Institutional change and plant variety provision in Australia

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Contributed Paper presented to the 47th Annual Conference

Of the Australian Agricultural and Resource Economics Society

At

Fremantle,

February 12-14, 2003

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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&E organisations responsible for varietal provision has become a more disparate group of varietal providers funded from a greater variety of sources.

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) and the increased importance of intellectual property protection (Maredia et al, 1999; Klotz-Ingram and Day-Rubestein, 1999). In this paper, however, a different approach to studying change in plant breeding is presented. Key ideas and concepts in new institutional economics are drawn upon to encompass previous findings and generate additional insights.

New institutional economics is not simply a consideration of organisational issues, although these are known to affect the progress and commercialisation of R&D (Hayenga, 1998; Huffman and Just, 1999; Athey and Roberts, 2001). Institutions are viewed much more broadly than organisations, being humanly devised rules and codes of behaviour that shape human interaction (North, 1990 p.3). Hence to examine institutional change in plant breeding requires reporting not only organisational change but also considering what legal, attitudinal and political influences have underpinned or stimulated the change.

The nature and role of institutions and costs of institutional change are the subject of a growing literature (eg Challen, 2000; Furubotn and Richter, 2000; Athey and Roberts, 2001; Vandenberg, 2002). A common view in new institutional economics is that institutional change occurs to facilitate transactions and reduce transaction costs (Dorfman, 1981; Williamson, 1989; Hubbard, 1997; Hanley *et al*., 1997; Easter, 2000) and thereby increases the prospects for efficient resource allocation. Hence when economists espouse the advantages of market-based solutions to resource allocation problems, such as provision of plant breeding services, they are arguing for institutions that provide property right formation, protection and policing, hopefully at low transaction cost.

This paper draws on new institutional economics concepts to examine institutional change regarding the provision of plant varieties in Australia. The first section of this paper develops a conceptual model of institutional change based on Hayami and Ruttan (1985) and North (1990). A second section applies this conceptual model to the provision of plant varieties in Australia. The roles of key economic and political agents are outlined, along with the impact of changes in biotechnology. Key changes in intellectual property rights and their impact on broadacre plant breeding are described and the emergence of crop improvement royalties as part of the new set of institutions is highlighted. A third section examines briefly some other possible pathways for provision of plant varieties and reflects on why those pathways are less

evident. A fourth section forecasts issues to face the current set of institutions governing plant variety provision. Finally, a set of conclusions is presented.

Section 1: A Conceptual Model of Institutional Change

Although recognising that institutional change was often a complicated process, nonetheless North (1990) argued that because institutions were created and altered by human beings, a theory of institutional change needed to start with the behaviour of individuals (North, 1990 p.5). The individuals he highlighted were entrepreneurs in political and economic organisations. These individuals played key roles in institutional change with the rationale for their action being their perceptions of the benefits and costs associated with institutional change (North, 1990 p.8).

Scott (1989) outlined four means of institutional change:
(i) spontaneous and discontinuous change by revolutions and conquest.
(ii) spontaneous and incremental change from the working of custom and common usage.
(iii) incremental change by judicial processes and evolution of common law.
(iv) incremental change created by imperial, bureaucratic or political means.

Of these four means the last three are most relevant to institutional change regarding the provision of plant breeding services in Australia. Preceding Scott, Hayami and Ruttan (1985) considered institutional change as a classical outcome of the demand for and supply of new institutions. For a variety of reasons, demands for institutional change could arise that would be satisfied by the supply of institutional change. Challen (2000) shows how the approach of Hayami and Ruttan could be re-expressed using the language and central ideas of North (1990) who emphasised the roles of entrepreneurs in political and economic organisations. For example, entrepreneurs in economic organisations (also termed private entrepreneurs by North (1990)) may perceive that changes in the economic environment may offer threats or opportunities to their economic well-being, and so in response they demand institutional change to protect or further their well-being. Entrepreneurs in economic organisations may also perceive political advantages or opportunities in demanding institutional change. The supply of institutional change will come from the same or other political entrepreneurs, often with support from private entrepreneurs, who perceive the net benefits of the change.

The conceptual model of institutional change that is applied to provision of plant breeding services in Australia draws on Scott's observations concerning the roles of custom and common usage, judicial processes and evolution of law, and bureaucratic or political processes. Also included are North's ideas about the roles of entrepreneurs in political and economic organisations and the transaction costs involving their organisations. The process of institutional change can be modelled as a series of transactions between economic and political agents with associated transaction costs. The conceptual framework of institutional change is shown in Figure 1. Institutional change is a function of the initial *status quo* of custom, law and bureaucratic and political processes. It is also a function of the perceptions of key economic and political agents and the transaction costs of generating change.

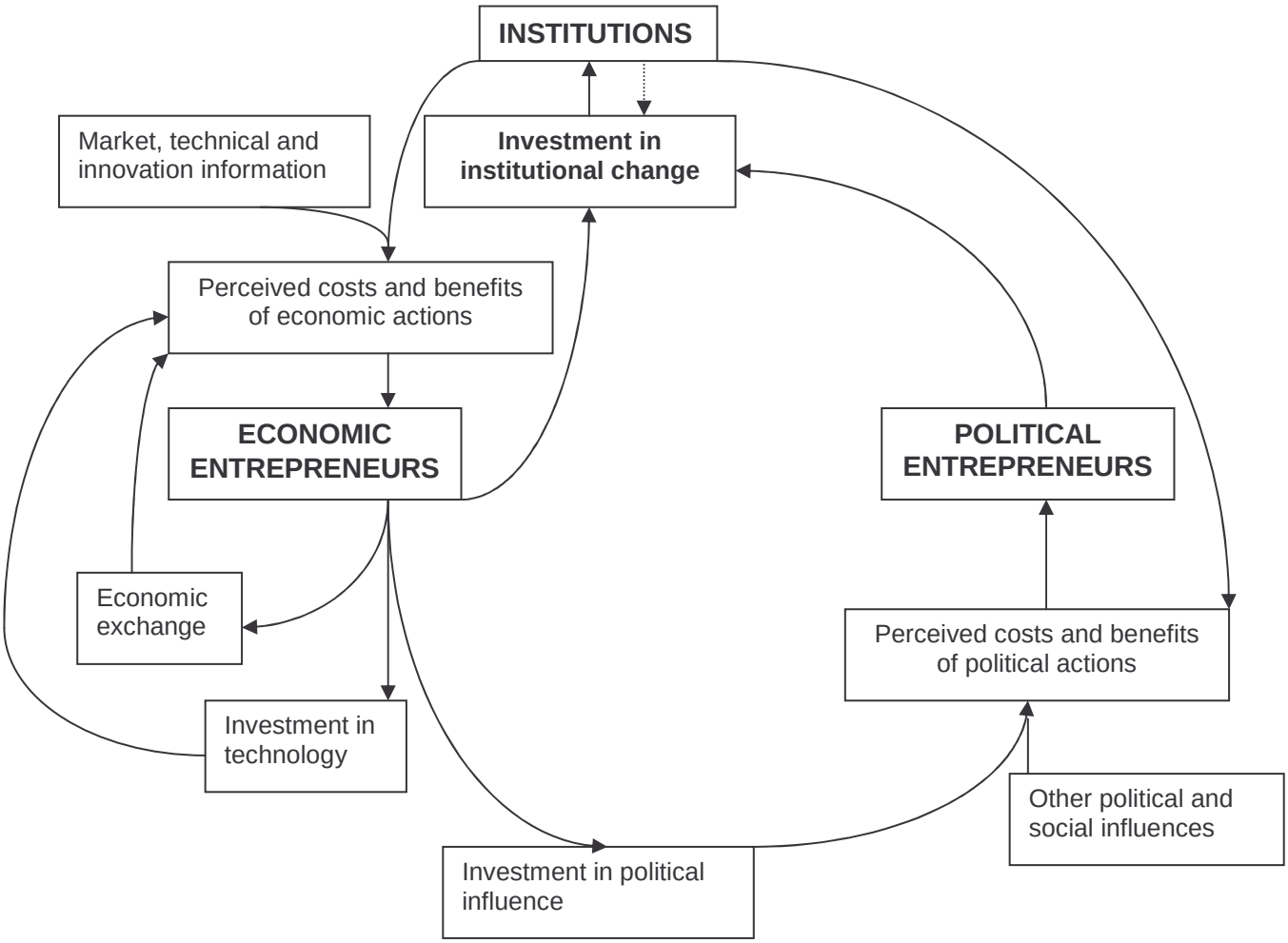

Figure 1: A conceptual framework of institutional change: adapted from Challen (2000)

This conceptual model is applied to provision of plant breeding services in Australia as a descriptive framework. First the *status quo* of the institutional setting of broadacre plant breeding in Australia is outlined. This is taken to be the plant breeding arrangements around 20 years ago. Then in greater detail is an exploration of the institutional change that has unfolded. The emergence of crop improvement royalties as part of the new set of institutions is highlighted. Then follows a discussion that draws on elements of the conceptual model to explain why certain institutional changes, and not others, have arisen.

Section 2: Institutions and Institutional Change in Australian Broadacre Plant Breeding

The Historical Status Quo

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).

[1] Commonwealth Scientific and Industrial Research Organisation

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. 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.

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)

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 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 (eg 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

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

Institutional Change

From the 1980s onwards a series of institutional changes occurred that altered the provision of services for broadacre plant breeding. These institutional changes and their causes are described in the following sub-sections and are components of the conceptual model of institutional change presented previously.

Changing perceptions of key political agents

During the 1980s and for much of the 1990s in Australia, as in many other developed countries, key economic and political agents accepted a revision of the role of government such that its priorities should be 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. 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 (eg 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 slowing 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 (eg 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 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 while increasingly scarce consolidated revenues were transferred to other activities of greater priority to government.

Changing breeding 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. 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 (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, actually 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 is likely to occur with passage of the Plant Breeder's Rights Amendment Bill (2002). This bill alters the 1994 Act in several ways including:
(i) clarifying the circumstances in which the breeder's right was exhausted;
(ii) further protecting commercially sensitive information;
(iii) making explicit the right of the owner of the plant breeder's right to initiate infringement actions and
(iv) 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 2002 Bill, growth in plant breeder's right registrations under the 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.

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. 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 a*l. 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). Nottenburg *et a*l. (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 Table 3.

Over two decades ago in Australia most plant breeding techniques were not subject to patents or licenses, and collaborative, 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 comparing Tables 2 and 3, 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, offers more revenue-raising opportunities to support plant breeding activity. These royalties have been introduced in several Australian States. The following sub-section describes how these payments have arisen, using the situation in Western Australia as a case study.

Table 3: Institutional schema of current property rights for broadacre plant breeding in Australia

Scope of allocation	Key parties involved in decision-making	Conceptual property-right regime	Allocation decision
(i) Seed in Australian germplasm collections allocated to Australian public sector agencies, private firms or overseas' plant breeders	Germplasm curator, plant breeders, plant or seed collector.	State property (Federal government)	Define criteria for release of seed to enquirers
(ii) Licensed or joint venture access by Australian breeders to gene sequences, plant varieties and/or biotechnologies	Plant breeders, biotechnologists, lawyers, intellectual property officers, senior managers, OGTR[a].	Private property	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

Nature and History of Crop Improvement Royalties in Western Australia

According to some analysts (Cook, 1996; ACIL 1997a), the Plant Breeder's Rights Act (1994) strengthened the opportunity to raise revenue from plant breeder's rights. It was believed feasible to impose a royalty on the sale of harvested material grown from seed subject to a plant breeder's right. This royalty payment was variously called an end-point royalty, end product royalty (Cook, 1996) or a crop improvement royalty (DAWA, 1999). The point of royalty collection was the first sale of harvested material derived from varieties protected by plant breeder's right. These royalties were seen as a desirable means to support plant breeding and to encourage additional private investment in crop improvement (Lazenby *et al.*, 1994; ACIL, 1997a, 1997b; Hamblin, 1997). However, Kingwell and Watson (1998) forecast a range of issues and problems that would surround the introduction of these royalties. Banks (1996) raised similar issues and problems for the general case of R&D funding diversification and sharing of equity.

As a champion of end product royalties, the Western Australian Department of Agriculture (DAWA) announced in October 1999 it would replace the existing seed royalty with a crop improvement royalty, from season 2000 onwards, on grain deliveries of its new varieties released in 1998 and 1999 and protected by plant breeder's rights (DAWA, 1999). Royalty levels were set for the different varieties following consultation with the GRDC, seed licensees, the Western Australian Farmers Federation and the Pastoralists and Graziers Association.

Following months of discussion initiated by DAWA, the concept of replacing a seed royalty with a crop improvement royalty on grain deliveries for new varieties gradually became widely accepted among growers and the grains industry. These discussions involved the political and economic agents within a range of grains industry organisations. To simplify the implementation of the introduction of the royalties, all new wheat varieties attracted a flat rate per tonne of grain delivered, rather than being an *ad valorem* royalty. However, the royalty rates for lupin and field pea varieties did differ according to variety. In these cases the royalty rates were set to encourage greater adoption of superior varieties.

Seed companies licensed to distribute the DAWA varieties were responsible for collecting the royalties. DAWA promised that its share of the royalties would be reinvested in its crop breeding programs, and approximately 30 per cent of the royalty would go to the GRDC as a joint owner of the varieties.

In May 2000 DAWA and GRDC jointly announced a reduction in the crop improvement royalty rates and a review of the crop variety commercialisation process. These actions were in response to grower concerns about the cost of royalty payments and unfolding poor seasonal conditions — season 2000 became a severe drought in many parts of the wheatbelt. Both organisations agreed to reduce the royalty rate by 30 cents per tonne on all DAWA/GRDC varieties to lower farmers' costs. A related issue was the seemingly high fees being charged by some licensees to collect the royalties. DAWA and GRDC considered that lowering royalties would add pressure on these licensees to lower their costs. Also a review of the crop variety commercialisation process initiated to improve its cost-effectiveness. Hence, alteration of the royalties reflected changed perceptions by key economic and political agents responsible for the royalty system.

Prior to harvest in November 2000, DAWA and GRDC announced further reforms to the crop improvement royalty system, including a reduction in collection or commercialisation fees that became a flat 25c/t on all DAWA/GRDC varieties. The royalty collection mechanism and on-farm auditing function of the seed licensee grower contracts was replaced by a more simple deed poll contract. These changes reflected behaviour consistent with a main postulate of new institutional economics that institutional change occurs to facilitate transactions and reduce transaction costs (Hubbard, 1997; Hanley *et al*., 1997; Easter, 2000). Further, facilitating transactions was the actions of DAWA and GRDC in offering an amnesty from prosecution under the Plant Breeder’s Rights Act (1994) to any grower that did not purchase seed of a DAWA/GRDC variety through the retail network. The amnesty was invoked if a grower returned a completed deed poll contract to DAWA. The crop improvement royalty and collection or commercialisation fee was automatically deducted from grain payments where a grower signed the deed poll and correctly declared their DAWA/GRDC variety at the point of sale.

Growers were also notified that there would be an increased random testing for variety identification. They were also informed that any attempt to avoid royalty payments by false declaration of varieties constituted a breach of the Plant Breeder’s Rights Act (1994). These reforms were developed in consultation with the Western Australian Farmers Federation, South East Premium Wheatgrowers Association, and the Grain

Pool of Western Australia and were supported by these organisations plus the Liebe Group, Western Australian Seed Growers Association, Pastoralists and Graziers Association, Australian Wheat Board Limited, Cooperative Bulk Handling, Elders-Paramount Seeds, SGB Australia and Australian Wheat Board Seeds. An information package fully explaining the reforms and a deed poll contract was direct mailed to every grain grower in Western Australia and growers were reminded about the reforms in January and February 2001 (DAWA, 2001a,b). In October 2001, with the grain harvest imminent, DAWA again reminded growers and haulage contractors to correctly identify the variety of grain being delivered and to declare varieties bred by DAWA/GRDC that were subject to royalty payments (DAWA, 2001c). Growers were also informed that samples would be taken of delivered grain across the State, with co-operation from Cooperative Bulk Handling and grain marketers, to ensure delivered grain was correctly declared and labelled.

The Plant Breeder's Rights Amendment Bill (2002) will further facilitate the introduction of these royalty payments, as the amendments addressed a range of legal uncertainties. The regulation impact statement for the Plant Breeder's Rights Amendment Bill 2002 states 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."

In 2001/02 DAWA had 15 varieties that were subject to royalty rates that varied between $0.70/t - $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. In 2001/02, grower compliance in correct variety declaration, upon which royalty payments are based, was around 99% and royalty receipts were $499,000. These receipts will gradually rise as the adoption of new varieties subject to royalty payments increases.

Changing perceptions of key economic agents

Enhanced property rights in plants, combined with advances in gene technologies and growth in crop production in Australia (see Figure 2) 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 they and their organisations benefit from plant breeding activity.

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 (OTTs) were established to commercialise R&D. Among universities in the United States in 1980 there were only 25 OTTs, yet by 1990 there were 200 (Mowery *et al*., 2001).

The need to protect existing and emerging intellectual property is seen as both a defensive and offensive tactic. It prevents "free-riding" by commercial firms on the intellectual property

developing within the plant breeding and biotechnology programmes of publicly supported organisations. It provides a bargaining chip in joint venture or biotechnology access discussions with other commercial or public parties. It is also a potential source of revenues that provides flexibility in management decisions for these public sector organisations.

Figure 2: Broadacre grain production in Australia (mill. tonnes)

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.

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

Some multi-national biotechnology companies 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 limits the returns to much of the current proprietary technology of these companies. Accordingly, these companies are not, at present, a major source of new varieties for many broadacre crop species. Their role in strengthening intellectual property rights in plants 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). Fuglie and Walker (2001) outline how and why in the United States, for example, large increases in private investment in plant breeding have occurred while investment in public plant breeding has stagnated or declined.

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 WA 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. 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. The GRDC has emerged as a major stakeholder in plant breeding and at various times has identified R&D strategic initiatives (eg GRDC, 1997) or reforms for plant breeding (eg 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

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

formed commercial linkages with a range of national and international R&D providers of biotechnologies and plant breeding services.

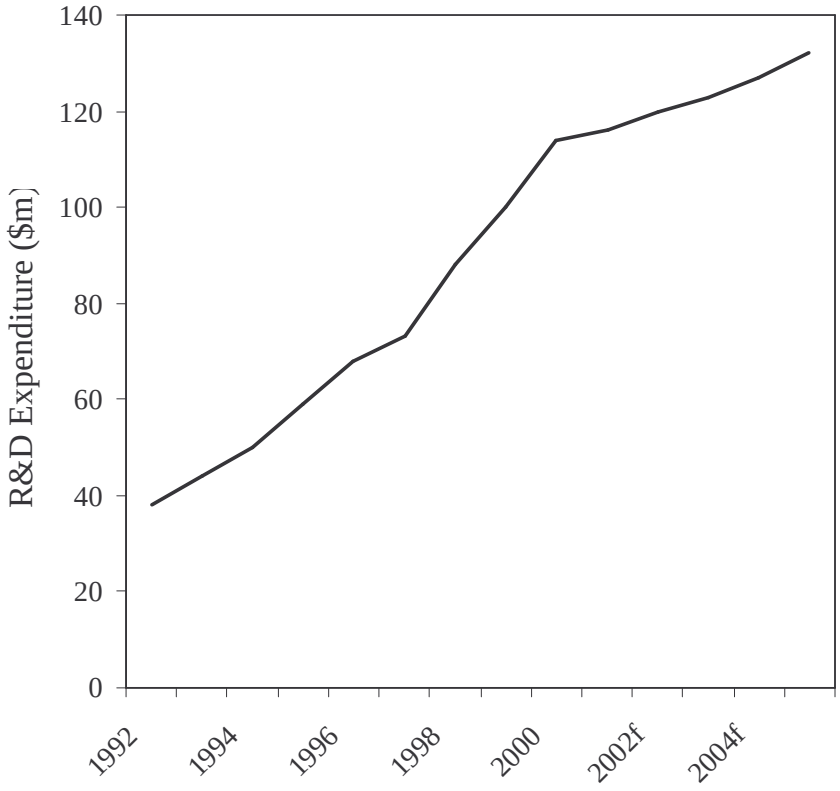

Figure 3: GRDC R&D expenditure since 1992.

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.

Section 3: Alternative Institutional Change

In the terminology of Hayami and Ruttan (1985) and Challen (2000), the supply of institutions arises from the actions of political entrepreneurs who initiate institutional innovations in response to demands from private or economic or other political entrepreneurs. The type and extent of institutional change to arise depends on the relative power and perceptions of gain for the political entrepreneurs, as well as the costs of transactions and

transition. 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 insights from new institutional economics are used in explaining 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 (eg Telstra) can offer large cash injections for some governments with all their associated political advantages. However, a sell-off of plant breeding assets 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 0.75 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.

Section 3: Future Institutional Challenges to 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. Every 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, including access to biotechnologies. Enabling markets to operate across the grain supply chain while at the same time lowering transaction costs and fuelling supply chain efficiency will be a major challenge.

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.

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 should be 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.

Section 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&E organisations,

employing mainly field-based simple techniques, to a more disparate group funded from a greater variety of sources and reliant on advanced biotechnologies. A model of institutional change is used to generate insights and explanations for the observed changes. This model draws on a new institutional economics paradigm that emphasises the roles of key economic and political agents, the impact of changes in biotechnology and changes in intellectual property rights; as well as the importance of transaction costs.

In Australia a range of political and economic agents have interacted and responded to threats and opportunities for publicly 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, this is leading to greater privatisation of the grain supply chain. In response, suppliers of plant varieties are forming horizontal and vertical linkages throughout the supply chain in a series of defensive and offensive strategies. They are also increasing their reliance on funds other than consolidated funds from government treasuries. Royalties on new varieties may become an important source of additional revenue.

What is unfolding is a set of complex commercial arrangements that underpin the funding and supply of plant varieties. The degree of institutional change, especially over the last decade, has been rapid and is uncovering a further set of institutional issues such as access to enabling biotechnologies, contestability in pricing of varieties 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 agriculture.

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