cooperative spirit among providers. The emergence of the Grains R&D Corporation (GRDC) since the 1990s as a major funder of plant breeding in Australia has placed it in a unique position to affect competition and co-operation between providers. The GRDC has already expressed its desire for rationalisation of breeding activity and through its funding it has encouraged greater cooperation between certain organisations. Kingwell and Watson (1998) argue that:

> "So long as a national funder such as the GRDC remains an equity partner in regional breeding programs that generate revenue from end point royalties, caveats on the GRDC support for plant breeding or related research and development within host organisations will ensure that cooperation between host organisations is continued. However, if regional breeding programs become privatised or national funders such as the GRDC have inadequate leverage or influence over the programs then either reduced cooperation between host organisations could occur or the cooperation will become more formalised through negotiated contracts and partnership agreements." (p.300).

Equity and efficiency issues

The shift toward the privatisation of breeding services raises a number of equity and efficiency issues. Gray (2003) draws attention to the range of market failure issues that still surround the greater privatisation of plant breeding. Lindner (2004) points out that "As private plant breeding replaces public programs, the efficient provision and utilisation of key enabling technologies for crop breeding, which are largely knowledge based and provide the foundation for variety improvement, might be at risk.' (p. 301). Heissey *et al*. (2002) comment that much more work is needed to "improve theoretical and empirical models of the influence of institutions, such as the intellectual property regime, on both private sector plant breeding investment and the public sector's freedom to operate and to collaborate with the private sector."(p.194, 195). As greater privatisation of plant breeding proceeds, there is a risk of it becoming a simple political mantra that results in inappropriately low levels of public R&D funds for pre-breeding and regional public good activity.

In Australia the switch toward privatised plant breeding may cause certain regions or crop types to attract less plant breeding support. For example, where end point royalties are the mechanism for generating a return from an intellectual property right, then crops like hay oats or lupins used on-farm may evade royalty capture. Private plant breeders will face a reduced incentive to invest in these crops. Also economies of size may dictate that private plant breeders ignore agro-ecological regions that are minor producers of main crops. Technical and economic issues about the feasibility of establishing cottage or orphan industry breeding programs will arise. Those paying GRDC levies and end point royalties, a share of which may flow to the GRDC, may seek to ensure that those funds are re-invested only in their region or industry. Hence, the privatisation of breeding services may unleash issues of equity and efficiency in the supply of new varieties. A challenge for agricultural and policy economists will be the provision of information that addresses these issues.

4: Conclusions

Since the 1980s the science, funding and organisation of plant breeding in Australia has shifted from being the responsibility of a handful of publicly-funded R&D organisations, employing mainly field-based simple techniques, to a more disparate group funded from a greater variety of sources and increasingly reliant on advanced biotechnologies. The roles of key economic and political agents are identified, alongside the impacts of changes in biotechnology and changes in intellectual property rights.

In Australia a range of political and economic agents have interacted and responded to threats and opportunities for either publicly funded or privately funded provision of plant varieties. Opportunities have arisen through a change in the hierarchy of property rights in plant varieties. The change in hierarchy has been facilitated by legal changes to intellectual property rights in plants and innovation in gene technology. In concert with other policy changes such as de-regulation of grain marketing, transport and handling, grain supply chains are being increasingly privatised. In response, suppliers of plant varieties are forming horizontal and vertical linkages throughout the supply chains in a series of defensive and offensive strategies. Publicly funded varietal suppliers are increasing their reliance on funds other than those from government treasuries. Royalties on new varieties gradually are becoming an important source of revenue. A set of complex commercial arrangements has unfolded to underpin the funding and supply of plant varieties.

The degree of institutional change, especially over the last decade, has been rapid and is uncovering further institutional issues such as access to enabling biotechnologies, contestability in pricing of varieties, funder capture and access to royalty collection facilities. The grains industry has entered a dynamic period of structural adjustment in the funding and supply of plant varieties for broadacre agriculture and this will unleash a further round of economic problems.

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[1] Commonwealth Scientific and Industrial Research Organisation

[2] Its enabling legislation is the Primary Industries and Energy Research and Development Act 1989

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