INTELLECTUAL PROPERTY RIGHTS AND AGRICULTURE: AN ANALYSIS OF THE ECONOMIC IMPACT OF PLANT BREEDERS' RIGHTS

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Introduction

Seeds are the most important input into agriculture – an importance that is belied by the cost of a packet of seeds. The importance goes beyond what has been recognised as a form of embodied technical change – technical change resulting from the varietal characteristics embodied within the seed (i.e. the variety). Other forms of technical change in agriculture relate to the organisation of agriculture and the range of inputs used in agriculture. Thus, the replacement of animal and human labour by machines – mechanisation – allows tremendous productivity improvements. However, the effective exploitation of the potential benefits of mechanisation depend on the seed – it is only with the development of uniform maturing varieties with characteristics amenable to machine-handling that mechanisation can become pervasive on the farm. A similar predicament faces the extensive use of a range of chemical inputs into agriculture – varieties that are developed to respond to these chemicals, with characteristics like short stature, improved partitioning, etc., allow the widened use of the chemicals. In this manner **seeds form the delivery mechanism for most inputs into agriculture**. As such, the adoption of any new input into agriculture is fundamentally contingent on varietal developments. By extension, plant breeding is of crucial importance in determining the direction of technical change in agriculture. Hence, the efforts to control breeding companies and the pressure to privatise agricultural research. Naturally, for private investment to enter into agriculture some form of control must be offered as inducement. Intellectual property rights (IPRs) as the preferred inducement is the subject of this extended paper. Here we provide an overview of the analysis that is to follow.

Chapter 1 focusses on the origins of the system of IPRs pertaining to plant varieties – plant breeders' rights (PBRs) which fall within the jursidiction of the International Union for the Protection of New Varieties of Plants (UPOV). The analysis reviews the debates that took place when UPOV was established. Of particular importance in this review are:

- What were the factors that favoured the establishment of PBRs and were there any conflicts or oppositions to their introduction? If so, how were those conflicts resolved.
- Importantly, given the existence of patents, why were plant varieties protected by a separate, *sui generis*, system?

The latter issue has contemporary relevance in that increasing pressure is being mounted to make plant varieties patentable subject matter. While, in the US patenting of plant varieties is possible, under the European Patent Convention plant varieties are excluded from the scope of application of patent law. An exemption that is reflected in the **TRIPs Agreement**, art. 27.3b.

The review establishes that the development of PBRs were closely related to regulatory systems controlling the seed market. In particular, the developments in the UK were largely confined to issues concerning the seed market. Farmers were concerned with the quality of varieties that entered the market and demanded the **introduction of merit tests as a requirement for marketing of a variety**. In addition, given the biological and variable nature of seeds, farmers demanded some legally-binding warranty in the form of **labelling of seeds**, which would ensure that the packaged seeds were actually of the named variety on the label. The latter demand related to possible misinformation that characterised trade in seeds. Breeders in the UK expressed their frustration with existing regulatory systems that did not adequately compensate them for the invention they produced. Enactment of the **Plant Variety and Seeds Act** in 1964 aimed at resolving these conflicts and tensions, whilst also enabled Britain to fulfill its obligation to UPOV (which it signed in 1962).

The analysis establishes the manner in which the demands by farmers were gradually appropriated by breeders and the regulatory authorities to introduce a system that provided breeders with greater control over seed production. Popular rationalisation of PBRs was based on the rhetoric of **biological necessity** – the breeder is best placed to maintain the genetic constitution of the variety. Further, reflecting a ***laissez faire*** approach, the demands for merit tests prior to market entry was entirely rejected. Instead, the system adopted was of voluntary controls, with farmers' choice through the market determining merit.

Historical analysis of the establishment of UPOV in 1961 sheds useful insights for contemporary debates concerning the patenting of plant varieties. The analysis here indicates that the primary opposition to the inclusion of plant varieties within the jurisdiction of patent law was from industrial property lawyers. Despite existing national patent law practice which provided patents on a range of species, mainly ornamentals and vegetables, the inclusion of the entire plant kingdom would have led to some dilution of standards and requirements of patenting.

Chapter 2 provides useful background **statistical information on the changing fortunes of agriculture in the UK**. Agriculture in the UK, as in most other developed countries, has been radically transformed in the 20th century. The practice of farming has become highly technical and mechanised. Of particular interest and importance are the broad macro changes in the status of agriculture as a dimisshing contributor to GDP and the labour force. In addition, the chapter reviews characteristic features of industrialised agriculture:

- Even while a range of indicators establish the tremendous productivity improvements in agriculture, there is compelling evidence of increasing immerisation of the farm

- Accompanying the general trend of land consolidation is evidence of increasing number of small holdings, which continue to persist but also remain marginal economic entities.

The chapter reflects on the above trends and presents statistical data to support the conclusions.

Chapter 3 provides additional background material on agriculture in the UK. Here attention is devoted to the historical struggle over controlling agricultural research in the UK. The pulls and pushes of differing political agendas, the changing fortunes of private industry and the varying demands of clients in agriculture have led to a number of changes in the agricultural research system in the UK. The discussion points out important stages in the changing complexion of the agricultural research system. In more recent years, the overarching philosophy grounding the governments attitude to R&D in general has been one of **radical liberalisation.** Under this approach the government, under Thatcher developed a plan to withdraw from any research that had a **near-market** position. Consequently, varietal development and much of plant breeding was deemed to be handed over to the private sector.

Chapter 4 presents an economic analysis of PBRs based on available evidence from the US and UK. As yet there is very little systematic work on the economic analysis of PBRs. Most of the available literature on PBRs is directed at the politics of the issue and avoids undertaking a comprehensive analysis of economic issues. The analysis presented here concentrates on three primary issues:

- **Investment in plant breeding:** One of the primary rationalisations concerning any IPRs is its ability to stimulate private investment. The analysis reviews the evidence in this regard and examines if investment has increased across the board, and if so, is the increase a result of the availability of PBRs.

- **Production of new varieties:** A key rationale supporting IPRs is the positive impact it has on inventive activity. In the case of plant breeding, the main inventive activity is the production of new varieties. An economic analysis of time series data on new grants issued is presented to examine this claim.

- **Market Power:** PBRs, much like any other IPRs, will aggravate market structures as they are a type of barrier-to-entry. One reflection of changing market power is the trend in seed prices. Statistical evidence in this regard is examined to enable a conclusion on whether excessive monopoly power has resulted in recent times.

Apart from the above primary focus, chapter 4 also presents analysis of equally important issues concerning PBRs, such as the exchange of genetic material and the issues confronting plant breeding in the future.

1. The Making of Plant Breeders' Rights

1.1 INTRODUCTION

It is important to keep in mind that PBRs are a very recent development – the first formal system emerging in the 1920s in Europe and the first legal right being the Plant Patent Act (1930) in the US. Given the contemporary nature of their development, it is pertinent to examine the historical and economic factors that led to the introduction of such rights. The question is of importance given the significance of plant breeding (and agricultural research) and the fact that plant varieties are living organisms. The questions that the discussion to follow addresses are:

- How did the international system of PBRs at UPOV come about?
- What were the factors that favoured the establishment of PBRs and were there any conflicts or oppositions to their introduction? If so, how were those conflicts resolved.
- Importantly, given the existence of patents, why were plant varieties protected by a separate, *sui generis*, system?
- All these questions bear on the developments in the UK which introduced PBRs through the **Plant Variety and Seeds Act (1964)** – hence the discussion of the UK case is also presented below.

1.2 EARLY EFFORTS IN CONTROLLING PLANT GENETIC RESOURCES

Colonialism is closely associated with efforts at controlling the movement and supply of critical plant genetic resources. At times, entire species have been moved across continents in what Mooney (1983) has characterised a `botanical chess game'. The development and spread of botanical gardens in the 17th and 18th century is implicated in this colonial exercise of securing strategic control over plant genetic resource (Brockway, 1979). It is recorded that the gardens themselves sponsored "plant hunters" on colonial expeditions (Allard, 1960: 21). Even while legal-sounding edicts have been made in the past, e.g. the edict issued by the Papal States in 1883 (Lange, 1985*), 20th century multilateral agreements have advanced the degree of control to a much higher level by enabling rights in particular genetic combinations that constitute a plant variety and/or specific genes themselves*.

In the early decades of the 20th century, across Europe significant steps were taken to establish rights for the plant breeder – 1921 law in Czechoslovakia and 1922 in France. Similar laws in Austria in 1938, the Netherlands in 1941, and Federal Republic of Germany in 1953 (Laclavičre, 1965; UPOV, 1984) followed these developments. Case law in Italy in

1948 and 1950 established new plant varieties as "industrial results" enabling their protection under patents (Wuesthoff and Wuesthoff, 1952). In contrast, in the US, efforts at securing control over plant genetic resources took a decidedly legal step. A bill for the protection of horticultural plants, vines and trees was presented to Congress in 1906 (Bugos and Kevles, 1992), which after a number of submissions and modifications eventually became the **Plant Patent Act, 1930** - making it the first patent act for plants (Fowler, 1994). The scope of protection varied from denominational protection and forms of seed certification (France and Czechoslovakia) to a limited form of exclusive control over the commercial exploitation of the variety (the Netherlands and Germany). In some cases the application of law was restricted to only vegetatively propagated species (US). Important features of the system were:

- **French Decree of 1922:** Three core elements define the system, a catalogue of cultivated species, legislation controlling the trade in seeds and trademark protection. In practise, the self-discipline of the traders ensured that only seeds of registered varieties (those on the catalogue) could be commercialised (under existing trade regulation) and were bought and sold using the variety name owned by the breeder (following trademark protection) (Berlan and Lewontin, 1986).
- **Plant Breeders' Decree of 1941 (the Netherlands):** The seed market was regulated through a certification process that only allowed named varieties to be transacted. Breeders had rights that allowed them to earn a royalty on first-generation seeds (Pistorius and van Wijk, 2000).

Two specific problems confronted the development of seed trade across Europe. Firstly, the nominal, though important difference between national practice across Europe proved to be a hurdle to the growing pan-European seed trade. Secondly, breeders themselves were dissatisfied with the inadequacies of trademark based protection – *here only the varietal name was protected, thus allowing identical varieties under different names to be marketed*. Efforts were aimed at enhancing the scope of breeders' rights, which, as will be clarified below, were closely related to establishing a pan-European regulation on seed moving in international trade.

1.3 Early Interest in Breeders' Rights in Britain

To an extent, Britain remained conspicuous in the above developments. The debate concerning PBRs in Britain is said to originate in a memorandum circulated by a Scottish breeder, JBF McGill, in March 1946. The proposal was for a system of official testing of varieties followed by an acreage levy that would accumulate to breeders. This memorandum was followed by a **Copyright Sub-committee** directed to examine `*the necessity and/or desirability of organising a scheme of copyright for new cereal varieties*'. While the committee concluded in the negative, concern within the private and public sector was increasingly

expressed in terms of trade-related problems. At that stage, under the **Seeds Act (1920)**, it was mandatory to declare the *variety name* in all transactions concerning seeds. However, there were some problems:

- **Quality and merit requirements:** There was no obligation on breeders and/or seed merchants to meet any minimum quality/merit requirement for commercially transacted seeds.
- **Seed labelling:** There was no binding obligation concerning labelling of seed packets, neither was it necessary to report the merits of the variety, nor were the declarations on a seed label legally contestable.
- **Plant breeders' rights:** As yet, breeders had no means of controlling the use and exploitation of varieties they bred.

Farmer groups were critically concerned with two of the above shortcomings of the seed market regulations. Not only was there a demand for good quality varieties to be bred domestically, but equally the concern was directed at ensuring supplies of authentic seeds. A **1950 Committee on Qualitative Control of Seeds** concluded that

- **Official register of variety names** should be developed to establish an unambiguous relationship between variety name and varietal characteristics, a process that would eliminate synonyms.
- The **use of variety name** should be restricted to **certified seeds** of the named variety so as to ensure that seed traded under a particular variety name would be authentic and corroborate to the varieties known characteristics. A development that would support the efforts in creating an official register of varieties.

The recommendations reflected a *consumer protection* rhetoric – one of the aims of the regulations was to ensure reliable transactions in the seed market so as to protect the farmer from wrongful labelling and/or substandard seeds. **Yet, the Committee did not make merit tests a statutory requirement for market entry nor seed certification mandatory** – seeds of any level of quality/merit could enter the official register and their seeds be transacted on the market. Adopting a *laissez faire* approach, the government considered it preferable to establish a voluntary system based on farmer-choice aided by the official register:

> *… use of improved varieties could be promoted more readily by short recommended lists of the best in performance trials than by legislation restricting the sale of seeds to varieties which were equal to those in current use (Wellington, 1974: 100).*

A subsequent examination of the two issues of merit tests and seed labelling by the **Committee on Transactions in Seeds (1957)** (CTS) maintained the legal impunity of declarations on the seed label:

> *… it would not be reasonable at this stage to require seed merchants to accept legal liability for civil claims in every case where a statement as to the variety made in good faith subsequently proves to have been at fault. Nevertheless, a buyer of seed who suffers loss through the sale and delivery of wrongly named seed should receive* ex gratia *compensation from the seller (paragraphs 303-04).*

Clearly, the approach adopted in Britain was to separate the requirements of merit from market entry of a variety. It was felt that breeders themselves would submit varieties for official merit tests on a voluntary basis. The **National Institute of Agricultural Botany** (in Cambridge) (NIAB) had been conducting variety merit tests for quite a while and reported the results in **Recommended Lists** and **Farmer's Leaflets**, which farmers used in deciding on the appropriate variety to purchase for planting. The Recommended List for cereals were introduced in 1944, following earlier work on potato. The work on merit of a variety was closely tied into the core effort of NIAB – eliminating synonyms in the trade. **Even while NIAB pioneered a system of `aiding' farmer-choice in the seed market, the regulatory system did not make merit-tests a statutory requirement for a variety to be commercialised**.

As far as the issue of seed labelling is concerned, the government and regulatory bodies adopted a similar *laissez faire* approach, with faith being expressed in the wider voluntary adoption of seed certification regulations by merchants. Once again, NIAB handled work on developing a system of seed certification that was dedicated to ensuring the maintenance of distinguishing varietal characteristics throughout the seed production process. Through the early 1940s a voluntary seed certification scheme was initiated and by 1954 a **National Certifying Authority for Herbage Seeds** was established and the following year the category of `certified seeds' became a trade entity. The mark of certified seeds was an important trade advantage:

> *.. an indication not only of varieties of merit, but also of seed which has been most carefully produced to preserve the valuable characteristics of those varieties (Kelly, 1968: 49).*

The discussion above demonstrates that much of the interest in breeders' rights in Britain was mediated through the struggle between farmers on one side and breeders and seed merchants on the other side. Demands by farmers for reliable seed labelling and merit tests as a prerequisite for market entry of a variety were repeatedly rejected. Instead, the regulatory authorities adopted a *laissez faire* attitude of developing a vast regulatory system focussed on (a) an index of varieties and (b) seed production processes. It was felt that the market would automatically weed-out inferior varieties and that farmer-choice, aided by the NIAB's Recommended Lists, would ensure the adoption of the best variety.

Importantly, demand to make breeders and seed merchants legally responsible for declarations on seed labels by the farmers was gradually being transformed into a reverse demand by breeders for greater control over seed production (see section 1.6).

1.4 The Development of Seed Regulation on the Continent

The one remarkable, though less reported, fact about the story of UPOV – the creation of a *sui generis* system for plant varieties – is the existence of its core elements in the seed regulatory system that was being rationalised and harmonised across by the **Organisation for European Economic Cooperation** (OECD's predecessor) in the 1950s. Despite national differences, two features stand out within the national seed certification schemes in Europe:

- **Index of Varieties:** developing a system of distinguishing varieties so as to eliminate synonyms and create a register/index of varieties.
- **Seed Certification:** Developing regulations to oversee the maintenance of varietal purity through all stages of seed production and issuing certificates of `trueness to type' – the packaged seeds are of the named variety.

The problems confronting the emergent cross-border trade in seeds in Europe related to key regulatory issues – national regulatory authorities used different terms to designate seeds of particularly standards. Further, increasing cross-border trade raised the potential problem of the introduction of the same variety under several different names – undermining national efforts at creating an Index of Varieties. Finally, breeders themselves were increasingly feeling frustrated in their efforts at not benefiting from the growing seed trade – **available trademark type protection did not protect the specific breeding effort – the new variety produced – instead it focussed on the variety name**. Anybody could replicate/copy the `protected' variety and trade it under a different name without infringing existing regulations.

The early 1950s saw efforts devoted at **harmonisation of terminology and standards of certified seeds moving in international trade**, initially concentrating on herbage seeds. The results of the work was development of "common basis for the procedure by which certified seed of comparable standards is produced" (Horne and Kelly, 1967: 260) – leading to an agreement establishing the **OEEC Herbage Seed Scheme (1958)**. Among the issues the scheme established were the conditions for market-entry of varieties, demarcation of the role and responsibility of breeders with respect to the authenticity of seeds, and necessary safeguards concerning seed production. Among these provisions, two are critical:

- Seeds of varieties entering from other countries must have the **breeder's consent** so as to ensure that "authentic seeds would be made available for multiplication".

- In the interest of maintaining the **authenticity of a variety**, the "breeder [is] responsible for ensuring that successive lots of seed were available to provide the continuity of the scheme".

These two provisions established **de facto breeders' rights** – making the supply of seeds contingent on the breeders' consent. Yet, the provision was rationalised through the **rhetoric of biological necessity** – the breeder is best placed to maintain the genetic constitution of the variety (Heitz, 1987: 77). The connection between breeders' consent and a rhetorical concern for authentic seeds attempted to resolve the consistent demand by farmers for quality seeds and legally binding seed labelling.

Importantly, the close connection between breeders' rights and the seed multiplication developed with seed certification schemes was not in variance with the demands for PBRs by breeders. This is amply demonstrated by the following quote from the President of the Seed-Flower Section of ASSINSEL, the lobby group of breeders canvassing for breeders' rights:

> *Only the production of stock seed is reserved to the originator. And this exclusive right is necessary to maintain the type and quality of the creation (Schreiber, 1962: 242).*

In accepting the close relationship between exercising exclusively control over seed production (i.e. stock seed, or first generation seed) and ensuring quality and authenticity of traded seeds that breeders were able to garner the support of regulatory authorities. The UPOV system, established later in 1961, followed the example of the seed certification schemes in two important directions.

Firstly, it made the scope of PBRs include the breeders' right to earn a royalty through seed multiplication – the production of stock seeds. Secondly, it required the breeder to be responsible for maintaining the variety `true to type' through out the period of grant, failing which the grant would be revoked. As such, UPOV played the role of harmonising and rationalising seed certification schemes across Europe with the additional benefit of providing a legally binding PBRs system.

1.5 UPOV – THE CREATION OF A SUI GENERIS SYSTEM FOR PROTECTING PLANT VARIETIES

A crucial historical question relates to the forces that led to the establishment of UPOV in 1961 – **what led to the protection of plant varieties by a *sui generis* system, separate**

from, and independent of, the pre-existing patent system? This question reflects upon a number of precedents and favourable factors in the run-up that led to a *sui generis* system for plant varieties – a system that specifically secured the protection of plant varieties under a more liberal and less monopolistic system of legal rights. In contrast to the final outcome, a number of factors actually favoured the inclusion of plant varieties within national patent systems:

- **The wide notion of industrial property within the Paris Convention** included agriculture products (see art. 1[3] of the 1934 London Conference), hence opening the possibility of plant varieties being considered `industrial products' and accordingly patentable subject matter. As noted below, some countries sought this route within national patent law.

- **The inclusion of plant varieties, of select species, within national patent law** was increasingly become common practice in a number of countries. In the US, the 1930 Plant Patent Act covered patents for vegetatively propagated species. Ornamentals were considered patentable subject matter in a number of European countries – Spain in 1929, Germany in the 1930s, France in 1949, Italy in 1951 and Belgium in 1958 (Mooney, 1983; Pistorius and Wijk, 2000).

- **Developments within the seed certification schemes**, in the 1950s, that were harmonising national regulatory schemes across the OEEC did not rule out patents for plant varieties as a possible route of enhancing existing systems for protecting breeders' rights (Rangnekar, forthcoming).

- **The international lobby group canvassing for breeders' rights, ASSINSEL,** had favourably considered patent protection as their main option in the 1940s-50s. ASSINSEL's approach was supported by a 1952 report to the international conference of industrial property lawyers, AIPPI, that concluded that "for a large part of their creations, the plant breeders' require a special protection, but they also require patent protection for their most important inventions" (Wuesthoff and Wuesthoff, 1952).

Interestingly, **the main opposition to the patenting of plant varieties emerged not from the Ministries of Agriculture in Europe, but from industry** (Pistorius and Wijk, 2000; Rangnekar, forthcoming). This view results from a close study of the debate and struggle between ASSINSEL and AIPPI. The latter were averse to the possible weakening of the patent system so as to accommodate plant varieties. Innovations in plant breeding, i.e. the production of most new varieties, would fail to meet two crucial requirements for the grant of patents – demonstration of an inventive step and the disclosure of the invention so as to enable reproduction of the invention. Hence, **in 1954, the AIPPI delegates voted overwhelmingly in favour of maintaining plants as non-patentable subject matter**. This opposition from the apex body of patent lawyers was critical, more so since a conference for the revision of the Paris Convention was slated for 1958. Not surprisingly, the 1958 Paris Convention meeting did not even consider the issue of patenting plant varieties. With these rebuffs, in 1956 ASSINSEL decided to convene an international conference to examine the

matter of protecting new plant varieties, which gets hosted by the French government in 1957. It is from this meeting that the UPOV gets established in 1961.

Behind the ASSINSEL-AIPPI struggle were developments concerning the **harmonisation of national patent laws in Europe**, which were initiated with the foundation of the Council of Europe in 1949. The Committee of Experts proposed a definition of industrial property – the subject matter that would be considered patentable – that placed plant varieties outside the ambit of patent law. This definition finally gets accepted as art. 2 of the **Strasbourg Convention** – Convention on the Unification of Certain Points of Substantive Law on Patents for Inventions (1963):

> *the Contracting States shall not be bound to provide for the grant of patents in respect of*
>
> *[…]*
>
> *plant or animal varieties or essentially biological processes for the production of plants or animals; this provision does not apply to micro-biological processes and the products thereof.*

The AIPPI itself submitted similar proposals to demarcate the patentable from the non-patentable in terms of distinguishing between microbiological and biological respectively (Bent et al., 1987: 66). The **European Patent Convention** itself affirms this distinction and separation in art. 53, hoping to establish separate spheres of law. Reflecting this prevailing legal opinion, UPOV in art. 2(1) identifies the jurisdiction of PBRs:

> *Each Member State of the Union may recognise the right of the breeder provided for in this Convention by either a grant of a special title of protection* [i.e. plant breeders' rights] *or of a **patent**. Nevertheless, a Member State of the Union whose national law admits of protection under both these forms may provide only **one** of them for one and the same botanical genus or species* (emphasis added).

The **important conclusion** from the above discussion is that the lobby of patent lawyers, AIPPI, were the main hurdle to the initial aspirations of ASSINSEL in securing patent protection for plant varieties. Substantive elements of the opposition reflected some of the **problems in making plants patentable subject matter**. Here I draw attention to three requirements for securing a patent: (a) the inventive step, (b) demonstration of industrial applicability and (c) provision of enabling disclosure.

The test for **novelty and inventive step** requires the invention to be considered novel when compared to the state of the art at the time of application, i.e. the inventive step is not obvious to a person skilled in the art. It is often argued that breeders develop new varieties "in just as true a sense as the chemist is said to create his new product" (CTS, 1960: 25, the

Committee that recommended PBRs in the UK). However, for the most, the production of new plant varieties is really **incremental inventions**. Further, the very method of breeding is itself suspect – not only is the underlying breeding process of common knowledge, but often the actual steps reveal possible acts of discovery. To avoid these taxing requirements for patents, UPOV has the following peculiar features:

- **There is no merit test** as part of the system of granting PBRs. To secure protection a new plant variety does not have to establish any improvement in the existing state of the art.
- **The novelty requirement for PBRs is highly simplified**, requiring the breeder to demonstrate that its is *commercially novel*, i.e. it has not been offered for sale within the last four years (art. 6[1][b], UPOV 1961).
- **There is no requirement for the demonstration of an inventive step**. It is only necessary for the variety to be **clearly distinguishable** from all other varieties whose existence is a matter of common knowledge at the time when protection is applied for (art. 6[1][a], UPOV 1961). As such, the variety could very well be an act of discovery.

One of the corner stone of patent law is the requirement of **utility –** to promote **inventions with industrial applicability**. In this regard, the invention is required to demonstrate industrial applicability, in that it translates into either a product or process, a principle that acts as a barrier against the possible patenting of discoveries in the sciences. Not all `inventions' in plant breeding have industrial applications, many new varieties are cosmetic developments upon existing varieties. **This requirement within patent law is not paralleled by any alternative requirement within the PBRs system.**

Within patent law, the **disclosures describing the invention must be enabling**, i.e. they should adequately describe the invention in a manner that enables others skilled in the art to replicate the invention. In this manner, patents are claimed to promote the disclosure and dissemination of new knowledge. Many species breed true-to-type, i.e. replicate themselves upon propagation, thus ensuring that the `invention' is automatically reproducible. However, neither is an adequate and enabling disclosure of the breeding process easy to provide, nor is a replication of the breeding steps a guarantee to the production of an identical variety. To avoid these problems, the UPOV system, borrowing from seed certification schemes, conducts field trials of the varieties to establish their distinguishing characteristics. **The submission of the plant variety and the conduct of field trials to establish the distinctive characteristics of the variety serves the purpose of `disclosing' the new variety**.

1.6 Introducing PBRs in the UK – The Plant Variety and Seeds Act (1964)

Britain participated in the deliberations that led to the foundation of UPOV in 1961. It signed UPOV in November 1962 and implemented its obligations with the passing of the Plant Variety and Seeds Act (1964).

There was little public debate on PBRs in Britain apart from efforts at developing a **copyright scheme** for protecting breeders. Much of the work in Britain took place within the public sector and concerned the seed certification schemes (discussed above). The first focussed official consideration of PBRs took place within the **Committee on Transactions in Seeds (1960)**. The enquiry took place at a time when there were crucial tensions between farmers on the one hand and breeders and merchants on the other. Farmers had been demanding merit tests for varieties that were marketed and declarations on seed packets that were legally enforced. The Committee proposed a compromise – introduction of legally enforceable seed labelling in exchange for greater control over seed production for the breeders.

> *The Committee on Transactions in Seeds did not consider that sellers could be reasonably expected to give a warranty on the variety unless they were in a position to exercise adequate control at all stages of the production of authentic seeds (Wellington, 1964: 61).*

Clearly, the **demands for `consumer protection' on the part of farmers were appropriated and transformed by breeders and merchants to take the shape of demands for PBRs**.

At the time the Committee was examining the case for introducing PBRs in the UK, it is fair to say that a ***de facto*** system of PBRs were already introduced through the national seed certification schemes agreed within OEEC. More importantly, the deliberations within UK took place in the shadow of the efforts on the Continent that led to the foundation of UPOV. Being a member of UPOV, it became obligatory for the UK to implement its obligations and introduce PBRs. **Thus, the question of the rhetoric used to create wider consensus to support the introduction of PBRs.**

Key to understanding the manner in which PBRs were introduced in UK is the relationship between the Committee on Transactions in Seeds and UPOV. Firstly, central members of the Committee participated in the debate at UPOV and the OEEC – many of these members were from the National Institute of Agricultural Botany. Most importantly, a MAFF official, Mr Smith, was both secretary to CTS whilst also being the key British representative to UPOV. Later, Smith becomes the first Controller of the Plant Variety Rights Office in 1965, and also

held the Chair at UPOV. **It is therefore not surprising that the recommendations made by CTS were entirely in agreement with the system proposed by UPOV.**

There was pressure to be part of the process of **increasing harmonisation of trade and patent laws across Europe** and hence the obligation to implement multilateral agreements. In the case of the UPOV, this tension between **international reciprocity and national interest** was apparent in the debate concerning whether **merit test** should be a prerequisite to market entry of a variety. **Farmers** had repeatedly made this request. Interestingly, the CTS (1960) **recommended that PBRs be granted to varieties that demonstrate distinctness, uniformity and stability and demonstrate reasonable merit** – a clear statement in favour of the demands being made by farmers. The Parliamentary debate shows wide support for this measure (reviewed in Rangnekar, forthcoming). Yet the final draft of the Bill excluded the merit requirement, which was explained as being in conflict with international obligations under the UPOV. Alternatives to the merit test were the mandatory field trials conducted by NIAB, with the results published for the benefit of farmers. **The overarching philosophy was that of a *laissez faire* approach of market choice determining merit**:

> *… [G]rowers should remain free to determine the commercial success or failure of varieties provided that they are given adequate information about them and were not confused by different names … (Wellington, 1974: 100).*

The "desire to act in concert with other countries" was the rationalisation presented in Parliament by Lord Oswald. Yet, the government tried to suggest that the legislation would `improve the quality of the crops in the country'. Obviously, Britain was desperately in need of maintaining its trade in seeds with the Continent – between 50-70% of the cereal seed market was based on varieties developed on the Continent. Without PBRs, continued access to them could have been stopped. Given the high dependence on foreign-bred varieties, the government sought to claim that PBRs would **stimulate the domestic private breeders** who till then occupied a marginal position in the market. With extensive pressure on Britain to `act in concert', the debate in Parliament glossed over the grant of PBRs as something "least contentious" (Lord Balerno, 1963 in House of Lords).

1.7 Conclusion

A review of the history of the foundation of UPOV and a review of the debates concerning PBRs in the UK sheds critical insights. Firstly, the review establishes that PBRs originated within the efforts directed at rationalising and harmonising national seed certification schemes in the 1950s. The demands by breeders for enhanced protection found useful

support with the regulatory authorities' concern for authentic and reliable seeds. While the seed certification schemes provided *de facto* breeders' rights, UPOV enabled their legal protection.

Importantly, the review draws attention to the factors that enabled the foundation of UPOV as a system dedicated to protecting new plant varieties – a *sui generis* system independent of, and separate from, patents. The discussion notes the opposition from the lobby groups representing patent lawyers. In addition, the activity of plant breeding and the nature of plant varieties also posed insurmountable problems for their inclusion within the application of patent law.

In the UK, the debate on PBRs closely followed Continental developments. Thus, once again we see the close relationship between seed certification schemes and the provision of PBRs. An examination of the conflicts between the demands being made by farmers and those by breeders is illustrative of the manner in which the *consumer rhetoric* of seed labelling gets transformed into a means for providing PBR.

2. Agriculture in the UK – Some Statistical Evidence

2.1 INTRODUCTION

The practice of agriculture in an industrialised country has undergone dramatic structural and economic changes in the last century. Many analysts have proposed the notion of *industrialised agriculture* as a superior notion to capture the realities of agriculture in an industrialised country. The discussion here aims to bring together statistical evidence of the state of agriculture in the UK, with the aim of shedding some insights on the following issues:

- The relationship between changes in agricultural productivity and the situation of farm income.
- The association between developments of an agri-industrial complex and changes in the economic vitality of the farm.
- Changing status of the farmer and the costs of sustaining agriculture in the UK.

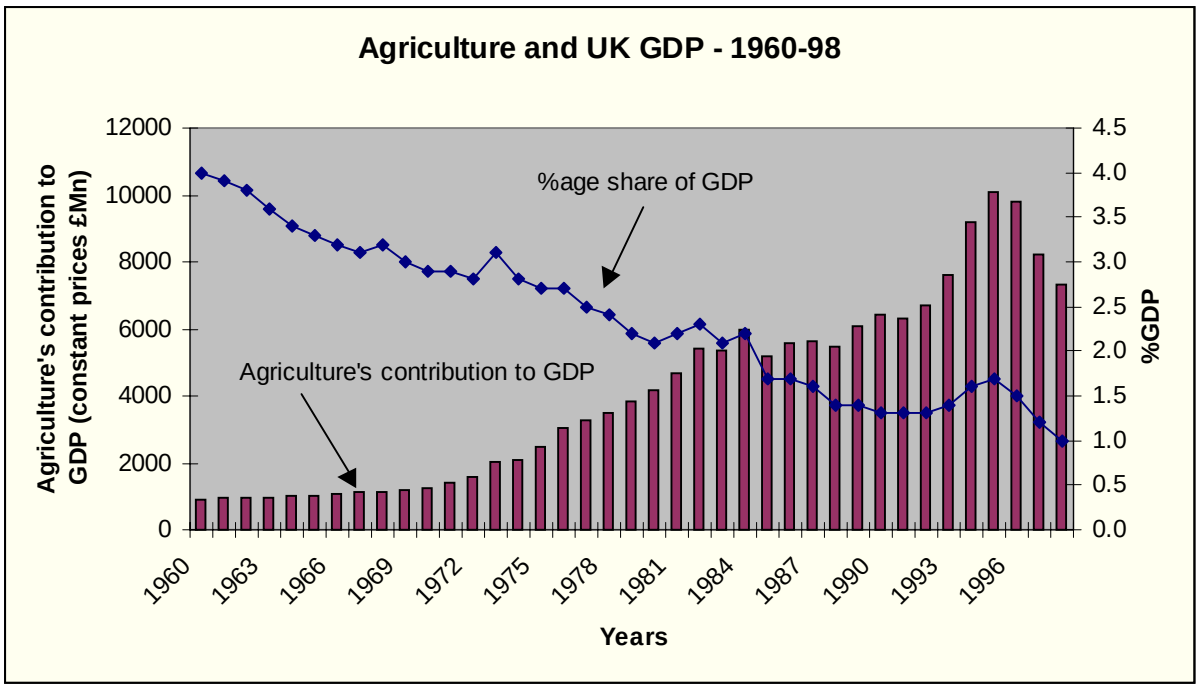
This background is considered useful for an appropriate understanding of the issues concerning PBRs in the UK.

2.2 MACRO INDICATORS

It is difficult to easily and unambiguously capture the significance of agriculture to the British economy. The difficulty in part reflects the definition for agriculture – are we exclusively referring to the farm-based activities or do we also include ancillary industries that support the farm (e.g. animal medicine, farm inputs and machinery, etc.). With respect to the latter broad-based definition, a case could easily be made for also including the food retailing industry which has grown substantially in the last couple of decades. However, following normal statistical approaches, agriculture is looked at from the narrow perspective of `farming'.

The contribution of agriculture to the GDP (Gross Domestic Product) has constantly declined. From a high of 4.0% in 1960 it fell to 3.1% in 1971 and has averaged a little over 1% in the 1990s. Thus, even with an increasing level of production over the years, especially in more recent years, the contribution of agriculture to the national economy is very low (**see figure 1 – Agriculture and UK GDP**)

Figure 1



Reflecting this diminishing significance of agriculture to the national economy is the proportion of **the workforce actively engaged in agriculture** (**see figure 2 – Workforce in Agriculture**). Looking at the historical trend, it is clear that the share of the workforce in agriculture has fallen substantially. In the first two decades of the 20th century, agriculture accounted for about 9% of the workforce. By the 1970 the share had fallen to 3% and in the 1990s it averaged 2.4%. The only remarkable aspect of the transformation is the minor

increase in employment in agriculture in the last couple of years (1995-97). This latter trend, unexplained in the literature, is part of the slow-down in the continuing fall in the number of people employed in agriculture.

Disaggregating the composition of the labour force engaged in agriculture sheds another light on the transformation of agriculture in the UK. A striking feature of the composition of the labour force engaged in agriculture is its predominant family base. A feature that reconfirms the trend towards family-operated farms (see **table 1 - Decomposition of Labour Force in Agriculture**). In 1975, 55% of the labour force originated in the family. This share has risen to 64% in 1990, at the expense of hired-regular workers whose share in the same period decreased from 33% to 21%. During the same period there has been a mild increase in the component of seasonal and casual labour, the share increasing from 11% to 14%.

Figure 2

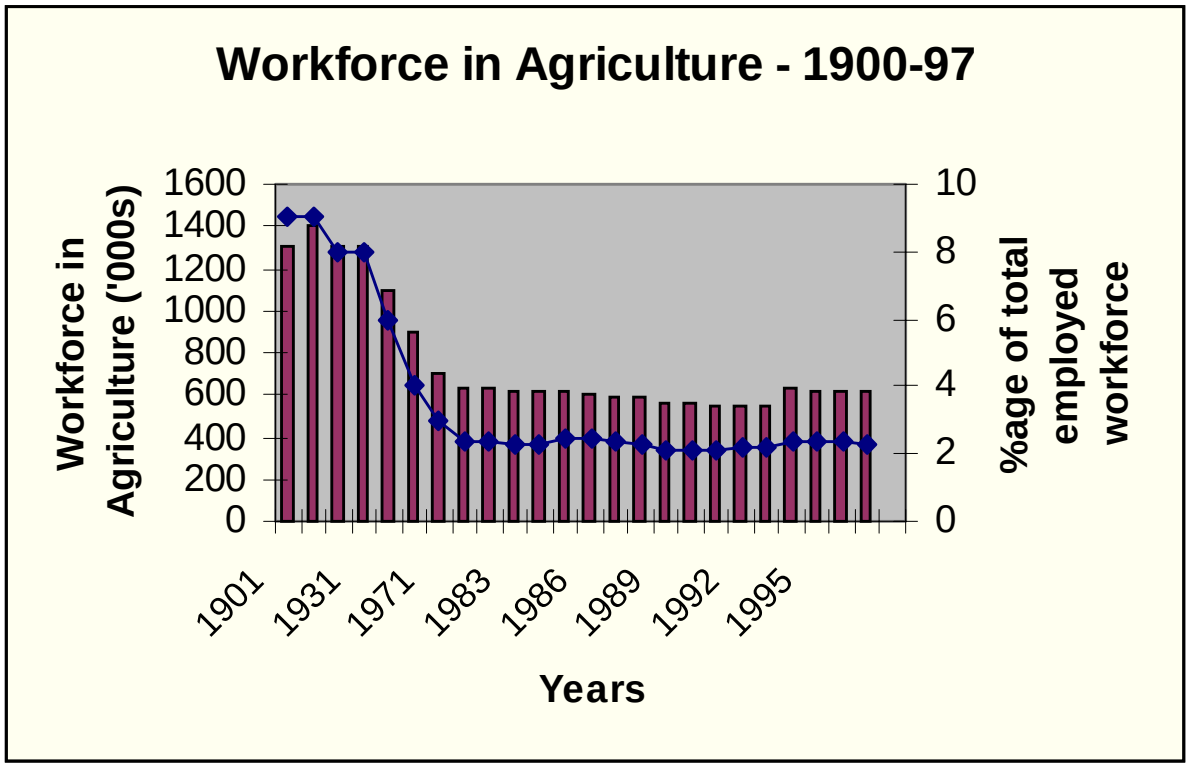


Table 1
Decomposition of the Labour Force in Agriculture

(All figures '000s)	1975	1980	1985	1990
Regular whole time	222	180	157	126
hired male	157	133	111	85
hired female	15	12	10	12
family male	37	30	31	25
family female	13	5	5	4
Regular part time	81	64	62	59
hired male	22	19	19	18
hired female	26	25	23	21
family male	15	13	13	14
family female	18	7	7	6
Seasonal or casual	73	100	98	91
male	41	57	59	57
female	32	43	39	34
Salaried Managers	7	8	8	8
Total Workers	383	352	325	284
Farmers, partners and directors	280	298	292	283
whole time	212	208	199	183
part time	68	90	93	100
Total	663	650	617	567
Spouses of farmers, partners and directors		75	77	77
Total Labour Force	663	725	694	644

One of the most remarkable aspects of the agricultural transformation in the UK – particularly in cereals – is the **phenomenal yield increases achieved and the widespread adoption of dwarf varieties**. Dwarfs emerged at a time when the introduction of fertilisers and other chemical growth inputs into agriculture made vegetative vigour (tall stalks) a negative yield advantage. The development of a range of chemical applications into agriculture enhanced the yield potential which was essentially frustrated by the vintage of existing varieties that could not efficiently convert nitrogen into grain yield – their long stalks that were too weak to hold the extra grain output. Consequently, breeders focussed on selecting for shorter and stiffer stalks that could withstand the increased weight of plants to realise the potential of chemical inputs. **Dwarfs became the idea of progress and by the early 1970s, being widely adopted across breeding programmes and by farmers**.

Agricultural yields have increased markedly with the adoption of dwarfs. In the case of wheat, national yields increased from 2.42 t/ha in 1947 to 4.97 t/ha in 1978, with almost half the increase occurring between 1967-78. By the mid-1980s, wheat yields had peaked at over 7.5 t/ha (see **figure 3 Wheat Yields in the UK**).

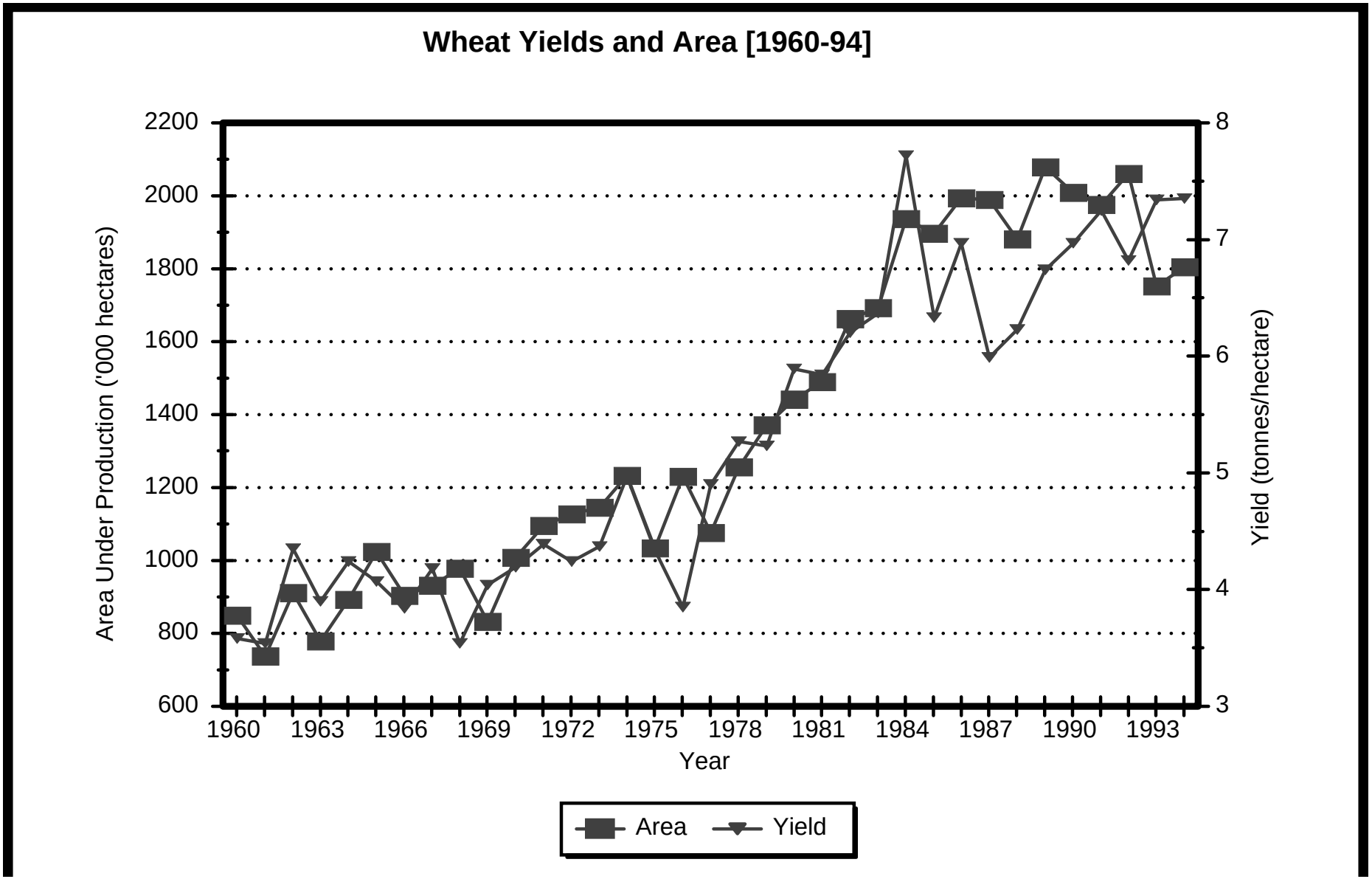

Wheat Yields and Area [1960-94]
Area Under Production ('000 hectares)
2200
2000
1800
1600
1400
1200
1000
800
600
Yield (tonnes/hectare)
8
7
6
5
4
3
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993
Year
Area
Yield

Figure 3

These transformations in agriculture can be also revealed in terms of productivity changes. For example, since World War 2, output per acre has increased across the board at 2.3% pa and output per worker has increased at 3.3% pa. Naturally, these changes are contingent on other factors – such as the mechanisation of farm work, the widespread use of a range of chemical inputs and better organisation and management of agriculture.

- **Labour input** in agriculture in the mid-1980s was 1/10th of that required in 1930.
- Total **horsepower of tractors** have grown more than 10-fold since 1945.
- **Nitrogen fertiliser** use has increased more than 6-fold since 1945.

How has the economic viability of farming changed following these tremendous productivity changes and structural transformations?

2.3 LAND DISTRIBUTION

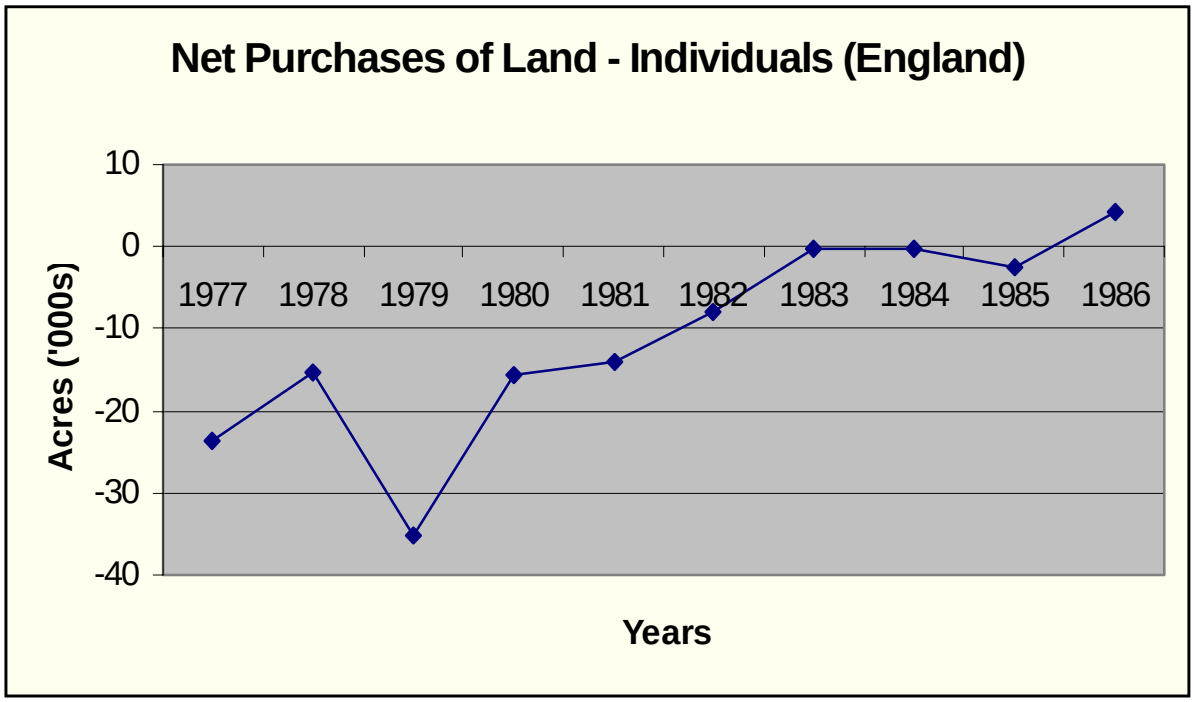
Land ownership data is one of the least documented statistics in agriculture as there is no comprehensive and constantly revised database. A turn of 20th century source of land distribution indicated a high concentration of land distribution:

- 25% of the territory was owned by only 1200 people, with **an average holding of 16200 acres**
- The next 25% was owned by 6200 people, with **an average holding of 3150 acres**.
- The next 25% was owned 50770 people, with **an average holding of 380 acres**
- The final 25% was owned by 261830 people, with **an average holding of 70 acres**

Much has been done to redress the stark inequality reported above. Yet the absence of reliable data makes the task of a comprehensive review difficult. One possible route towards examining the changing picture of land ownership is to examine **data on land transfers**. Most land transfers take place within families with inheritance playing an important part. **Yet, studies indicate that land changing hands is absorbed by existing farmers who aim at enlarging their businesses** – estimates indicate that between 60-80% of land transfers in the 1970s fall within this category (Burrell et al., 1987). This would suggest a tendency towards increasing concentration of agricultural land.

One useful indicator of the changes in land distribution is the little data that can be collected on **land sales**. With increasing pressures on the land and the difficulty of sustaining a profitable livelihood, there have been increasing land transactions in the 1970s-80s (the

Figure 4



period for which data has been collected). Individuals as a category are the largest active component – buying and selling land. **Yet, the evidence also shows that individuals have become net sellers in the land market** (see **Figure 4 – Net Purchases of Land (England)**). The main group benefiting from the sale of lands appears to be financial institutions and property groups – on average, financial institutions purchased 8400 acres per annum during 1977-84.

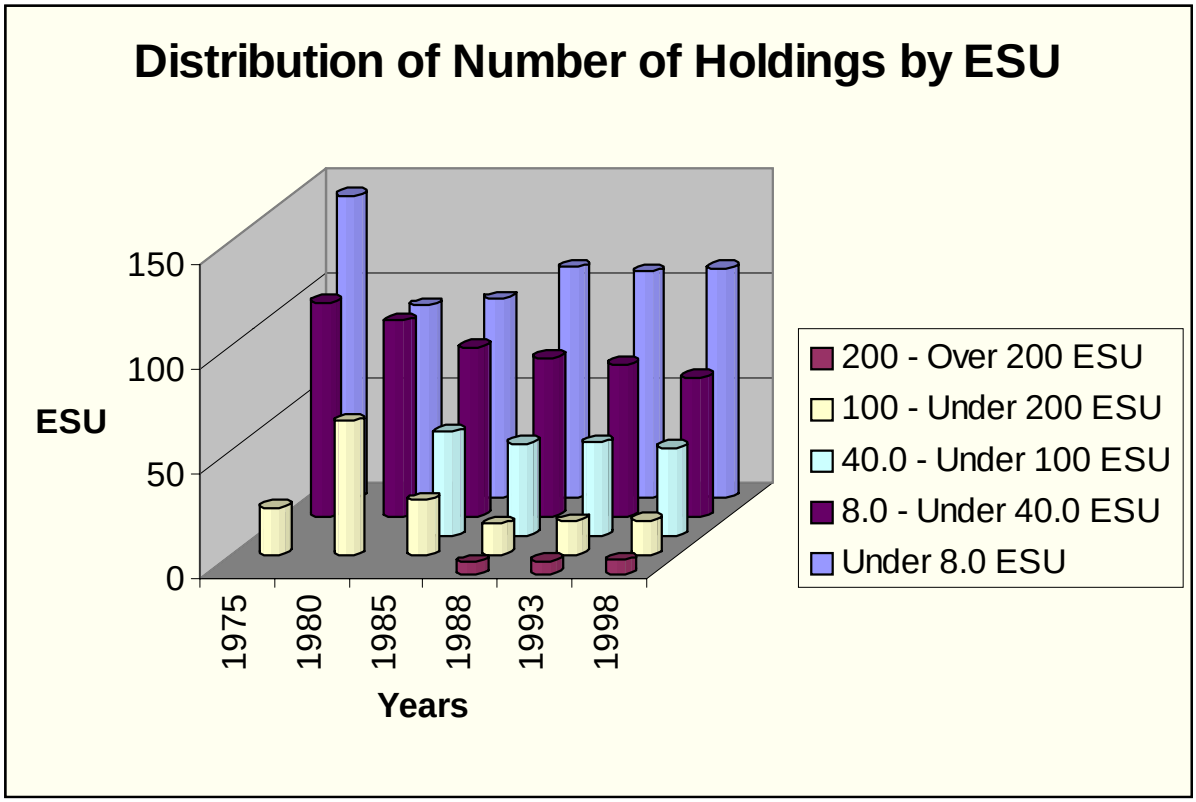
Hence, the concern whether land distribution has worsened. Evidence reported in Burrell et al. (1987) indicate the following trends:

- **Increasing land concentration:** Holdings in excess of 200 acres account for less than 6% of the number of holdings, but occupy over 45% of the total area. There is evidence of an increase in the number of holdings above 200 acres.
- **Small and fragmented farm holdings:** At the other extreme, there are a large number of small holdings – more than 25% being under 10 acres. The authors suggest that "many do not form independent units because of the phenomenon of multiple holdings" (pp79).

The changing distribution of farm size is closely connected to the **economic viability** of farming. Here the general perception is that a 100-200 acre plot appears as a watershed mark – differentiating the total area into two groups of large farms and small and fragmented holdings. The `watershed mark' itself appears to be increasing with time – **reflecting the process of expanding size of land holdings in the UK**. An effort to examine the economic

aspects of farm is possible through an analysis of indicators representing the value of output generated on the farm. One such measure, **the European Size Unit** (ESU), gives the value of output measure of farm business based on the costs and incomes generated from farming.

Figure 5



The **distribution of land holdings** in terms of ESU shows the marked inequity of land distribution in Britain. At the one extreme are the smallholdings (under 8.0 ESU) which represent the main category of holdings – between 45-55% of the number of holdings during this period. At the other extreme are the very large holdings (over 100 ESU) which make up between 20-25% of the total number of holdings. (**see Figure 5 – Distribution of Number of Holdings by ESU**). Statistical evidence establishes the decrease in the number of very large holdings with time relative to the total number of holdings: 10% in 1985 to little over 8% in 1998. **However, the proportion of holding over 200 ESU has increased with time – reconfirming the evidence that the size of land holding has increased.**

The more compelling evidence of land holdings is the distribution of acreage across land holdings. It is the case that the while there are very many smallholdings (as noted above), they collectively account for a negligible share of the total acreage under agriculture. The statistical evidence is as follows:

- In 1984, while 44% of the holdings were less than 20 acres, the collective share of total acreage was under 8%. By 1998, the number of these holdings were marginally lower at 43%, but their acreage share fell to 5%. **Clearly, the average size of smallholdings has decreased with time.**

- For the very large holdings – greater than 100 acres, in 1984 this group constituted 13% of the number of holdings, but occupied 51% of the acreage. By 1998, the group constituted 17% of the holdings and 67% of the acreage. **Clearly, the average size of very large holdings has increased with time.**

The substantive increase in the share of very large holdings has been at the expense of all other categories of land holdings. Importantly, **this trend corroborates with evidence in terms of land enlargement** within British agriculture. Even in terms of agricultural output, large farm are dominant – in 1985, the **10% of the biggest farms produced 25% of the output.** Bringing in the medium and large farms together, 80% of total agricultural output produced on these farms.

2.4 Farm Incomes

Establishing the situation of farm incomes is made difficult by inadequacies of data on the levels of inputs used on the farm. To some extent, farming practices of over-the-fence sales of inputs (e.g. seeds and feeding stuffs) do not help. Yet, there is a widely held perception that the purchased inputs have increased considerably over the years. The increased dependence of the farm on off-farm inputs is part of the larger transformations taking place in the agri-food industries.

Analysts recognise a process through which on-farm activities are **substituted** by purchased inputs while many farm-based activities are **appropriated and replaced** by industrial production. Historically, this has been identified with the replacement of manual and animal labour by machines. Following these changes has been the introduction of chemical fertilisers.

In the UK, the **introduction of dwarf crop species** in the late 1960s-early 1970s was followed by substantial increases in the dependence on non-farm inputs, particularly fertilisers and crop protection chemicals. **Seeds** have also become an important purchased input – replacing the traditional on-farm processes of seed saving and exchange.

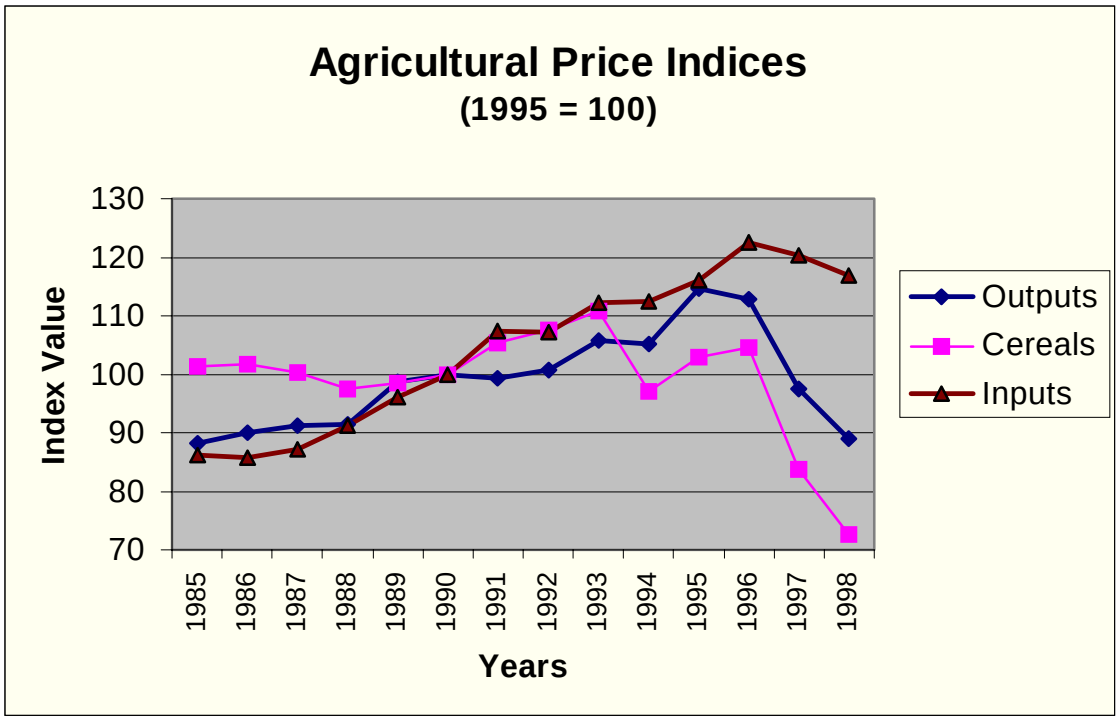


Figure 6

Recent data on the price indices of agricultural inputs and outputs reveal the following trends (**see Figures 6 and 7 – Agricultural Price Indices**):

- **Agricultural input prices** index has increased rapidly during the entire period – registering a 43% increase between 1985-96. In comparison **agricultural output price** index increased by only 28% and has remained lower for most of the period. While both indices have tended to decrease after 1996, the fall in agricultural output prices is more marked – 21% compared to a 5% drop in input prices.

- **Cereal prices** have tended to remain stable in the first half of the period – rising by a mere 10% only between 1985-93. After which there have been substantive decreases totalling about 34%. **Cereal prices in 1998 were a third less than prices in 1985 or 1990.**

- **Seed prices** have tended to increase through most years within this period. Marked increases were registered between 1985-93, when seed prices increased by 34%. This increase is only second to that registered by **plant protection chemicals** that increased by 50% in the same period.

- Apart from **fertilisers**, all input prices reported have demonstrated significant increases. Prices in 1998 ranged between 10-20% higher than the 1990 prices. In comparison to 1985, the increase is of the order of 14-59%.

The evidence above would suggest that commercial viability of farming is under threat. Using farm business surveys, we are able to affirm this perception. Even while agricultural productivity has made substantive strides in the recent past, the impact on farms has been devastating. In stark contrast to increases in agricultural yields and the support prices being offered, **farming incomes in 1986-88 were less than half that earned in**

1971-73 (Burrell et al., 1987). The diminishing commercial viability of farms lies behind the trends noted elsewhere – individuals as being net sellers of agricultural land, increasing consolidation of farm sizes and worsening distribution of land, transformations in the agricultural input industries and privatisation of agricultural research.

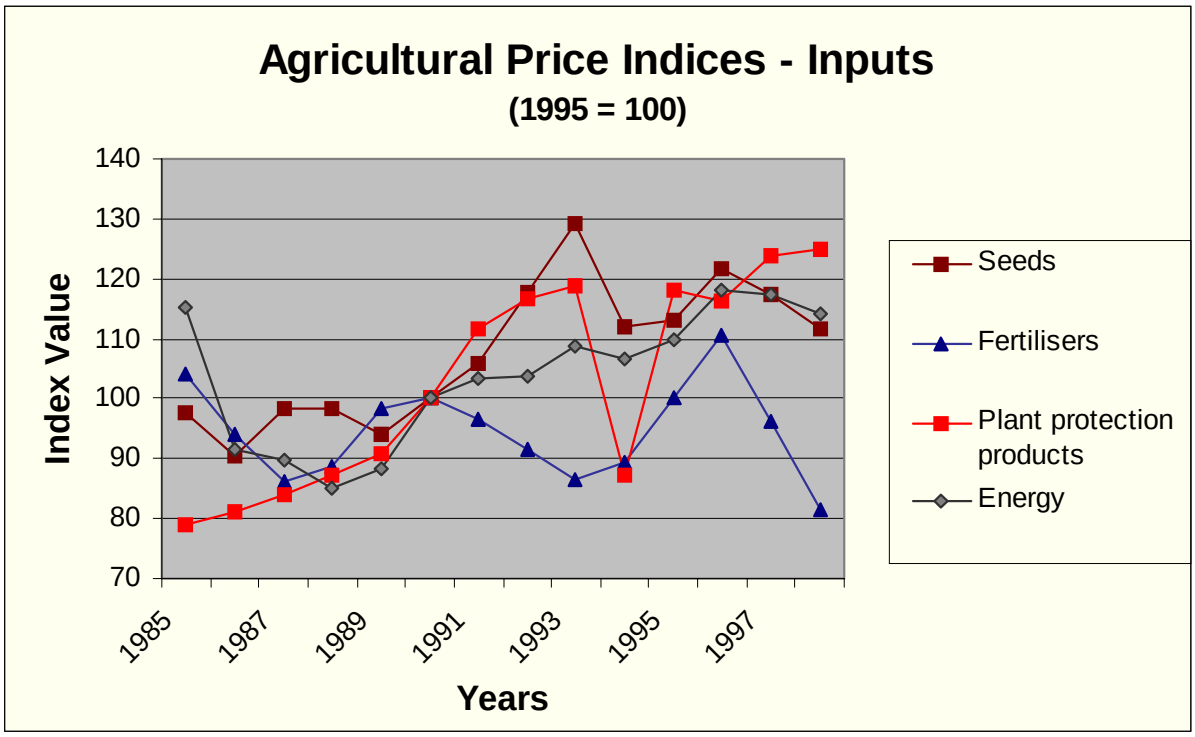


Figure 7

2.5 Some Closing Points

A number of apparent paradoxes characterise the techno-economic transformation of agriculture in the UK. Foremost amongst them is the **contradiction between efforts at increasing agricultural productivity in the face of diminishing commercial viability of farming**. Closely related to this is the evidence of dramatically worsening land distribution borne out by the dual trends of increasing land consolidation and diminishing size of small holdings.

Another paradox that reflected in the statistics reported above is the **conflict between the growing diversification of the agri-input industries even while the commercial viability of farming is being undermined.**

3. Agricultural Research in the UK – Brief Notes on the Struggle to Control Science

3.1 Introduction

The statistical trends noted above must be placed in some context. For example, what factors have generated the particular focus on raising agricultural productivity by developing dwarfs and the supporting range of chemical inputs? To shed some insights on the context surrounding the changes in British agriculture I sketch some brief points about the control of agricultural research in the UK.

Two core points are reviewed in the discussion below. Firstly, the changing nature of public research in agriculture. Over the years, the philosophy of government intervention has changed radically. The second point of relevance is the emergence of private funded and controlled research in agriculture. The latter has been substantially promoted by the privatisation of key breeding facilities in the UK.

3.2 The Early Period

The turn of the century orientation to agricultural research policy in Britain was characterised by a *laissez faire* attitude – the state maintained a healthy distance from interfering with the level of agricultural research underway or the direction the research adopted. This approach was complemented by the over-riding philosophy concerning the pursuit of scientific research – independent search for knowledge. In the sense, the pursuit of science was separate from any commercial outcomes that otherwise might result from the results of research. Reflecting the separation between science and commerce, the *Journal of Agricultural Science* established by scientists at Cambridge University in 1903 had an editorial policy of not accepting papers dealing with farming as opposed to agricultural science.

Despite this general separation of science from commerce and a *laissez faire* principle on the part of the government crucial **initial steps in forming an agricultural research system** were taken with the creation of plant breeding stations in Britain (**see Table 2 – Brief History of Plant Breeding Centres in UK**). With the re-discovery of Mendelian genetics at the turn of the century, fundamental research in plant breeding adopted a greater scientific orientation. State patronage in the form of establishing institutions and bringing forward necessary funds proved crucial.

Table 2

A Brief History of Plant Breeding Centres in the UK

Institution	Year Established	Location	Current Status
John Innes Horticultural Institute	1910	London and Norwich	AFRC Centre in 1986
Plant Breeding Institute	1912	Cambridge	Privatised in 1987
Welsh Plant Breeding Station	1921	Aberystwyth	AFRC Centre in 1986
Scottish Plant Breeding Station	1919	Edinburgh	Closed in 1986

With the redirected attention on agricultural *genetics*, an additional intervention took the form of starting a process of **regulating the seed market** under the auspices of the *National Institute of Agricultural Botany* (NIAB), which was established in 1919. NIAB's work, as reflected in it's institutional motto - `better seeds – better crops', was directed at the seed. With time, the institute developed two broad areas of work:

- **variety testing** to confirm the distinctiveness characteristics of each variety, hence eliminate synonyms,
- **seed testing** aimed at ensuring that the distinguishing characteristics of the named variety are maintained throughout the seed production process, via a system of seed certification.

The depressed state of the economy, and agriculture in particular, in the early decades of the 20th century provided an unquestionable basis for greater state intervention. In 1931 the **Agriculture Research Council**, the *real* predecessor to today's Biotechnology and Biological Science Research Council (BBSRC), was established to oversee the conduct and management of agricultural research.

3.3 Centralised State Agricultural Research – 1947-71

This period is characterised by the development of a highly centralised agricultural research system with some shortcomings of duplication of activities and responsibilities between ARC and the Ministry of Agriculture and Fisheries (MAF) – the latter disbursed funds under the Development Commission for the regeneration of rural areas. The problem was in the relationship between ARC and MAF, given the overlap in the focus on agricultural research.

In 1946, the new Labour government sought to re-organise agricultural research and extension work by creating a centrally controlled **National Agricultural Advisory Service** (NAAS), which would supply advice and information. The **Agriculture Act (1947)** transferred all authority concerning agricultural research funding to MAF; the case for Scotland and

Northern Ireland being slightly different. The centralisation of control under MAF was strengthened by later Conservative government in 1955 by consolidating the Ministry of Food within MAF, as food rationing had by then ended. Importantly, control over research funding for food remained outside the jurisdiction of the newly christened **Ministry of Agriculture, Fisheries and Food** (MAFF).

On the other hand, the ARC fostered and developed much closer ties with institutes of higher education. In contrast, MAFF expanded its links with the farming and food industry through NAAS. Consequently, there developed two overlapping systems supporting agricultural and food research.

In the mid-1960s, the Labour government undertook another re-organisation of the funding for research and development. The **Science and Technology Act (1965)** transferred all responsibilities concerning the various research councils to the Department of Education and Science, thus institutionalising the agricultural research system. To some extent the authority of MAFF was undermined by this development.

3.4 Rothschild Report Period – 1971-79

This period is characterised by the parliamentary review of government support for R&D, later published as the **Rothschild Report (1970)**. The core recommendation made by the report was to reorient the basis and nature of R&D in terms of the needs of the commissioning agency. This *customer-contract* principle required the agenda of R&D to be set by the client – the commissioning government agency. In this sense, the ARC was criticised for being divorced from the needs of the core clients of its research – the farmers, agricultural input suppliers, the food industry and MAFF. Though MAFF was recommended to adopt a more interventionist role in directing the agenda of agricultural R&D, the struggle over resources between Whitehall and scientists continued.

In 1976, the **UK became a full-member of the EEC** and adopted the **Common Agriculture Policy**. The latter led to the introduction of a system of guaranteed support prices, well in excess of world market prices or those previously paid nationally. Farmers rationally responding by adopting intensive cropping practices supported by greatly increased applications of a range of chemical inputs. As result, not only were there gross environmental impacts, highlighted by conservation and nature groups, but a massive build-up of agricultural products. In response, the avowed focus of agricultural R&D, normally aimed at enhancing productivity, required substantive change in focus.

3.5 RADICAL LIBERALISATION – 1979-PRESENT

The 1979 election of a Conservative government deeply committed to a radical agenda of cutting-back the state and curtailing public support for R&D had significant impact of agriculture, as it did in most other aspects of social and economic sectors. Not only did the ARC immediately experience a drastic cut in funds, but the its budget continued to decline till 1987-88 – a 23% reduction from £156Mn to £120Mn. With the reduced funding, the number of research centres under ARC reduced from 18 to 8. Other institutional and organisational changes led to the integration of agricultural and food research issues, leading to the ARC being renamed as the **Agriculture and Food Research Council (AFRC)**. By 1988-89, 15% of the AFRC's budget was devoted to food safety issues – an issue that still remains a crucial political embarrassment in the UK.

The 1980s witnessed the most radical form of liberalisation with the outright sale and closure of a number of public institutions (**see Table 2 above**). A key privatisation with respect to agricultural research was the sale of the **Plant Breeding Institute**, Cambridge to **Unilever** in 1987 for £66Mn. Unilver managed to outbid other contenders like ICI Chemicals and Booker Seeds. There was much consternation at this sale:

> *Somewhat ironically, at the same time as it was being fragmented and privatised, US science policy-makers were advocating the establishment of research stations that would emulate the interdisciplinary approach of the PBI. The PBI was regarded as a particularly successful establishment in terms of its breeding of cereal crops for the UK: over 87% of UK cereal crops grown in 1987 were PBI varieties (Webster, 1989: 225).*

Even breeders at the Institute were alarmed at the privatisation of their institute and the breakdown of its interdisciplinary approach to crop development:

> *It now seems likely that many of the specialist departments of which the [Public Breeding] Institute was formed may, for political or economic reasons, be dispersed or disbanded. ... In this casual way one of the greatest successes for all time in crop research could be destroyed. Whether either of the separated parts can long survive is unclear (Lupton, 1987: xi-xiv).*

The general philosophy underlying the radical privatisation of the public sector was eventually articulated in an internal Cabinet document, the **Barnes Review**, of 1988. This document pioneered the view that research that is `*near-market'* should be entirely conducted by the private sector. In contrast to the earlier *customer-contract* principle, the new mantra within the government was that public R&D should be more contained and focussed on basic science. With respect to agricultural R&D, the Review recommended a cut amounting to £30Mn – about 30% of the research budget.

Finally, in 1994 the government re-organised all the research councils to create 6 centres with a greater technological focus cutting across industrial sectors. The AFRC was renamed the **Biotechnology and Biological Research Council**. Ironically, the title does not reflect its core sectors of food and agriculture!

4. The Economic Impact of Plant Breeders' Rights – Evidence from USA and UK

4.1 INTRODUCTION

There are few systematic and substantive studies on the economic impact of plant breeders' rights in developed countries. This lack of literature is surprising given the heated debate that accompanies the subject of IPRs and plant genetic resources. The discussion here will closely study four empirical-based studies of PBRs:

- **Perrin, Kunnings and Ihnen (1983):** An academic work produced by the North Carolina State University. The report is an empirical evaluation of the PVPA (1970) in the US focussing closely on the re-direction of R&D towards soybean breeding. The data used is derived from questionnaires circulated amongst breeding companies.
- **Butler and Marion (1985):** The report results from a request of Senate Agriculture Committee (US) which reviewed conflicting views on the social costs and benefits of PBRs at the time of extending the scope of application of PVPA (1970). The study is based on questionnaire responses from breeding companies in a wide range of crops.
- **ALP da Rocha (1994):** This PhD thesis examines econometric issues concerning the relationship between availability of PBRs and the rate of introduction of new varieties for a range of fruits, vegetables and ornamentals in the UK. The results shed useful insight into the question of whether the availability of PBRs *caused* increases in the rate of introduction of new varieties.
- **Rangnekar (forthcoming):** This PhD thesis examines issues concerning the relationship between the direction of technical change (innovation avenues) and strategies of appropriation so as to draw implications shed insights into the consequences of privatising agricultural research. Conclusions are based on a case study of wheat breeding in the UK.

The two studies concerning PBRs in the US have drawn extensive attention in the literature, partly because of their favourable conclusion on the positive impact of PBRs. For example, a *World Bank* survey on IPRs reviewed the US-based studies and concluded

> *protection for intellectual property in seeds and plants in developed countries has resulted in increased private breeding activity […] Some potential costs of*

> *protecting intellectual property in agriculture have been anticipated but not established (Lesser, 1990: 68).*

Given the importance of these studies we need to examine them closely as well as analyse the data that provides the foundation for the results. The following points need to be kept in mind.

- **Are the studies representative of the US seed industry?** Butler and Marion (1985) [henceforth BM] petitioned 398 firms in the US, of which 67% responded. However, only 60 firms (15% of total petitioned firms) provided financial information that could be used in the study. These 60 firms represent roughly 50% of seed sales and variety grants. Perrin et al. (1983) [henceforth PKI] began with a sample of 214 firms, where some 60% responded, with only 34% providing complete/usable data.

- **Are firms reliable sources for data?** Firms may have a reason to furnish inaccurate data, which would raise problems for economic analysis. The PKI study draws attention to discrepancies between their estimates of the seed market and those resulting from the data provided by the companies. As the studies do not resolve these discrepancies, some of the results need to be treated with caution.

- **Do the studies provide a historical analysis?** Both studies analyse a very brief period, 1960-80, focussing on the period immediately around the 1970 enactment of PVPA. Unfortunately, neither studies contextualise the evidence in terms of general historical trends so as to differentiate the *actual impact* of PVPA from other structural changes occurring in agriculture. Consequently, the weight of the results is undermined.

Three primary issues will be reviewed in the following discussion: (a) the evidence in terms of investment in plant breeding, (b) data concerning the production of new varieties – the primary inventive activity being impacted by PBRs, and (c) influence on market structure in terms of monopoly power and seed prices.

4.2 Investments in Plant Breeding

A primary rationalisation supporting IPRs is the incentive it provides private investment, a point empirically validated by evidence establishing the increased level of private investment. In the context of plant breeding, studies have tackled this issue by providing a number of indicators of private investment in plant breeding.

- Number of firms in plant breeding
- Private R&D expenditures in plant breeding
- Number of new varieties released (i.e. PBRs granted)

4.2(A) FIRMS AND INVESTMENTS IN PLANT BREEDING

Following the argument that IPRs act as an incentive to private investments it should be the case that the provision of PBRs is succeeded by an increase in the number of firms in plant breeding – new firms becoming active in plant breeding. A related indicator would be the initiation of breeding programmes.

Evidence of firms in plant breeding in the UK is based on the membership of the British Association of Plant Breeding, the apex body of private breeders that oversees the royalty payment system among other things. The only reported evidence of this is from Murphy (1980), which is a submission to the US House of Representatives during the debate over extending PVPA (1970). Murphy states that the number of members increased from 10 to 23 during the period 1967-73. In contrast, **in the Netherlands**, the availability of PBRs was followed by consolidation within the industry that led to disappearance of a number of smaller cereal breeders (Leenders, 1976).

With respect to the US, BM provide information on 60 breeding companies:

- 20 companies (33%) had breeding programmes before 1960, i.e. well before the legislation was enacted in 1970;
- 13 companies (22%) initiated breeding programmes between 1960-69, probably in anticipation of the legislation;
- 27 companies (45%) started breeding programmes after the 1970 Act.

Since the majority of breeding programmes began in *anticipation* of PVPA or soon after it, the conclusion that PVPA encouraged private investment.

The number of firms or breeding programmes remain an unreliable indicator, partly since there is no evidence of the trend rate of growth in the number of firms or acknowledgement of possible exiting of firms and changes in market structure. Further, membership to the apex association would appear obvious, particularly since it oversees the collection of royalty payments. To make the number of firms a meaningful indicator it is necessary to examine the structural changes occurring in the seed industry as well as investment data. An increase in the number of firms has little or no association with economic value or efficiency. As far as the evidence of breeding programmes is considered it may be the case that breeding programmes initiated after 1970 are smaller in magnitude or only focused only on select crops. It could also be that newer breeding programmes are

more in number but each being relatively small when compared to those initiated in the pre-1970s period.

Consequently, is it the case that increases in the number firms and breeding programmes is accompanied by an increase in the level of private investment? In this regard, Murphy (1980) reports that private investment in plant breeding in the UK increased by as much as 500% during 1975-80. This surprising figure remains unsubstantiated by Murphy. There is no supporting evidence to confirm whether (a) the increase is nominal or real, (b) a trend unique to plant breeding or uniform across a range of industries, (c) other factors led to the increased investment activity (Godden, 1983). Even if the increase is in real terms, it is necessary to establish the *causality* of PBRs being the primary factor motivating the investment behaviour.

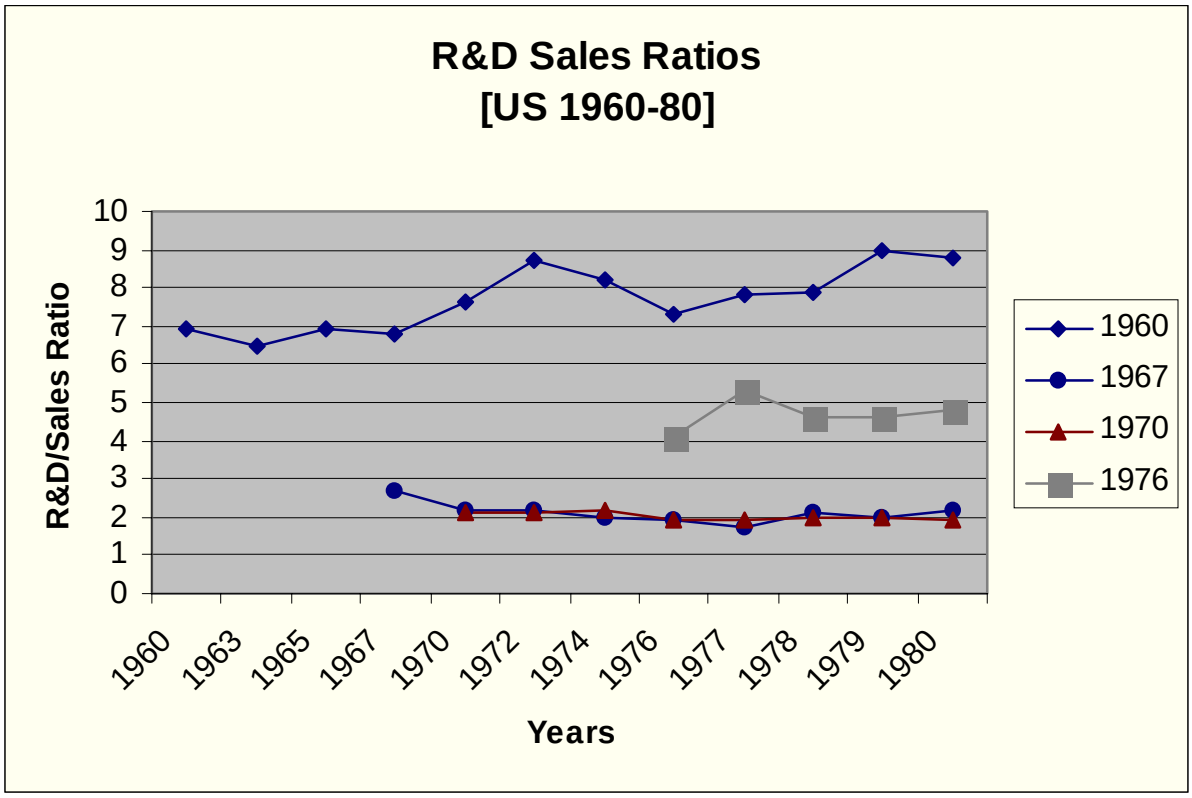


Figure 8

A comparison of the investments made by different groups of companies would provide useful insights. BM attempt this task in terms of the 60 companies providing complete data. In simple magnitude terms, the older companies (i.e. pre-1970s) that pre-existed the enactment of PVPA are more R&D-intensive. This difference itself would warrant scepticism of the positive impact of PVPA on private investment – *new entrants, though being many in number, do not bring forth high levels of investment*. However, in terms of economics the concern is equally in terms of the relationship between R&D and sales. In the

sense, *is the higher level of R&D expenditures of older companies translated into commercial success?* To examine this question, we need to compare the level of R&D per dollar of sales. The following graph is developed from the data reported in BM.

From the figure (**Figure 8 R&D/Sales Ratios**) it is clear that pre-1970s breeding companies, which on average are much larger, spend more on R&D per sales-dollar earned. The post-1970s companies, which allegedly initiated breeding programmes following the enactment of PVPA, do not invest as much per sales-dollar earned.

- For the 1960s companies, the average R&D expenditures were $1.4Mn in 1980 and average sales were $40Mn.
- For the 1970s companies, the average R&D expenditures were $0.4Mn in 1980 and average sales were $11Mn.

The evidence suggests the incentive effect is not as strong as often claimed in the literature. For the new entrants, the availability of PBRs appear as inadequate incentives to achieve a level of investments comparable to the pre-1960s companies. In other words, the pre-1960s companies maintain their advantageous position, further strengthened with PBRs. BM make the following conclusion:

> *While total R&D expenditures (deflated) increased over the period 1960 to 1980, the period of most rapid increase occurred in 1967-70 and was due mainly to those firms with older plant breeding programmes, possibly in anticipation of the PVPA (BM: p29).*

Whether the investments were made in *anticipation* of PVPA is itself a moot point that the study fails to empirically support, making one feel it is more conjecture than scholarly proof. PBRs aside, other changes in agriculture are equally relevant factors stimulating private investment. Kloppenburg (1988) draws our attention to the massive increases in acreage that would independently act as demand incentive to increased breeding of a range of crops.

4.2(B) CHANGING DISTRIBUTION OF PRIVATE INVESTMENTS

Increases in private investments suggest that changes have occurred in the distribution of R&D in breeding. An examination of the evidence of R&D by crop would establish which crops have benefited from the availability of PBRs, or to put it differently, which crops appear as profitable avenues for private investment. With respect to the UK, none of the studies have attempted this task. Other reports on agriculture in the UK have not focussed on the changing distribution of R&D across crops.

The BM report provide data on R&D expenditures by crop species for a very small sample of 14 firms, whereas PKI report similar data for 56 firms. The most notable result from this data is the increased R&D expenditure devoted to soybean and wheat (**Figure 9 R&D Expenditure by Crops**). In the PKI database, wheat and soybean reveal a marked increase in the share of total R&D expenditures – increasing from 5% and 1% respectively in 1965 to 10% in 1979. Thus, while R&D expenditures have increased across the board, the increases for soybean and wheat have been the most marked, increasing by 89% and 29% respectively (BM). Correspondingly there has been a fall in the share R&D expenditures accounted by hybrid corn – though its share still stands at over 70% (BM) or 47% in PKI

How to explain the specific focus on wheat and soybean? BM agree that "potential profitability" of the crop in terms of market size and expense of breeding the crop may be relevant. PKI note that the focus on soybean could be because of the "increased commercial importance of the crop". **However, without adequately examining these factors or adopting a reasonable historical approach, the implicit**

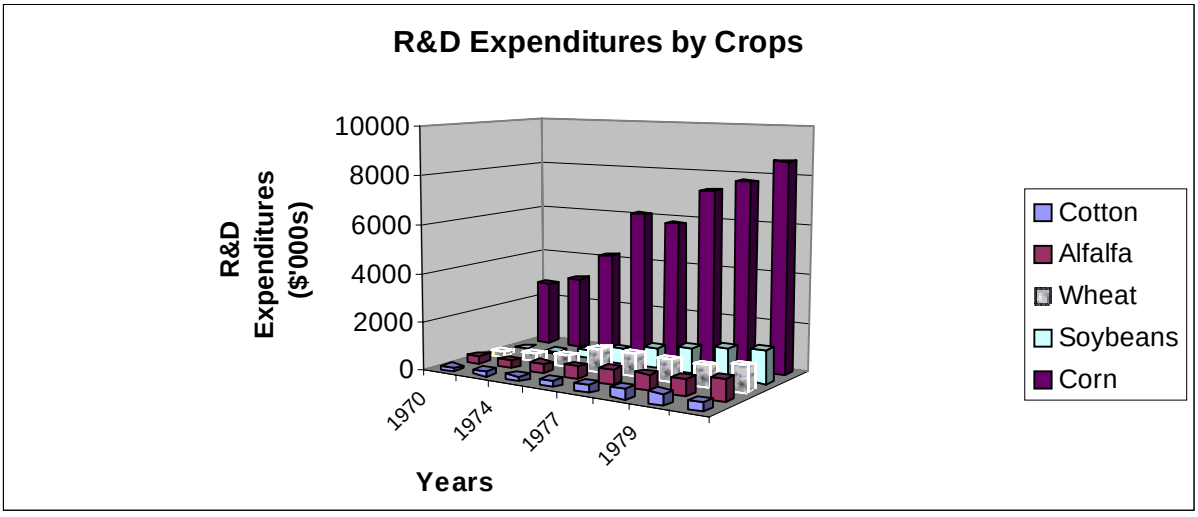


Figure 9

effort to establish a positive incentive-impact of PBRs remains wanting. Acreage under soybean increased 132% between 1939-58 (Kloppenburg, 1988: 134) and another 172% between 1950-70 (Fowler, 1994: 102-3). Importantly, the soybean germ is highly fragile and breaks down during the harvesting process thus rendering it impossible for farmers to save and reuse (Berlan and Lewontin, 1986: 786; Fowler, 1994: 103). Clearly, this was a strong motivating factor underlying the emergence of private investment in soybean breeding.

Additionally, on the demand side, soybean occupied an important, if not central, position in the "power farming" techno-economic base of US agriculture. The transformation of the turn-of-the century corn-hog agri-economy of the US Corn Belt into a power-intensive agri-complex required changes in the cropping pattern. The corn-oat crop rotation became

redundant as cattle were replaced by tractors; with the loss of animal manure (as animals get replaced by tractors) and the increased intensity of farming there was need for a new legume for nitrogen fixing in the soil (Berlan, 1991). It is this role that soybean occupied. The commercial end-use of soybean remained highly lucrative, making it the most valuable crop by the 1950s. Export markets during the surplus food regime during 1947-72 added additional commercial interest in soybean (Friedmann, 1993).

Bringing these factors to bear on the analysis of the role and impact of PBRs (in the case of the US) prompts Kloppenburg to conclude that **the PVPA is more a marketing act, rather than an act promoting research.**

> *There is little evidence to support the contention that the PVPA has powerfully stimulated additional private investment in plant breeding research. Much of the investment that has been forthcoming would probably have been made even in the absence of the act. More firms are doing more research, but the intensity of their effort* [reference is to the R&D/Sales estimates] *has, since 1970, been more or less flat (Kloppenburg: p141).*

4.3 New Varieties

The crux of the system of PBRs is the introduction of new varieties, protection being granted to varieties that satisfy the requirement of distinctness, uniformity and stability. Hence, the popular focus on the introduction and release of new varieties:

> *Several studies conducted since 1980 suggest that the availability of PBRs has increased the number of private sector breeders, as well as the number of private varieties released and planted (Lesser, 1990: 60).*

While attention is devoted to the number of new varieties entering the market, it is important to keep in mind the qualitative aspect of the new varieties. **Economic value is only added if the new varieties are qualitatively better and demonstratively push out the production levels**. Also to be kept in mind is the general direction of innovation that the new varieties trace out – relevant in this respect is the ecological aspects of modern varieties revealed in their increased chemical dependence.

What has been the trend in terms of the number of varieties released? The evidence in the US for the period 1970-1983 indicates that out of 1758 applications for protection, 1199 had been granted PBRs, 295 were withdrawn, 153 were in the search stage and the balance were being held for action (BM). This reveals a reasonably high success rate of securing PBRs – 68% of all applications were successful. PKI report similar data for the period 1973-79 for soybean only.

Table 3

Plant Variety Certificates – 1971 – 1982 (USA)

	Soybean	Wheat	Alfalfa	Cotton	Peas	Garden Beans
1971	9	1	0	6	4	14
1972	8	11	2	21	5	6
1973	13	5	2	7	6	8
1974	15	11	1	5	8	10
1975	11	7	2	7	16	8
1976	13	16	3	6	7	9
1977	20	15	0	10	16	16
1978	20	11	2	10	10	3
1979	35	8	2	8	8	3
1980	38	13	5	8	18	14
1981	51	15	2	11	12	14
1982	42	14	4	14	13	6
Total	**275**	**127**	**25**	**113**	**123**	**111**

While 13 varieties very granted protection in 1973, the corresponding number was 21 in 1979 – establishing a positive trend of increased new varieties being released. Importantly, private breeders produced three-fourths of the new soybean varieties during the period**. Clearly there has been a positive growth in the introduction of new varieties** (see **Table 3 Plant Variety Certificates – 1971-82 (USA)**). Even critics agree that more varieties have been produced in recent times (e.g. Mooney, 1983: 153).

In the UK, between 1965-95 there were 810 applications for PBRs in (winter) wheat of which, a total of 248 were granted PBRs. This represented a relatively low success rate of 31% success rate (see **Table 4 Plant Breeders' Rights – Wheat in the UK (1965-95)**). Looking at the number of grants being issued across time, leads us to conclude that there is evidence of an increasing rate of introduction of new varieties – 33 grants in 1965-69, 25 in 1970-74, 36 in 1975-79 and 55 in 1990-95.

Table 4

Plant Breeders' Rights – Wheat in the UK (1965-95)

	1965-69	1970-74	1975-79	1980-85	1986-89	1990-95	No date	Total
Applications	61	96	113	202	120	200	18	810
Withdrawals	30	71	77	153	78	90	11	510
Grants	33	25	36	49	43	55	7	248
Surrenders	0	2	3	7	10	18	0	40
Terminations	32	23	31	35	17	1	7	146
Full Term PBRs	1	0	0	0	0	0	0	1

However, since Rangnekar (forthcoming) **did not examine the difference between the pre-PBRs and post-PBRs period no statement can be made on the *impact* of PBRs on the rate of introduction of new varieties**. There may be other factors influencing the introduction of new varieties.

Are PBRs the sole factor *causing* an increase in the number of new varieties released? This is a more complicated issue concerning (a) changes in historical trends concerning the rate of release of new varieties and (b) econometric issues concerning causality. An examination between a pre- and post-PBRs period is a necessary prerequisite to confirm that the rate of varietal release has increased after the enactment of PBRs legislation. Further, to establish that the availability of PBRs ***caused*** the rate of introduction of new varieties requires an isolation of the influence of all other factors and demonstrating that they have a trivial impact. **None of the US studies reviewed here have conducted this task.** A number of factors play an important role in determining the rate of introduction of new varieties. Apart from the various *demand-side* factors noted earlier (e.g. changing acreage, increasing crop profitability), the *supply-side* must also be considered. For example, improvements in breeding techniques and the use of computer-based systems for information processing and monitoring of crosses has enabled increased production of new varieties. The relationship between innovations and IPRs is more complicated than what the various reports reviewed here suggest.

An econometric exercise to test *causality* can be conducted. The only econometric exercise to test the *causality* relationship between availability of PBRs and the rate of introduction of new varieties concerns fruits, vegetable and ornamental breeding in the UK (da Rocha, 1994). The following evidence is based on examining historical data for the period 1930s-90s and conducting a series of econometric tests to assess the issue of causality. Following results were reported:

- **Apples:** There is no statistical support for the claim that PBRs have led to increased rate of introduction of new varieties. PBRs have had no perceptible impact on changing the trend rate of introduction of new varieties.
- **Strawberries:** The availability of protection has had a positive impact on the rate of introduction of new varieties. However, the main beneficiaries of the availability of PBRs have been public breeders and foreign breeders, i.e. their respective shares of the PBRs granted have increased.
- **Rose:** The number of rose varieties released after the availability of protection has increased substantially indicating a positive influence. However, statistical tests suggest that there has been a feedback effect between the number of grants made and the pace of innovation. The latter result casts serious doubts on the significance of PBRs in influencing the rate of introduction of new varieties.

- **French Bean:** PBRs have had some positive influence on the rate of release of new varieties, though this appears marginal in comparison to the impact of regulations (e.g. National Lists).

The evidence of the *impact* of PBRs on the rate of introduction of new varieties is clearly mixed. Any effort to suggest that PBRs have singularly caused the increase in the number of new varieties is misplaced and based on shaky academic foundations. Interestingly, da Rocha's very mixed results also raise crucial questions in terms of the mixed fortunes of different breeders. Here compare the success of British private breeders in apples with those in strawberry. While strawberry breeders have remained an insignificant economic entity, apple breeders have just about managed to maintain their share of grants. The differential performance suggests that **the availability of PBRs, while probably necessary, remains insufficient in drawing forward private investment**. In the absence of an adequate scientific base with which to promote breeding programmes, private investment will not come forward.

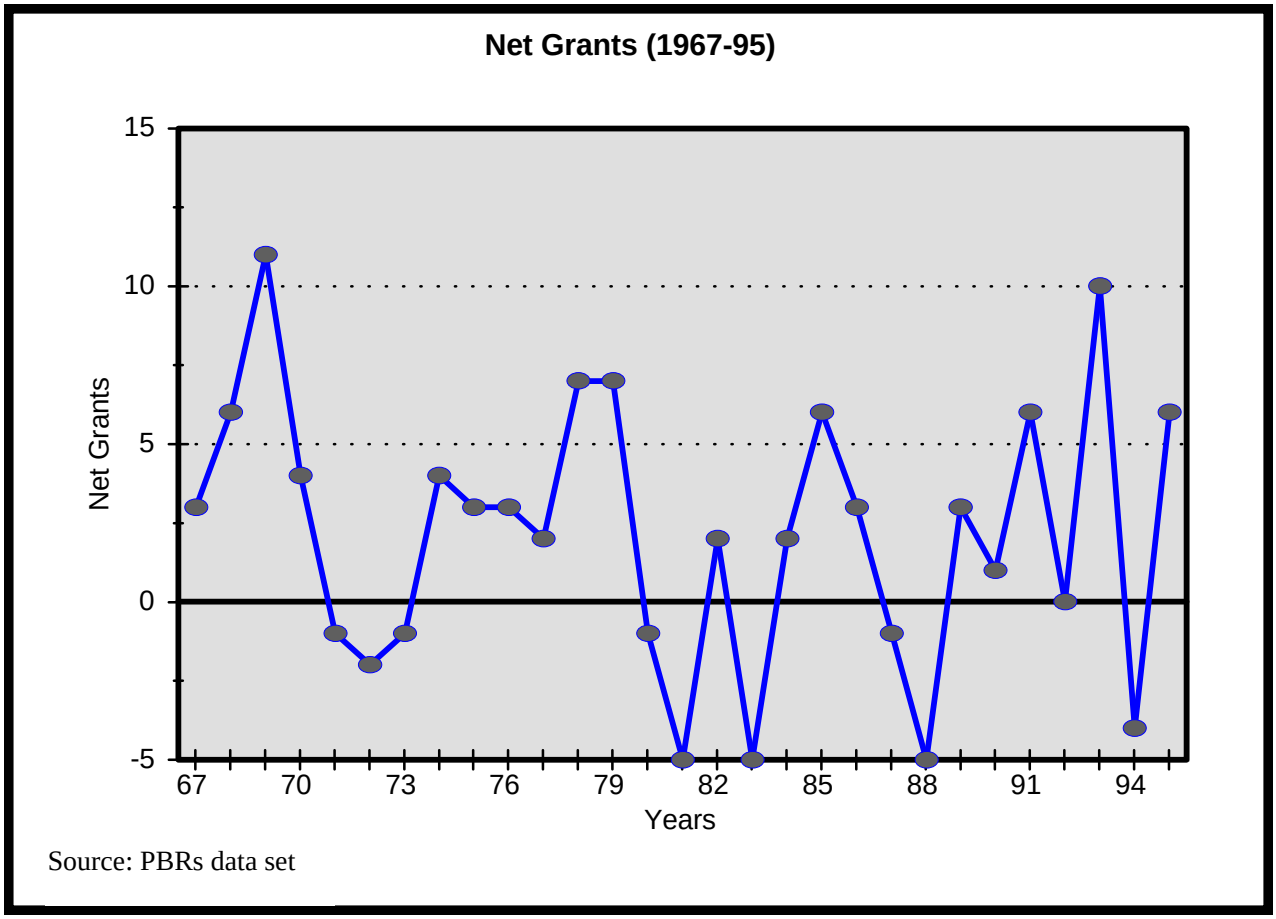


Figure 10

Is there more to the evidence of new varieties being introduced? Is it the case that new varieties are periodically being introduced because varieties of an earlier vintage are being

withdrawn? Terminations of grants are purely commercial decisions and may be part of deeper strategies of appropriation. Rangnekar (forthcoming) examines this issue for wheat PBRs in the UK. The evidence in terms of **net grants**, i.e. new varieties released less old varieties withdrawn, suggests that the level of inventive activity based on the number of new varieties is an overstatement (**Figure 10 Net Grants (1967-95)**). Other researchers have emphasised the breeder's strongest sale's pitch is `new' variety – thus, there is a vested interest in reducing the life-span of older varieties and continuously changing the portfolio of existing varieties (Berlan and Lewontin, 1986).

Two important points fall out from analysis the evidence in terms of net grant:

- There are **periods when the market suffers a net withdrawal of varieties** – more varieties are withdrawn from the market than those entering the market – such as 1971-73, 1980-81, 1987-88 and 1994.
- There is **limited empirical support for an increasing level of inventive activity**. To be clear, the trend of net grants does not demonstrate a significant positive rate of growth during the period of analysis, 1967-95.

Based on the case of wheat in the UK, it is clear that the popular focus on new varieties entering the market is an incomplete analysis of the *impact* of PBRs. None of the studies, including da Rocha, have attempted to compare the entry and exit of varieties. Looking at the entry-exit dynamics sheds useful insights into the wider corporate strategies of appropriation

Naturally, one needs to also examine the characteristics of the new varieties – are they substantively better – in the sense, do these varieties add economic value to the production base of the economy? This is a crucial question since there is **no test for inventiveness or utility** in the system for grant of PBRs. Unlike a patent grant where the invention is tested for its industrial utility and non-obviousness, varieties are only tested for distinctness, uniformity, stability and (commercial) novelty. The absence of a *merit/inventive* test for new varieties raises the possibility that **trivial/cosmetic** developments may be granted protection and could be the basis for much of the increase in the number of new varieties. In the US, the National Academy of Sciences has noted that much of commercial plant breeding is focussed on genetic `fine-tuning' of improved varieties. However, all such cosmetically differentiated varieties do not add economic value or contribute to enhancing the nation's production possibilities. Consider the following extract from the *Plant Variety Protection Office Journal* (1984) (of the US) with respect to the distinctness of a new soybean variety, S30-31, bred by Northrup King and Co.

> *S30-31 is most similar to Pella, Cumberland and Agripro 25; however, S30-31 has grey pubescence vs. twany for Pella, yellow hila vs. imperfect black for*

> *Cumberland, and white flowers vs. purple for Agripro 25 (quoted in Kloppenburg, 1988, p144).*

Drawing attention to the wasteful nature of cosmetic breeding reflected in the proliferation of near-identical varieties is important. **Given our earlier evidence of differential success in securing PBRs across the range of crops, it is useful to closely examine the distribution of grants between companies and crops.** Of importance here is the distribution of PBRs, both in terms of the concentration of grants held by companies and the share across crops. Collecting empirical evidence of this is difficult, as it requires co-ordinating all PBRs grants with ultimate corporate owners. Since interest is in the *change* in the distribution of grants, tracking changes in the corporate ownership of the seed industry is an essential prerequisite. Unfortunately, the enormity of this task has dissuaded most analysts from undertaking this task.

As far as the distribution of PBRs in the US is concerned we have evidence only for a point in time. For the period 1971-82, the following evidence is reported in BM:

- Of the 83 species covered by the PVPA, **five species accounted for 63% of all grants** issued: soybean (23%), wheat (11%), garden peas (10%), cotton (9%), and garden beans (10%). And 21 species accounted for 89% of all grants.
- Of the 200 separate breeding institutions (public and private) that had been issued a grant, only 27 institutions secured 10 or more grants. The share of grants made to these 27 institutions amounted to 56.7%; though, **the top 15 grant holders together controlled 43% of the grants**.
- Bringing together the crop-wise distribution of grants with the company shares reveals that the 27 top grant holders controlled 52% of the grants:

There is clear indication of **concentration of PBRs** within companies and differential distribution of PBRs across crops. Not surprisingly, **the availability of protection does not guarantee that private investment will accordingly be devoted to all crops**. As noted earlier, the *profitability* of a crop is a stronger factor motivating private investment. The distribution of PBRs between companies, i.e. top 15 holders accounting for 43% of the total grants made, is itself not too alarming. **Maybe a closer look at the crop-level distribution is warranted.**

Data of PBRs distribution at the crop level supports the widely held view is heavily concentrated with a few firms controlling most of the market (**Table 5 Distribution of PBRs in the US**). For the most part, **the share of grants issued to the top four firms range between 50-100%.**

Table 5

Distribution of PBRs in the US

	Number of Certificates Issued	Percentage of total certificates	Number of Firms holding certificates	Percentage of certificates held by main holders			
				Top 1	Top 2	Top 3	Top 4
Soybean	275	22.94%	44	11.3	20.4	29.1	37.8
Wheat[1]	127	10.59%	35	14.4	22.9	31.4	39.0
Peas	123	10.26%	19	31.7	41.5	50.3	57.7
Cotton	113	9.42%	26	19.5	28.3	37.2	43.4
Beans[2]	111	9.26%	23	25.2	43.7	55.3	67.0
Lettuce	48	4.00%	10	22.9	39.6	54.2	66.7
Fescues	30	2.50%	17	10.0	20.0	27.0	33.3
Marigold	27	2.25%	6	33.3	59.3	74.1	84.2
Alfalfa	25	2.09%	10	48.0	64.0	72.0	76.0
Ryegrass	25	2.09%	15	12.5	20.8	29.2	37.5
Onion	22	1.83%	6	50.0	68.2	86.4	90.9
Bluegrass	21	1.75%	13	15.0	25.0	35.0	45.0
Oat	16	1.33%	7	37.6	56.3	75.0	81.3
Corn[1]	15	1.25%	8	40.0	53.3	66.7	73.3
Tobacco	15	1.25%	3	40.0	86.7	100.0	
Barley	14	1.17%	8	28.6	42.9	57.1	71.4
Watermelon	13	1.08%	8	23.1	38.5	53.8	69.2
Rice	12	1.00%	6	33.3	50.0	66.7	83.3
China Aster	11	0.92%	1	100.0			
Tomato	11	0.92%	5	27.3	45.5	63.6	81.8
Cauliflower	10	0.83%	5	50.0	70.0	80.0	90.0

Even in crops which have attracted the most investment, soybean and wheat, where a total of 44 and 35 firms received grants respectively, the share controlled by the top four is disproportionately large – 38 and 39% respectively. My closer analysis indicates the following three features to the distribution:

- The tendency towards entrenched market concentration is more marked when the data is disaggregated at the crop-level.
- Even in the more profitable crops, which have attracted the most level of breeding activity, e.g. soybean, wheat, cotton, peas and beans, the share of the top four companies lies between 38-67%.
- In some instances, the market is extremely concentrated with few firms gaining all the grants, e.g. tobacco where 3 firms hold 100% of the grants, cauliflower and onions where four firms hold over 90% of the grants, and barley, rice, tomato and corn where four-firm concentration ratios range between 71-84%.

Accordingly, BM make the following conclusion:

> *That is, the majority of PVP certificates issued are for a few crops and are issued to a few plant breeding organisations.*
>
> *There are a number of possible reasons why this skewed distribution has occurred:*
>
> *Most of the research has been on crops which have the greatest profit potential for private industry.*
>
> *The firms holding the major share of PVP certificates issued are seed firms with large plant breeding programmes that were established well before the passage of the PVPA. (BM, 1985: 33-38)*

This conclusion is telling. Firstly, it establishes that the profitability of the crop has a more decisive influence in drawing private investment for breeding. Secondly, larger and older breeding programmes have disproportionately benefited by securing a larger share of total grants issued. As such, the new entrants into the breeding industry have not succeeded in securing grants and making a market presence.

Table 6

Distribution of PBRs Grants in UK Wheat (1965-95)

Range	1965-74			1975-85			1986-95		
	No. of Applicants	Applicants as %age	Share of grants (%)	No. of Applicants	Applicants as %age	Share of grants (%)	No. of Applicants	Applicants as %age	Share of grants (%)
0	63	74.12%	0	69	81.18%	0	64	75.29%	0
up to 5%	17	20.00%	33.62	13	15.29%	18.82	16	18.82%	21.43
5 - 7.5%	2	2.35%	11.21	0	0.00%	0	0	0.00%	0
7.5-20%	2	2.35%	20.69	1	1.18%	11.76	4	4.71%	40.82
20-40%	1	1.18%	34.48	2	2.35%	69.41	1	1.18%	37.76
above 40%	0	0.00%	0	0	0.00%	0	0	0.00%	
Total	**85**	**1**	**100**	**85**	**1**	**99.99**	**85**	**1**	**100.01**
Range relates to the %age of grants held by an individual applicant.									

Since the availability of PBRs have disproportionately accrued to bigger and older breeding companies, is it the case that larger companies have increased their share of grants with time? This question returns to the issue of changes in the distribution of grants with time. The only available evidence is from Rangnekar (forthcoming) on wheat PBRs in the UK, which we report below. Table **6 Distribution of PBRs Grants in UK Wheat (1965-95)** reveals the following trends in the distribution of PBRs in wheat for the UK:

- The share of grants controlled by the top five increased from 68% in 1965-74 to 88% in 1975-85 and settled at 79% in 1986-95. **About 5% of the applicants controlled between 68-89% of all grants.**
- **Between 75-80% of the applicants received no grants**.

Roughly 10% of the applicants, with individual holdings under 5% of total grants, have seen their collective share fall from 34% in 1965-74 to 21% in 1986-95.

There has been a clear worsening of the distribution of grants across the period. Importantly, the top five grant-holders are part of larger multinational seed companies. Thus, even successful continental cereal breeders, e.g. Maison Fernand Lepeuple and Paul Guillman, that held a sizeable portion of grants in 1965-74, have virtually vanished from the market. It is on this basis that one concludes that the main beneficiaries of PBRs have been the multinational breeding companies.

4.4 Market Concentration

Taking forward the discussion from the distribution of grants, one would assume that market shares would reveal similar evidence of a highly concentrated market. **It is widely felt that PBRs, much like any other IPRs, aggravate market distribution since they act as a type of barrier-to-entry**. This perception finds support in the trend of increasing mergers and acquisitions that have plagued the seed industry in the 1970s-80s. However, perceptions and feelings apart, what is the empirical evidence. In this regard, BM suggest that the point of importance is the *level of concentration* and not whether concentration has increased following the enactment of PVPA. This is not entirely appropriate – changes in the level of market concentration over a long enough period of time is an essential indicator of changes in the level of competition within an industry.

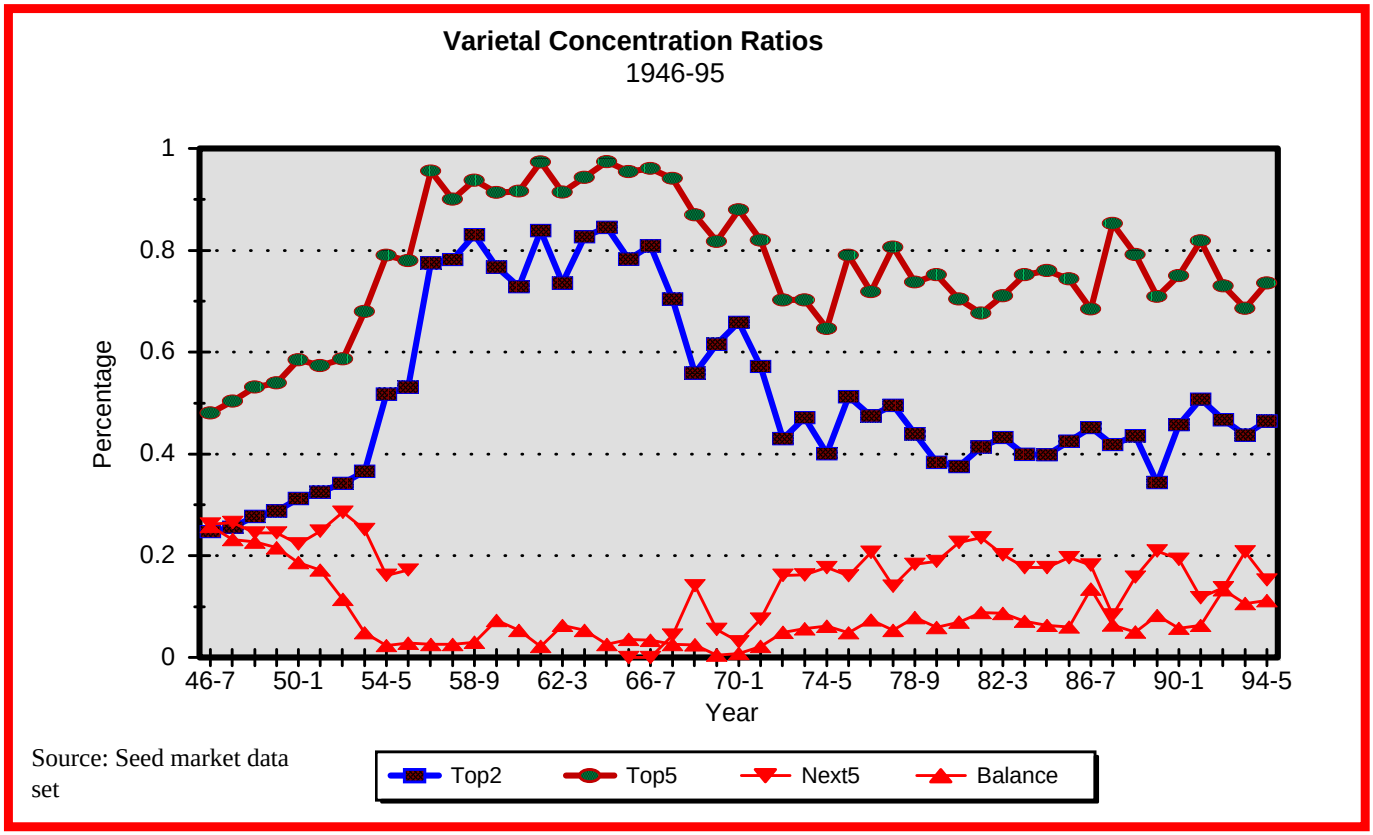
The task to estimate market shares is difficult. To achieve a reliable indicator of corporate market share a couple of tasks need to be completed. Firstly, ultimate corporate ownership must be carefully discerned. Secondly, varieties must be unambiguously identified with their respective corporate owner. Given the continuous nature of mergers and acquisitions both tasks are formidable. Further, in the US unprotected varieties exist and are marketed by a number of different companies. A problem compounded by the availability of publicly bred varieties that are marketed by a range of companies. It is for these reasons that BM focus on the acreage planted to varieties, a solution adopted by Rangnekar (forthcoming).

In the US, varietal concentration ratios are not disproportionately high. Data in BM for 1979-80, indicates the relevant varietal concentration ratios, which suggests that except in rice and barley, the top four varieties fail to register a collective market share greater than 35%. It is only at the level of the top ten varieties that the ratio is upwards of 50%. Yet, it is worth noting that publicly bred varieties are the main varieties in active cultivation. However, we need to keep in mind the following points:

- BM fail to report and consider the historical trend of varietal concentration ratios that would otherwise shed light on whether there has been an increase/decrease in the relevant indicator.
- As companies do market a portfolio of varieties, the evidence in terms of market concentration ratios would be quite different. For example, if the top varieties were all owned by a single company the relevant concentration ratio would be markedly higher.
- Importantly, the concentration ratios in some regions would be much higher than the national average, which is the figure reported here.

Without historical evidence of changes in varietal concentration ratios a reliable conclusion cannot be made. Unfortunately, apart from the case of wheat in the UK, no other available evidence has been reported with respect to either corporate market shares or varietal concentration ratios.

Figure 11



Varietal concentration ratios are displayed in **Figure 11** for wheat in the UK. There has been a marked transformation in the wheat market. Firstly, very high levels of concentration marked the early period with the top two varieties together accounting for 75-80% of the market. In contrast, the post-1970s reveals a share of 40-45% for the top two varieties. Secondly, a similar reduction in the share of the top five varieties is revealed – the share

falling from 75-95% (pre-1970s) to 60-75% (post-1970s). Finally, a third category of varieties emerge in the post-1970s period (labelled `next5' in the figure) with a collective market share of 15-20%. **The increasing proliferation of varieties, supported by diminishing varietal concentration ratios may suggest that the post-1970s has experienced less concentrated markets.**

However, this is not the case. An accurate representation of the seed market requires analysis of corporate market shares. Changes at the varietal level may simply be a manifestation of deeper corporate strategies of rapid varietal replacement – reflecting the entry-exit dynamics noted earlier (**see discussion on p**). In the sense, companies may be securing their market presence through a changing portfolio of varieties – each having a relatively small share in comparison to the corporate share. A conclusion based solely on varietal concentration ratios would be misguided.

Figures 12 and 13 presents market shares for the top wheat breeding companies in the UK. Here the formerly public Plant Breeding Institute (at Cambridge), later owned by Unilever (1987 onwards) and finally purchased by Monsanto (1998), is the clear market leader with its share rising from 20% in 1972 to 80% in 1980. The main competition to the leading position of Plant Breeding Institute/Unilever emerges from a set of multinational breeding companies – **Weibull**, **Zeneca** (formerly under ICI, than Advanta of the Netherlands, now AstraZeneca), **Nickerson** (formerly owned by Shell, now Limagrain of France), **Cambridge Plant Breeders** (initially independent, purchased by Petkus in 1996 – CPB/T in the figure). In figure **13** PBI/C refers to the Plant Breeding Institute under its private ownership of Unilever. Not only are all the competitors multinationals that have been involved in mergers/acquisitions – **but, they are all old breeding companies that pre-existed the enactment of PBRs in UK.**

Evidence from the seed market puts in doubt any claims that provision of PBRs led to increased entry of breeding companies. The **sole beneficiaries of PBRs in the UK have been public breeders and large breeding firms that pre-existed the enactment of the legislation.** More importantly, as will be shortly demonstrated, the main participants in the market have all undergone significant merger and acquisition activities.

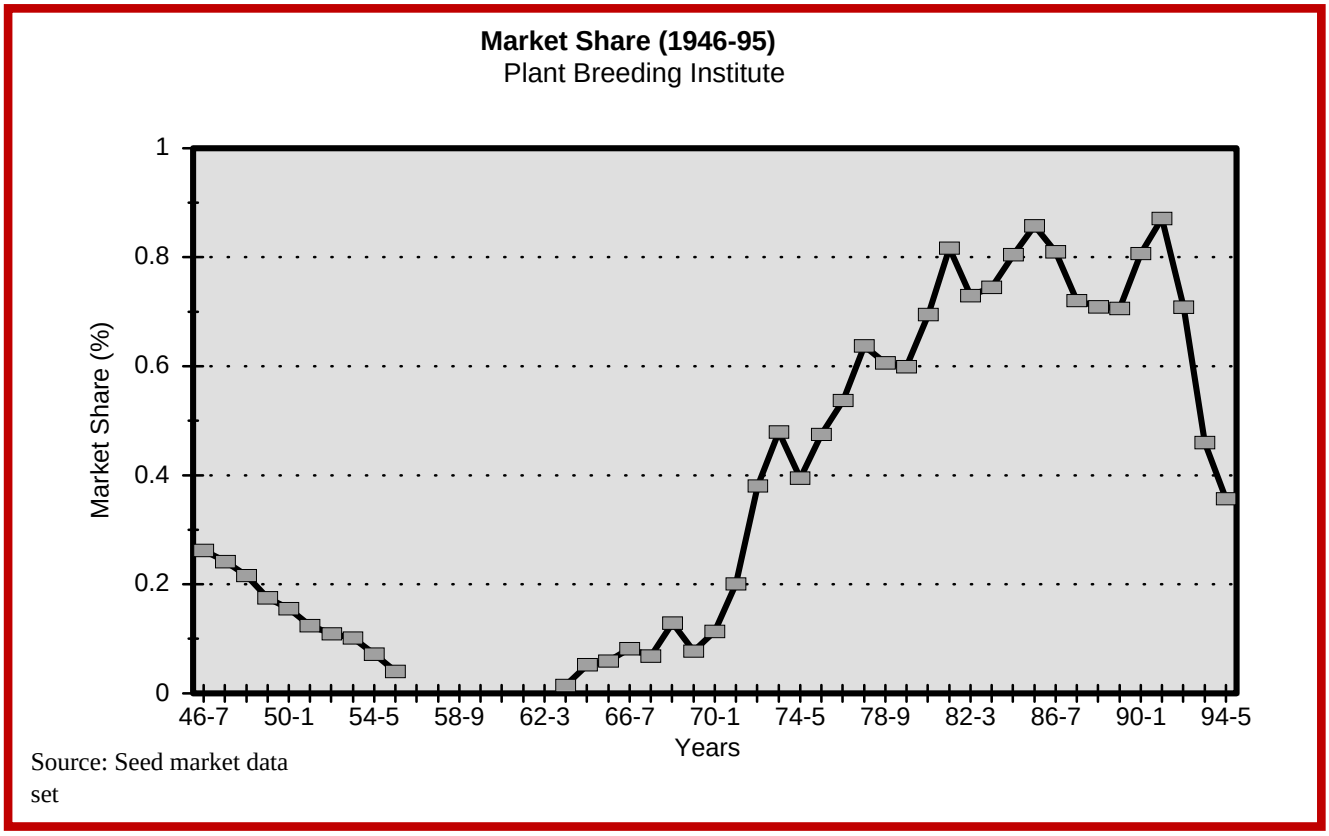


Figure 12

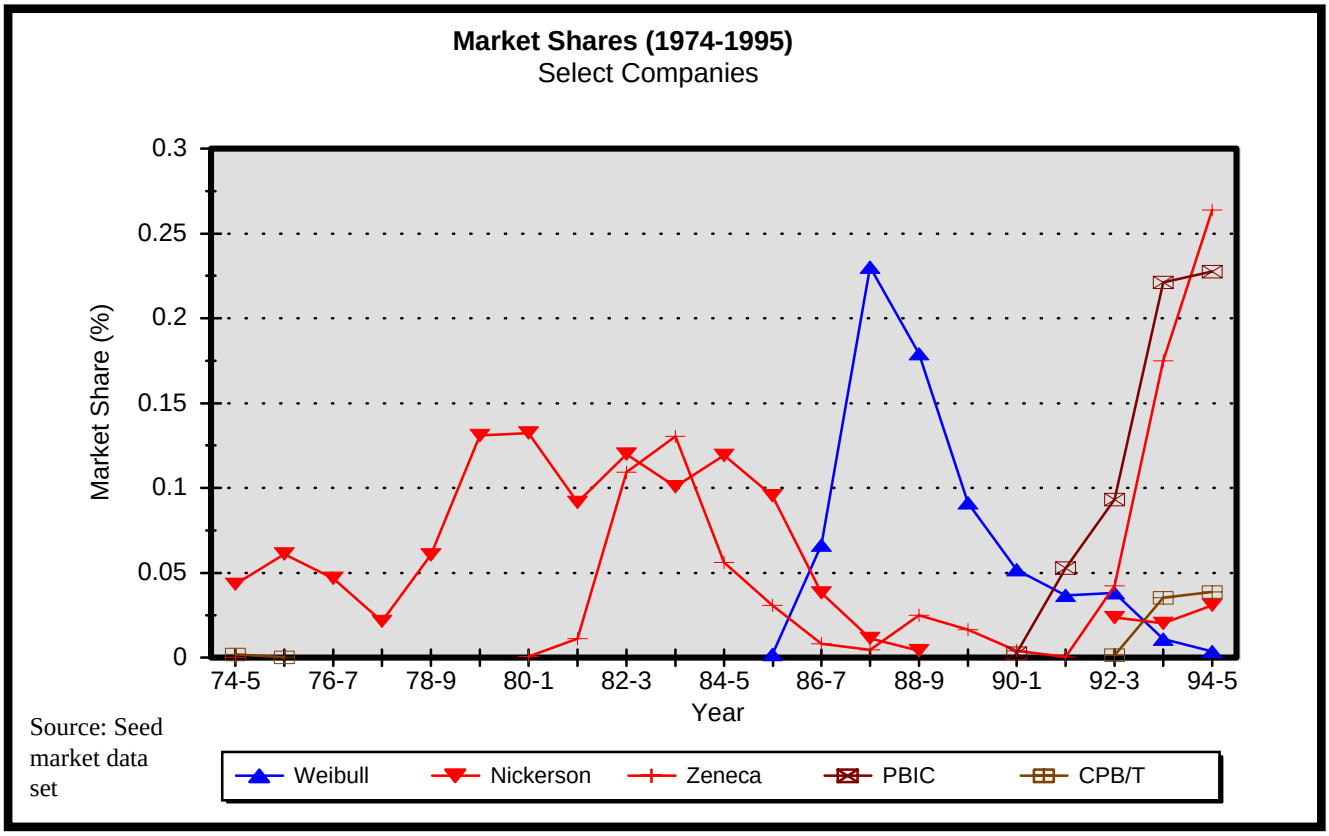


Figure 13

Discussion on market concentration is closely related to the merger and acquisition activities witnessed in the seed industry. Reports in the US note the general perception that the PVPA had promoted increased acquisitions within the seed industry leading to much higher levels of conglomeration – two-thirds of public breeders and four-fifths of seed company respondents felt that the PVPA had led to an increased acquisition of independent seed companies by non-seed companies (see BM). The companies that have bought into the seed industry originate in the following industrial sectors:

- Petro-chemical and pharmaceuticals;
- Grain and food-processing
- Genetic engineering and seed companies

Mooney (1983) reports evidence of 762 corporate take-overs in North America and Europe during the 1960s-80s – chemical companies alone made 246 of these purchases. Between 1976-86, a total US$10 billion world-wide was spent in this acquisition drive – largely led by chemical companies like Sandoz, DeKalb-Pfizer, Shell, ICI, and Ciba Geigy (*The Economist*, 1986). In the US alone, of the 100 corporate take-overs reported in McMullen (1987) only 2 occurred prior to PVPA – 61 occurred between 1970-79, 19 in the 1980s, and dates could not be established for the remainder. The purchasing drive was well-directed and aimed at seed companies with active breeding programmes and strong marketing channels (BM, 1985) – an aspect re-confirmed with respect to wheat breeding in the UK (Rangnekar, forthcoming). **The evidence clearly indicates that the merger and acquisition drive in the seed industry was fostered by the availability of PBRs. Equally relevant are other factors**, such as the success in hybrid breeding across a number of crop species, the widening global seed market and the growing use of chemical inputs, advances achieved in dwarfing (i.e. green revolution varieties).

With the increasing transformation of the seed industry in the US, some commentators note that by the mid-1980s there were hardly any independent seed companies remaining save the anomaly of Pioneer Hi-Bred. In the UK, cereal-breeding companies faced a similar fate – the only possible solution for survival was to consolidate and merge. The main MNCs active in the UK emerged either from the petro-chemical industry or the food industry. As far as the US case goes, BM offer the following conclusion:

> *On balance, conglomerates have probably had a negative influence on the seed industry by acquiring many previously independent companies, eliminating actual and potential competitors in some cases, consolidating plant breeding activities and thereby reducing diversity, and in other cases reducing the viability of the seed companies acquired (p51).*

In the case of the wheat market in the UK, we reiterate the earlier points: (a) the sole beneficiaries have been breeding companies that have been historically active in the sector and (b) managed to consolidate and merge with MNCs. Clearly, the availability of PBRs has not prompted any new entrant into the market.

Consequently, the view that formidable barriers-to-entry have been erected in the seed industry. Much economic research in a wide variety of industries concludes that highly concentrated industries erect formidable entry barriers, which get further entrenched by the system of IPRs. These entry barriers may correspond to scale economies, the cost of conducting R&D, the advertising budget required to secure brand presence, etc. While little of this research has been directed at the seed industry, the following points are worth considering.

The presence of publicly bred varieties and the varietal release policy practised by the public sector is of crucial importance. The availability of these varieties potentially allows small breeding companies to make a market presence without having to incur the substantive costs of developing parental breeding material. Yet, larger companies with the advantage of their scale of operations are able to profitably utilise the newly released parental lines developed by the public sector – a point well established in the case of the US. With respect to the UK, the withdrawal of the public sector, which in the case of wheat occurred with sale of public breeding stations to Unilever, the possibilities for new entrants to participate in the seed industry become more difficult.

The science of breeding has changed tremendously in the last few decades with the increasingly wide spread application of biotechnology. Correspondingly, the costs of developing new cultivars have increased. Importantly, much of this science base remains privately owned. Thus, new entrants are faced with formidable start-up costs of acquiring/replicating the necessary science base. Further, the high levels of concentration in the seed industry make survival for a new entrant all the more difficult.

Exchange of genetic material is fundamental for continuous breeding of varieties – new improved varieties are the result of crosses of locally adapted material. While PBRs do have a liberal research exemption clause, the possibilities of patents encompassing plant varieties will substantially reduce the exchange of genetic material. This would pose new dangers for the seed industry with potentially greater control over the direction of agricultural research being vested with MNCs. There already indication of the of increasing threats to exchange of genetic material. Given the crucial important of genetic material for the continued activity of plant breeding, this is indeed alarming. Recent evidence from an informal survey conducted

with public breeders in the US confirms our apprehensions (Price, 1999). Based on a simple questionnaire, Price received 86 responses, representing 25 US universities and 41 crops. The responses were as follows:

- 48% indicated that they had experienced difficulty in obtaining genetic stocks from private companies;
- 45% indicated that this had interfered with their research;
- 28% felt that it had interfered with their ability to release new varieties,
- 23% reported that it had interfered with the training of graduate students.

The results raise a number of questions related to the fundamental role of public breeding? And highlight possible issues concerning on the location of agricultural research - Is it in the public interest to have future varietal releases done predominantly by industry? If training of future breeders is being threatened, who will ensure the continued recruitment of breeders?

4.5 Reflections on Market Power – Evidence of Changing Seed Prices

An empirical indicator of market power is the trajectory of seed prices. **Theoretically, it is believed that an industry with a high level of monopoly power demonstrates markedly higher prices, as corporations are able to create barriers to entry and forestall competition**.

A number of factors are relevant in determining the market price of seeds. For example, the range of varieties available and the competition between different companies producing the varieties, the presence of publicly-bred varieties and the availability of on-farm saved seeds. Equally important are the productivity improvements revealed by the new varieties being produced and the market competition in the downstream sectors using the variety. Evidence of changes in the seed prices are represented in the following trends:

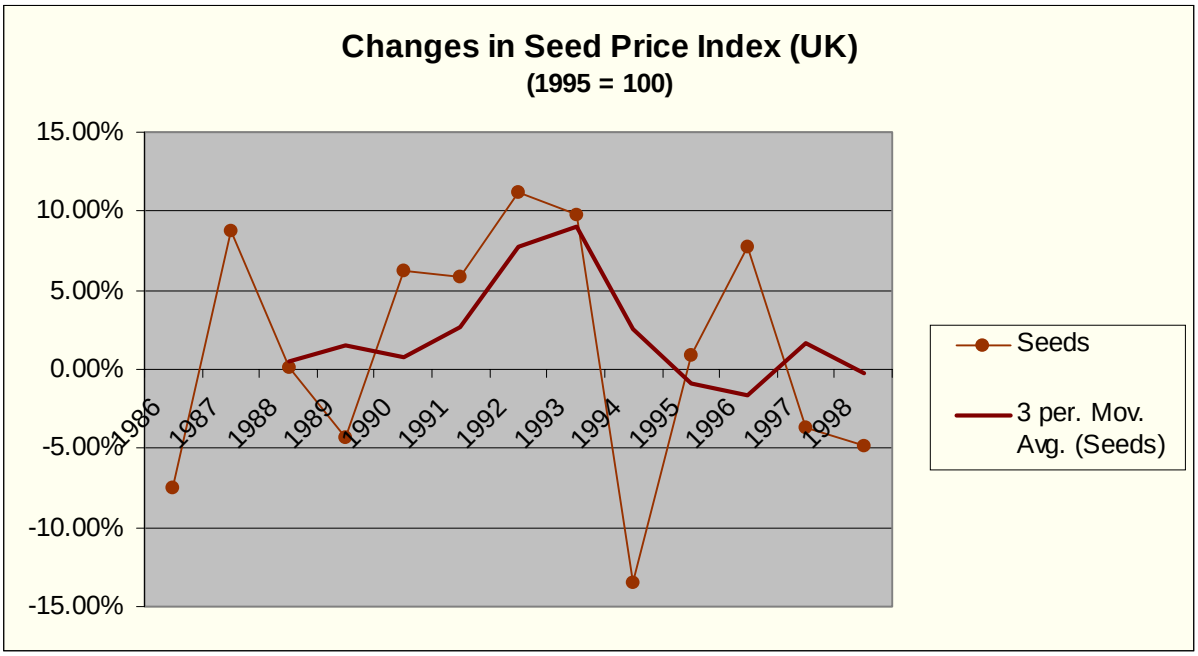
- Expenditures on seeds as a proportion of total expenditures for farm inputs have increased from 1.9% in 1960 to 3.2% in 1977 and settled at 3.0% in 1980. However, for some species it is much higher – corn 10.4%, soybeans 14.3%, wheat 11.1% and peanuts 18.3% (1979 figures).
- Seed expenditures quadrupled between 1970-80 – a rate of increase comparable to the increases in fertiliser expenditures – three-fourths of the increase were attributed to increases in seed prices, the balance being on account of increased amounts of seed purchased (BM). In constant dollars (1960), seed expenditures increased from $519Mn in 1960 to $1515Mn in 1980 (PKI)

- Disaggregating seed prices increases to the species level reveals that price increases in wheat, soybean, barley and cotton have been comparable to those established by hybrid corn during the 1970-80 period (Claffey, 1981).

How has the evidence of increases in seed prices been explained by the literature?
Interestingly, much of the literature appears as apologists for the system of PBRs. BM suggest that it would be "misleading to attribute all or a major portion of the price increase to the enactment of PVPA" since it would only have an influence on privately protected varieties. This argument is partly true – however, public varieties that are protected would also contribute to increases in the seed prices. Further, the increased monopolisation of the industry, in part driven by the availability of IPRs, lies at foundation of these changes.

PKI provide a more alarming explanation by suggesting the (a) the seed price increases at the species level reported by Claffey (1981) is simply a catching-up of non-hybrid species with hybrid corn and (b) the price premium is essentially a reflection of the increased productivity of the new varieties. Unfortunately, PKI fail to establish that the new varieties are more productive. Further, most of the acreage is devoted to publicly-bred varieties. Finally, the fact that non-hybrid crops demonstrate seed price increases comparable to hybrid corn (which is produced by a highly concentrated industry) is alarming given the option of on-farm seed saving and over-the-fence seed sales. **Naturally, there is more to market power of the consolidated seed industry than what these authors are willing to accept**.

Figure 14



In the UK, the index of seed prices has increased remarkably over the last two decades – the 1985-93 period saw an increase of 34%. Compared to other agricultural inputs, e.g. fertilisers, energy, etc., the increase in seed prices comes only second to the 50% increase registered by plant protection chemicals. **By 1993, seed prices were over 30% more than there real value in 1985** (**Figure 14 Changes in Seed Price Index (UK)**) The period of rapid increase in seed prices – 1989-94 – coincides with the sale and/or closure of various public breeding station (e.g. the sale of Plant Breeding Institute, Cambridge to Unilever – see Table 2). With the withdrawal of the state from the market the possibilities of controlling seed prices and maintain a competitive presence in the market was immediately lost. It is felt that this withdrawal of the state is manifested in the seed price increases. For example, in the case of wheat, Unilever inherited a disproportionate market presence – over 80% of wheat seed market was sown to PBI-bred varieties – it must have been the case that Unilever exercised its market power in pushing up seed prices. There is limited data on disaggregated seed prices to help establish the above perception. One possible factor supporting the increase in seed prices is the royalty rate breeders are legally allowed to charge. In 1989, the system changed as each firm was allowed to independently establish its own royalty rate. A 1990 study of the wheat seed industry provides very limited quantitative data on royalty rate changes (Persson, 1990).

- **Royalty rates increased through 1988-90** on all categories of certified seeds.
- **Increases in royalty rates were greater than the increase in seed prices**.

The latter point is a reflection of the ability of breeding companies to charge a **mark up**. **Consequently, the view that farmers are probably paying more for agricultural research under a system of private ownership** (Pray, 1996).

Conclusion

Here I will briefly identify some of the key points established in the analysis presented above. In chapter 1 the analysis was devoted to the history of the PBRs system. An important point of the analysis is a realisation that PBRs originated within the efforts devoted to rationalising and harmonising national seed certification schemes across Europe. Much of the core aspects of UPOV were developed by seed certification regulations. While the concerns of regulators was on varietal quality and seed authenticity, breeders succeeded in developing there demands in terms of trading enhanced protection for guarantees for maintaining seed quality. The discussion establishes that seed certification schemes provided *de facto* breeders' rights, however, UPOV enabled their legal articulation.

Conclusion

It is always important to keep in mind the factors that prompted the creation of a *sui generis* system for the protection of plant varieties. The analysis draws attention to a number of factors that favoured the widening application of patent law in the 1950s to include plant varieties. Yet, the exclusion of plant varieties from patenting was primarily a result of the opposition from lobby groups representing patent lawyers. In addition, the activity of plant breeding and the nature of plant varieties also posed insurmountable problems for their inclusion within the application of patent law. Consequently, some peculiar aspects of UPOV – the absence of a test for inventiveness or merit test for new varieties, the relaxed requirement for novelty and the unique method of disclosures.

In the UK, the debate on PBRs closely followed Continental developments. Thus, once again we see the close relationship between seed certification schemes and the provision of PBRs. An examination of the conflicts between the demands being made by farmers and those by breeders is illustrative of the manner in which the *consumer rhetoric* of seed labelling gets transformed into a means for providing PBR. Farmers were demanding a merit test prior to market entry of varieties and legally-binding seed labelling. In response, breeders argued that seed quality can only be guaranteed if greater controls over seed production were offered to breeders. In this manner, one of the demands of farmers was accommodated whilst breeders succeeded in securing PBRs.

Chapter 2 reviewed statistical evidence representing changes in the status of agriculture in the UK. Agreeably, there have been marked technological and productivity improvements in agriculture, partly captured in the following trends:

- **Labour input** in agriculture in the mid-1980s was 1/10th of that required in 1930.
- Total **horsepower of tractors** have grown more than 10-fold since 1945.
- **Nitrogen fertiliser** use has increased more than 6-fold since 1945.

Reflecting these changes has been key varietal developments – particularly the introduction and adoption of dwarf varieties. Consequently, yields have increased tremendously in agriculture. Yet there are a number of apparent paradoxes within the techno-economic transformation of agriculture in the UK. For example, contrast the productivity indicators with the reality of diminishing commercial viability of farming -–the latter captured in the fact that net farm incomes have consistently fallen in recent decades. Farm incomes are falling as agricultural input prices are rising faster than agricultural output prices, despite the extensive support system. Finally, the review drew attention to the worsening land distribution system in the UK.

Conclusion

Chapter 4 reviewed the development of UK's agricultural research system, which drew attention to the general struggle to control resources devoted to agriculture. Part of the struggle was a reflection between differing political ideologies of central control and *laissez faire*. Consequently, the last century has experienced great reversals in the state's role as provider of agricultural research. In the more recent past, the prevailing ideology of radical liberalisation witnessed the withdrawal of the state from `near-market' research. As a result key plant breeding stations were either closed or sold to the private sector.

Chapter 5 presented economic analysis of the impact of PBRs in the UK and US, focussing on three themes: (a) private investment, (b) introduction of new varieties and (c) market power.

With respect to private investment and the number of firms active in plant breeding, the following evidence has been reported earlier:

- Mixed evidence in terms of number of firms active in plant breeding. While evidence of increasing entry of firms into plant breeding is mixed, **there is compelling evidence of seed industry consolidation**. The latter is well supported by reports of widespread mergers and acquisitions within the industry.

- There is indication of increasing levels of private investment in plant breeding. Yet, **the clear influence of PBRs on the level of investment is not theoretically convincing**. More importantly, older firms that pre-existed PBRs legislation have been the most active.

- Private investment appears to concentrate on select crops, suggesting that the **profitability of the crop is more crucial in bringing forth private investment.** As such, the stimulating role of PBRs is questionable. Alternatively, PBRs on their own cannot account for increased private investment. The latter point is amply demonstrated in the discussion concerning soybean.

The evidence of PBRs is most often presented in terms of increased number of new plant varieties. The study establishes that this focus is mistaken and deluding. **The important questions is whether PBRs *caused* the changes in the number of new varieties.** None of the US-based studies have theoretically addressed this question. Econometric exercises with respect to the UK convincingly establish a very mixed result – in some cases, PBRs can be claimed as having ***caused*** an increase in the rate of introduction of new varieties.

Yet more important is the empirical evidence in terms of the **entry-exit movement of plant varieties – net grants**. It has been demonstrated that companies are constantly replacing the portfolio of varieties – the rate of introduction of new varieties is part of deeper commercial strategies of changing the portfolio of existing varieties. Consequently, **there are a number of periods when the market experiences a net withdrawal of varieties.** This evidence undermines claims concerning PBR's positive impact on inventive activity.

Conclusion

Statistical evidence on the distribution of PBRs grants confirms our suspicions of a highly concentrated market. Data concerning the US establishes that across a range of crops there is an unhealthy level of concentration. **Time series data for wheat in the UK confirms that PBRs distribution has tended to worsen with time** – about 5% of the applicants controlled between 68-89% of the grants issued. An overwhelming 75-82% of applicants did not receive a single grant throughout the period of study, 1965-95. **The main beneficiaries of the PBRs system have been the older breeding firms that have been subsequently consolidated within MNCs.**

The high level of concentration in the distribution of grants is reflected in market shares. The only **time series data available confirms that market shares have remained quite aggravated**. While there may be more varieties in the market, corporate shares have not diminished. **Entry-barriers exist in the seed industry, compounded by the skewed distribution of grants**. One reflection of **market power** is the behaviour of seed prices. The following evidence has been reported:

- In the US, three-fourths of the increase in seed expenditures is attributed to increases in seed prices, the balance resulting from increased amounts of seed purchased.
- In the UK, seed prices (aggregated for all species) increased by 34% between 1985-93 – an increase second only to the increase in price of plant protection chemicals. The increase in royalty rates (a result of PBRs) has been higher than the increase in seed prices.

On all three issues, investments, number of varieties introduced and monopoly power one finds limited theoretical proof for the positive role of PBRs. One defining feature of the results reiterated above is the general fact that older breeding firms, now consolidated within MNCs, have been the primary beneficiary of the availability of protection. Further, the study establishes the influence of a range of other factors that have compelling impact. Based on the review completed here it would be difficult to recommend the generalisation and harmonisation of PBRs (the UPOV system) across developing countries. Equally, there is no theoretical support for further expanding the scope of PBRs.

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