Privatization of Crop Breeding in the UK: Lessons for Other Countries

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Abstract

In the face of higher grain prices and slowing agricultural productivity growth the G20 Ministers announced the International Wheat Initiative. In North America, the privatization of public wheat breeding programs is seen as a means foster productivity growth. This paper explores the UK experience with the privatization of wheat breeding that began with the sale of Cambridge Plant Breeding Institute to Unilever in 1987. Beginning with an economic framework, the analysis presented in this paper is based on interviews with sixteen experts currently involved in wheat research/breeding in the UK, all interviewed during the month of July 2012. Taking a snapshot of UK wheat research today, it would be easy to conclude that the UK sector made a smooth transition from public to private breeding. However, this is not the case. The UK faced many challenges in establishing an integrated wheat innovation system and has only recently developed policies and funding processes that have allowed upstream public scientists to work with small, arguably underfunded, downstream private wheat breeding industry. As policy makers around the world contemplate the privatization of crop breeding, important lessons can be drawn from the challenges and successes of the UK crop research funding model.

Keywords crop research funding, innovation, privatization of research

JEL code (**Q160** Agricultural R&D, **O320** Management of Technological Innovation and R&D)

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1.0 Introduction

1.1 Background to the Study

The food crisis of 2007, and the higher grain prices that have prevailed since, have renewed both private and public interest in agricultural research. Despite persistently high estimates of rates of return to agricultural R&D and the compelling evidence of significant contribution of R&D to increases in farm productivity (Alston et al. 2000), most developed countries have reduced the intensity of crop research and breeding since 1990 (Alston et al., 2010). While some crops with strong property rights, such as maize and canola, have witnessed increased private investment to replace public funds, most crops have not. With the current economic conditions and budgetary pressures that most of the developed world currently faces it is unlikely that government support of agricultural R&D will be as generous as it was a half a century ago. Given this prognosis, there is a need to design an innovation system with sufficient research investment to sustain a more optimal pace of innovation.

The privatization of wheat breeding, is increasingly viewed as a means to increase breeding activity. In the United States several land grant Universities[1] have announced wheat breeding partnerships with private multinational firms. In Canada, Bayer Crop Science has recently initiated a wheat-breeding program in Western Canada. Agriculture and Agri-Food Canada, which currently operates Canada's largest wheat breeding program, has indicated its intention to privatize its commercial breeding activities (Jones, 2012). Australia has privatized its wheat breeding industry over the past decade and has attracted investment from many global crop research firms.

[1] Bayer Crop Science-South Dakota State University and Nebraska, Monsanto-Kansas State, North Dakota SU, and Virginia Tech, Limagrain-Idaho and Colorado (National Association of Wheat Growers, 2012)

While the privatization of public crop breeding is a means to increase total research investment, it can also induce significant changes in knowledge sharing, research linkages, research networks, research practices, the role of public research and other relationships. These consequences are also very important for research outcomes. It is therefore important to fully understand these broader implications of privatization of crop breeding. Some of this understanding can come from examining the experience of other countries where privatization of breeding has already taken place.

The UK is an example of a country that has restructured its crop research funding by privatizing commercial wheat breeding. Twenty-five years have elapsed since the UK government sold the dominant Cambridge Plant Breeding Institute to Unilever in 1987. About a decade after privatization there were a number of studies that examined the UK agricultural research system reaching somewhat different conclusions. Pray (1996), suggested that "while it was still too early to tell" the privatization appeared to be successful in attracting additional research in the sector. McGuire (1997) expressed more concern suggested that "In the UK, the declining public support for basic research and germplasm enhancement has proven to be a major constraint in the pursuit of new lines of work."1997. Thirtle et al. (1998) showed that the declining research output was predictably linked to declining investment in basic and applied research. Now that 25 years have elapsed, there is sufficient time to update these studies by observing the longer run consequences of privatization such as industry structure, investment patterns, pricing behavior, and see how public policies have been modified and adapted to support the private breeding sector. Given this path of development the UK provides excellent case study for other countries contemplating a similar move.

The objective of this study is to examine the development of wheat innovation system in the UK subsequent to privatization of wheat breeding. The lessons that we draw from British experience can guide future policy initiatives for wheat industry in Canada and other countries where privatization of crop research is being contemplated. To the extent that properties of knowledge as either public or private good have similarities across sectors, the paper identifies some of the new incentives and challenges that can more generally emanate from the privatization of a public applied research program.

The analysis presented in this paper is based on public information and personal interviews conducted in July of 2012 with sixteen people involved in wheat research/breeding in the UK. The interviews employed an open-ended question structure allowing the participants to describe the system, and as discuss in detail the perceived advantages and disadvantages of the UK crop research funding model. The interviews reflected viewpoints of both public researchers and private breeders including wheat scientists from the University of Bristol, John Innes Centre, Rothamsted Research, and National Institute of Agricultural Botany (NIAB); wheat breeders from Limagrain-UK, KWS-UK, DSV, Saaten Union-UK, and Syngenta; and experts from the British Society of Plant Breeders.

Presenting our finding in a conference length paper is challenging.[2] We begin by reminding our readers some of key economic forces at play in privatizing research. In section three we describe several of the institutional and policy changes that have shaped the sector since 1987. In section four we qualitatively and quantitatively describe how

[2] For a more comprehensive report see Galushko and Gray 2012.

wheat breeding has evolved since privatization. Finally, in section five we draw some conclusions that can form the basis of lessons for other countries embarking on a journey of privatization.

2.0 Market Failures in Agricultural R&D

When unprotected by intellectual property, the knowledge embodied in a seed for a new variety shares the non-excludable and non-rival characteristics of public good (Gray, 2012). When farmers are free to replant the harvest for seed, the knowledge is non-price excludable making is difficult for private firms to capture a return from breeding investment. The knowledge is also non-rival, because once created a variety be reproduced and used over and over again without exhaustion. These characteristics are both sources market failure and are at the root of public involvement of crop research.

2.1 Excludability and the private incentives to invest

The implications of non-excludability are well understood. When a good is not price excludable, benefits can spillover users without payment leaving private firms without incentive produce the good (Alston 1992). Governments have typically used property rights to create the foundation for market transactions. For many types of knowledge patents and copyrights have played an important role. In the case of self-pollenated crop varieties, plant breeders rights (PBR) laws are used to improve excludability and to increase incentive to invest. From a market failure perspective the strength of property rights are important because any value from research that spillover to user without payment, reduces the private incentive to produce a good.

2.2 Non – rivalry and toll goods

The implications of the non–rival characteristic is also important but arguably less understood. Once knowledge is created, it is non-rival in use because it can be used again

and again without exhaustion. Years of breeding and testing effort goes into the development of new variety, once created these large costs are sunk and become a fixed cost. The marginal cost of applying this new embodied knowledge on more acres, is very low and approximates zero once the variety reaches commercial production. Given the large fixed costs and low marginal cost the breeding firm has significant economies of size, in the production of a variety. These size economies are further enhanced by firm specific knowledge, complementary assets and capital, which are employed in the creation of subsequent or multiple varieties.

These toll good related size economies create conditions for a natural monopoly where one firm has a significant cost advantage over multiple firms, creating strong incentives for creation of a concentrated breeding industry (Fulton, 1997; Lessor, 1998). If only one breeding where to exist in the breeding industry, it would enjoy the maximum economies of size but would also had incentive monopoly price, which would impede adoption. Any profits of the monopoly will tend to attract additional firms into a private breeding industry, thereby increasing pricing competition. Unfortunately additional entry fragments the markets and because of the toll good natures of the knowledge inputs, entry will drive up average industry costs, as each firm operates with a smaller market share. (Gray, 2012). As shown in Figure 1 social welfare impacts of entry are ambiguous depending on whether gains in surplus from lower seed prices is greater than the losses associated higher industry breeding costs. As result of these two effects a breeding industry is likely to exhibit a combination of some market power and some duplication of effort.

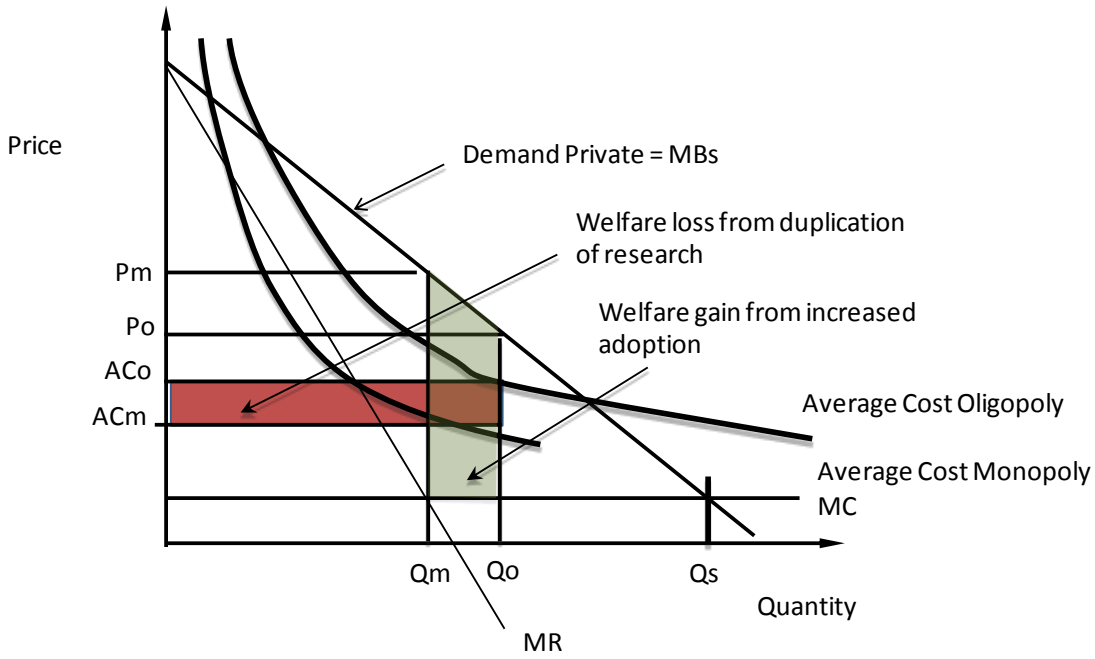


Figure 1: The welfare effects of Firm entry in a Toll Good Industry (Gray, 2012)

In sum, economic theory suggests that privatization of breeding requires intellectual property rights. In the absence of complete property rights, spillovers will reduce the market demand for varieties. The non-rival characteristics of embedded knowledge suggests that crop breeding will have economies of size and create a toll good industry that will be subject to market power and duplication of effort. In the analysis to follow we will reflect on the extent these effects are apparent in the UK wheat industry.

3.0 The privatization of wheat research

3.1 The evolution of Plant Breeding Institute

The Plant Breeding Institute (PBI) held a dominant position in the history of the UK wheat research/breeding industry for 75 years. PBI was established at Cambridge in 1912 as part of the Department of Agriculture. In the early years, its work mainly evolved around development of improved wheat varieties with an emphasis on grain quality. Prior to the Second World War PBI had about 25% of winter wheat variety share (Thirtle et al.

1998). During and following the war PBI market share had fallen to zero as foreign bred wheat varieties dominated UK winter wheat. After the Second World War it became a national priority to increase food production and research was considered an essential means to this end. As a result, in the post-war years funding to agricultural research centers in Great Britain was increased substantially and the breeding work at PBI was expanded to include barley, peas, maize, oilseed rape, and others. The increased investment paid off. The PBI made a significant contribution to the UK wheat research and breeding industry and helped Great Britain play a major role in global wheat research during the green revolution through the introgression daylight insensitive, semi-dwarf wheat. PBI's wheat varieties averaged about 80% market share from the 1970s onward.

The returns to PBI research were very high. Thirtle et al. (1998) estimated a 50% annual social rate of return wheat breeding during this period. Pray (1998) estimates that in 1986 the royalties generated from the commercialization of PBI varieties was sufficient to pay for all PBI breeding and pre-breeding research and still generate a surplus of 23%. So not only were the breeding activities creating a social benefit they were being paid for by the downstream users at no direct cost to the taxpayer.

Despite PBI's apparent success, the Thatcher government felt that it was not the government's role to be closely involved in near-market research (variety development). In 1985 the Agricultural and Food Research Council proposed a policy that would re-organize British research institutes. The privatization of PBI crop breeding programs was one of the pillars of the proposed policy. In 1987, PBI's breeding programs and farm sites were sold to Unilever, a private food company. The units doing basic research on cytogenetics, molecular genetics, and plant pathology were excluded from the sale, and

were later transferred to the John Innes Centre in Norwich. The commercial portion of PBI acquired by Unilever became known as the Plant Breeding International Cambridge (PBIC), a "private" breeding organization. This sale effectively ended public commercial wheat breeding in the UK.

3.2 The Development of a Private Wheat breeding sector

A private wheat sector has existed in the UK for many decades. From the 1920s to 1950 UK private firms had the largest share UK winter wheat variety sales, only to become dominated by foreign variety sales during the 1950s and 1960s and by PBI varieties during the 1970, 80s and 90s. (Thirtle et al., 1998). Presently, the private sector again dominates new variety sales. A small wheat breeding industry had co-existed with PBI after the introduction of PBRs in 1964. Because PBI was large, well-funded, and very effective, private companies found it very difficult to compete PBI. At the time of PBI's sale each firm only had had three or four percent market share while PBI dominated the market.

In 1998, the PBIC was sold to Monsanto, which was interested in wheat as a crop with high potential for application of genetic engineering techniques and development of hybrids. Strong consumer resistance towards GM wheat, and failed attempts to produce commercially viable hybrid wheat contributed to the loss of interest in wheat. Monsanto gradually pulled out resources from wheat research/breeding and sold the breeding unit to RAGT Seeds Ltd in 2004. McGuire notes that in 1994 PBIC still had a market share 59% of the winter wheat seed market. As shown in Figure 2, between 2000 and 2011 KWS UK Ltd has released the most varieties in the UK. However, over the past 3 years RAGT was the breeder for less than 12% of Recommended Winter Wheat varieties (HGCA,

2013). Thus the remnants of PBI has only retained a minor market share UK wheat varieties.

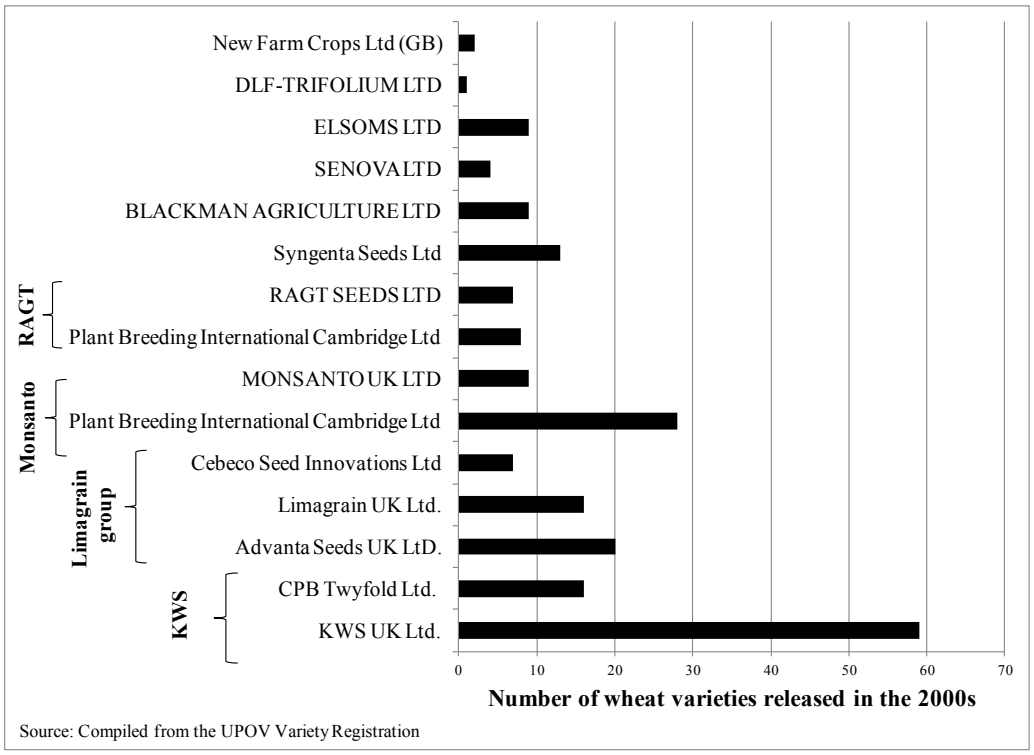


Figure 4. The number of varieties released in the UK in 2000-2011, by breeding companies (Galushko and Gray, 2012 p.6)

In the past 20 years the private UK breeding industry has also seen considerable consolidation. Some interviewees expected more consolidation in the future, while other felt that the UK wheat market was pretty mature and expected no major changes are to be expected in the next 10-20 years. Currently, wheat breeding programs in the UK reside with Limagrain UK Ltd., KWS UK Ltd., RAGT UK Ltd., and Syngenta UK Ltd. with the largest breeding programs being in the range of £1.5 Million per annum. There are also a few of smaller private companies involved in wheat breeding and these include DSV (Deutsche Saatveredelung AG) UK Ltd., and Saaten Union UK Ltd.

3.3 Plant Breeders Rights and Royalties

The development of the UK private wheat breeding sector has been heavily influenced by the development and use of Plant Breeders Rights (PBRs). Without an appropriate intellectual property rights the farmers ability to reproduce seed undermines the ability of the seed developer to generate enough rents through seed sales. To address this issue, almost all countries in the world have now adopted some form of plant breeders rights (PBRs) based on the principles of the International Union for the Protection of New Varieties of Plants (UPOV), an international agreement that encompassed 70 countries as of April 2012.

PBRs are intended to preserve the interests of both farmers and breeders. To this end, two exemptions are built into PBRs – the breeders' exemption and the farmers' exemption. The breeders' exemption allows breeders to use any variety protected by PBRs in their breeding program without permission from the PBRs holder. Farmers' exemption allows farmers to use harvested seed for subsequent reproduction on their own farm. To adjust to changing market conditions and to create stronger incentives for private investment, UPOV was revised in 1972, 1978, and 1991. Even though farmers' and breeders' exemptions are present in all of the revisions, in UPOV-91 the right to save seed is no longer an automatic right. UPOV-91 leaves it at the discretion of individual countries to decide whether to grant farmers the right to save seed. Countries that are signatories to UPOV-91 can also choose to collect royalties on farm saved seed.[3] Western European countries except Italy, Norway, and Portugal have all adopted the 1991 revision of the UPOV.

[3] Although a signatory to UPOV-91, Canada still adheres to UPOV-78.

In 1994, the EU passed legislation to become complaint with UPOV-91 that enables plant breeders to apply for EU wide protection of registered plant varieties. In this legislation, the EU allows breeders to charge a royalty on farm saved seed as long as it is *sensibly lower* than the royalty on certified seed.

The UK has revised its own PBR legislation a number of times to remain compliant with changing UPOV agreements and consistent with EU PBR legislation. This process began in 1964 when the UK passed UK Plant Variety and Seeds Act to become compliant with UPOV 1961. This act was amended again in 1983 to become complaint with UPOV 1978. The 1997 Plant Variety Act was a significant change and contained provisions for royalties on farm saved seed making the UK compliant with the UPOV-91 and consistent with the 1994 EU PBR legislation.

The EU and UK legislation provides for three different ways in which farm saved seed royalties can be collected. The first one is through a direct contractual relationship between the breeder and the grower, in which case the farm saved seed royalty is established between the two parties. The second one is through an agreement between a breeders' association and a farmers' association. If neither of the two options can work, then the third option is the default royalty rate on farm saved seed of 50% of that on certified seed.

Using the second option, the British Society of Plant Breeders has negotiated a contractual arrangement with the National Farming Union (NFU) setting a uniform royalty rate on farm saved seed. The royalty rate is set up through collective bargaining and negotiation between the BSPB and the NFU. The royalty rate on farm saved seed currently set by formula to be equal to 52.5% the weighted average royalty rate on

certified seed grown one year before. This agreement combined with the provisions of the 1997 Plant Variety Act creates the legal framework for royalty collection in the UK.

While paying levies on far saved seed is a legal obligation, the collection of farm saved seed requires cooperation of farmers, particularly those farmers who clean the seed on their farms. The BSPB works closely with the NFU to promote the importance of royalty payments to support breeding. They also maintain contacts of all farmers who are contacted twice a year to remind them of the importance to support plant breeding and pay royalties. Because the royalty collection from farmers heavily relies on good will, the BSPB tries to avoid any measures that can be viewed as coercive. Although it has taken many years for the system to become fully functional, the royalty collection system has a high compliance rate with low costs. Overall, the system gives the UK breeders the ability to collect royalties on virtually all certified seed and about 90% of farm saved seed. The administrative costs of the system represent only a small proportion of collected royalties: the BSPB only retains 1-2% of the royalties to pay for the costs of running the program for certified seed and about 10% to run the program for farm saved seed; and the remaining funds are returned back to the breeders.

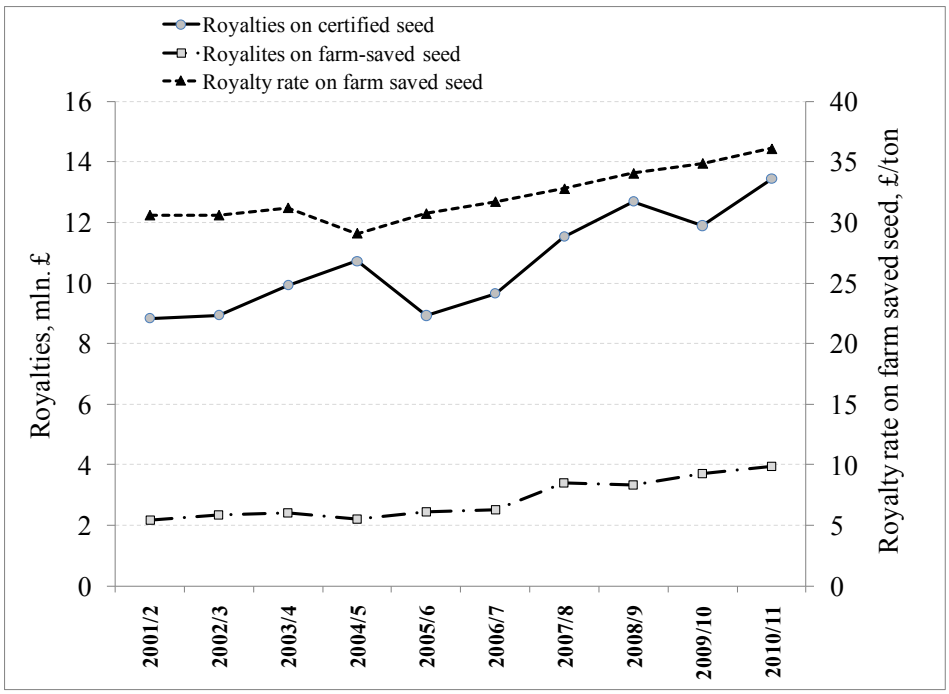
3.4 Wheat Breeding Revenue and Research Investments

Despite the well-defined PBR property rights and the effectiveness of the UK royalty collection system, total royalty revenue remains very modest in the UK. The 2010/11 total royalty income of £17 Million is about £1 per tonne produced or .5% of gross sales. As a point of comparison, Gray (2012), estimates the Canadian hybrid canola seed sales generate $578 Million in rents for breeders in a similar sized industry. As shown in Figure 3, as new better varieties have been adopted over time, UK royalty rates have only slowly increased. Royalty rate on farm saved seed was £36.1 per ton of seed in 2011,

which is equivalent to £0.56 per ton of harvested grain. Because these FSS royalty rates are 52.5% percent of the weighted average of the previous years certified seed, this implies a 2010 weighted average royalty was £68/t. While these royalty rates have increased over time has to also keep in mind that wheat prices have approximately doubled since 2006, a further indication of a royalty system that does not generate a lot of revenue relative to the gross sales of wheat.

Several interviewees indicated that about one-third of generated royalty income is re-invested back into breeding programs. Although this rate of reinvestment is a higher proportion than for most other industry sectors (Webb, 2010), this suggests private breeding expenditures of about £6 million per year for sector, or about £1 million per breeding program. As each of the firms indicated, they operate small breeding programs in the UK. Arguably the royalty structure UK wheat sector has failed to generate significant revenue for private wheat breeders and accordingly large investments have not occurred. Many firms also have strong linkage to breeding programs on the continent, which augments their effectiveness in the UK breeding resources. However, the limited size of royalties collected is a very significant constraint on the effectiveness of the private breeding industry.

From an economic perspective any wedge between what a farmer is willing to pay for varieties and the benefits they receive from those varieties will limit the ability to generate revenue for private breeding. The ability of farmers to plant last year's varieties as a farm saved seed, while paying only 52.5% of the average royalty rate, severely constrains what any firm can charge for seed royalty on a new variety. As a result, new seed royalties must be conservatively priced in order to capture some market share. In



Source: The British Society of Plant Breeders

Figure 3: Wheat royalties in the UK 2001-2011

turn, next year 52.5% of these conservative seed royalty rates are reflected in the farm saved seed rate perpetuating the under pricing. The private sector also views a 52.5% royalty rate on farm saved seed as an element creating some underinvestment in the system and this is supported by a quote from one private wheat breeder:

> "The one factor I think which actually interferes with the function of the free market is the situation with farm saved seed. I think the European regulation where farmers can go with farm saved seed and pay half the royalties, saying it is inequity is probably the wrong emphasis but I think it's an artificial subsidy in the system".

3.5 Funding for upstream or Pre-breeding research

The sale of PBI and the relocation of some public scientists to other institutions, was accompanied with a watershed of change in science funding and the combination had a devastating impact on public wheat research. The Biotechnology and Biological Sciences Research Council (BBSRC) allocated funding to individuals and their institutions'

programs, on the basis of the citation rates and the journal impact factors of their peer reviewed publications. While this policy may have improved the scientific rigor of the work, it had a side effect of moving scientific effort away from applied wheat research toward more basic science on *Arabidopsis* and other model crops. The result was disconnect between what the public researchers could get funding for and what the private wheat breeding firms needed as input into their programs…and the public researchers followed the money.

As outlined in more detail in Galushko and Gray (2012) report, several interviewees refer to the early period of post privatization as "lost years". Both public ad private researchers, although satisfied with the current system, felt the UK system lost 15 years of progress, by fracturing an integrated research system. Over the past decade, the public sector has made progress in developing funding systems and new institutions that provide incentive for public scientists and public institutions to undertake a portfolio of research that has long term commercial value for the industry.

In response to the efforts of the private sector to bring public scientists closer to plant breeding, the UK government launched a number of initiatives that are outlined below:

- *LINK program* created by the Department for Environment, Food, and Rural Affairs (DEFRA) was one of the first initiatives of the British government to bridge the gap between breeding and science. Within LINK, private breeders would collaborate with public researchers on research projects that had a direct relevance to industry needs.
- In 2003 DEFRA launched an initiative called the *Wheat Genetic Improvement Network* (WGIN). Meetings are organized every four months and are attended by researchers, breeders, and sponsors of wheat research including representatives of BBSRC, Home Grown Cereal Association (HGCA), and wheat breeding firms. By including a good cross section of wheat sector the WGIN can incorporate feedback right through the genetics to farming. The WGIN has been a rapid catalyst for getting breeders and academic people in the same room to talk about their common

problems and after the review of a 5-year WGIN initiative it was decided that the government support to WGIN had to be continued and funding was extended until 2013 in the amount of almost £1.7 million over a five year period. The UK government is now looking into WGIN-3.

- *Crop Improvement Research Clubs* (CIRC) is program supported by the BBSRC: for every hundred thousand pounds raised by industry the BBSRC contributes nine hundred thousand to the 'Club'. CIRC is £7.06 million, five year research partnership run by the BBSRC, the Scottish Government, and a consortium of 14 leading biotech, grain, and oilseed companies.
- *LOLA/WISP pre-breeding program* is a publicly funded collaborative program between the UK academic and private sectors involving NIAB, John Innes Centre, Rothamsted Research, University of Bristol, University of Nottingham, and the private breeders who sit on the advisory board. The goal of the pre-breeding program is to have public researchers involved in the development of novel germplasm that can then be introduced by the private breeders into their elite lines. Germplasm developed in the pre-breeding program is publicly available and is free of IP.

The current role of the *public* sector in the UK is to undertake fundamental and applied research that can feed into private breeding programs. The centers of wheat research include two universities – the University of Bristol (Bristol) and University of Nottingham, and two research institutes – Rothamsted Research Limited (Harpenden) and John Innes Centre (Norwich). The research institutions are funded primarily by the government – BBSRC and DEFRA – with a very small proportion of research funding coming from the private sector either in cash or in-kind, farmer organization (HGCA), and European Union. The BBSRC funds about £14 million worth of wheat projects annually (Wheat Initiative, 2012). It supplies about half of the institutes' funding through five-year programs called Institute Strategic Programs (ISP) grants and these grants form the core funding for the institutes.

Each of the research institutes and universities have a distinct roles. The John Innes Centre has its strengths in crop genetics. Scientists at the Rothamsted Research come with agronomy and crop production background and the institute has built a strong

scientific base in science of crop nutrition. Both institutes are involved in a recently established pre-breeding program, with John Innes Centre leading the genetics part of that program and Rothamsted Research performing the phenotyping and trait evaluation. The University of Bristol runs a wheat genome program where large-scale genome sequences are generated and then released into the public domain so that the UK research institutes, the UK private breeding companies, and other players in the wheat industry globally can make use of the data.

Taking a snap shot of UK wheat research today, it would be easy to conclude that the UK sector made a smooth transition from public to private breeding, and operates a small, integrated wheat innovation system. However, the UK faced many challenges in establishing an integrated wheat innovation system and has only recently developed policies and funding processes that have allowed upstream public scientists to work with the downstream private wheat breeding industry. Understanding the situation that initially existed after the privatization of PBI, and the changes that were required to bring the innovation system to its current state, provide many lessons for any country planning a similar journey.

4.0 Outcomes and the performance of the UK wheat breeding system

4.1 A 15 year GAP in applied research

The physical separation of crop and plant scientists from the wheat breeders, combined with changes in the research funding model reduced amount of pre-breeding research required to support the private breeding industry. In PBI wheat breeders and scientists doing research on cytogenetics, molecular genetics, and plant pathology, worked together to improve wheat varieties. The researchers understood the challenges faced by breeders and producers, while the breeders were exposed to new knowledge and theories that

could improve their practice. The sale of PBI and dislocation reduced this communication. At the same time, public scientists were then expected to fund 50% of their research through competitive grants that were based to a large extent on publications. This changed the incentives for the scientist to pursue research with long-term high risk returns to shorter term research with more certain publishable results. As a result, there was a shift away from applied crop research toward work on model crops and model species, leaving the private breeders without upstream research support. Both public scientists and private breeders now recognize this period as a fifteen-year gap in the progress of UK wheat varieties.

4.2 *Limited revenue generation and total breeding investment*

When PBI was sold there was a belief that revenue generation from wheat breeding would create a revenue stream that would create and sustain a profitable wheat breeding industry, a belief that failed to materialize. The Plant Breeders Rights which is accompanied by the UK farm saved seed royalties have proven insufficient to fund significant investments in private breeding, and provide almost no resources to fund upstream private research. As shown in Figure 3, the total wheat royalties are less then £6 18 million per year. Even with research intensities of 30% this revenue stream generates about £6 million per year in research investment, about the same that PBI generated 25 years ago. An investment stream this size will only support modest short-run results oriented research, leaving no resources for the higher return longer term breeding activities. At the root of the problem, is the inadequacy of the intellectual property rights. Given that farmer can reseed varieties and pay only 52.5% royalty rates, this changes the pricing structure for royalties, with the result the producer only have to pay a small

fraction of the value of a new variety. The result is lack of revenue generation and a corresponding lack of private investment.

4.3 Fragmented breeding effort

The non-rival nature of the knowledge in new varieties, results in a toll good cost structure for the breeding industry with economies of size. In the UK, the prospect of making future returns has attracted at least six firms into the breeding industry. While having six firms is good for competition, it results in a significant duplication of effort in terms of breeding effort, licensing, distribution etc. The result is that no firm can exploit the economies of size in wheat breeding, exacerbating the overall lack of resources available for breeding and pre-breeding activities. In an attempt to survive firms tend to spend modestly and undertake activities with more certain returns, forgoing longer term higher risk- higher return activities.

4.4 Loss of sustained effort – grant funding

The UK wheat breeding system is now funding important pre-breeding wheat research through public-private research consortiums. While this is welcome move that has reengaged public scientists and reduced the fragmentation of effort in the industry, the funding model relies on research programs and research grants that are typically five years in length. The problem with this method of five year block grant funding is that many important breeding activities, such as introgression of a distant cultivar into a commercial lines takes, more than a decade to complete. Notably, Alston et al. (2010) found that the maximum impact of US agricultural research investment occurred on average 25 years later! The incongruences of funding period and research period creates risk for the private firms and the public scientists that must commit resources with the hope that future grants will be available to finish the project.

4.5 Narrowing genetic diversity in UK wheat varieties

There is some evidence that the privatized UK wheat breeding system has narrowed the genetic diversity. While PBI made its mark introducing semi-dwarf wheat genetics into UK varieties, very little novel introgression happened post privatization. McGuire flagged this issue in 1996, arguing that most of the wheat varieties in the UK were coming from a very similar genetic base. It would appear that the industry shares this view and is now willing to participate in the LOLA/WISP pre-breeding activities with the objective of introducing novel germplasm into UK wheat varieties. Fulfilling this research need requires substantial long-term public investment, which a noted above is challenge for public funding models were shorter-term accountability is required.

4.6 Evidence of long term performance

The performance of the system over time is perhaps the most important measure of the success of privatization. Clearly the primary goal of wheat breeding is to increase productivity by increasing the yield of wheat varieties (while maintaining or increasing quality). Figure 4 shows UK wheat yields from 1961 to 2009. After two decades of rapid growth wheat yields leveled off beginning in the late 1990s and have been very flat since. The same is true in France and Germany. There are a few theories about why this has occurred, including climate change, compressed crop rotations, decreased inputs due to environmental regulations, and a slowdown in genetic improvement. Despite the range of theories, governments in each of these countries are now investing heavily in genomic pre-breeding projects designed to introduce germplasm with novel traits into wheat germplasm. This longer-term development activity had been part of PBIs success prior to privatization. While it is difficult to determine the extent that privatization caused the yield slowdown, as outline in point 4.1 to 4.5 above it is clear that privatization brought

many changes that collectively could contribute to a slow down in genetic improvement.

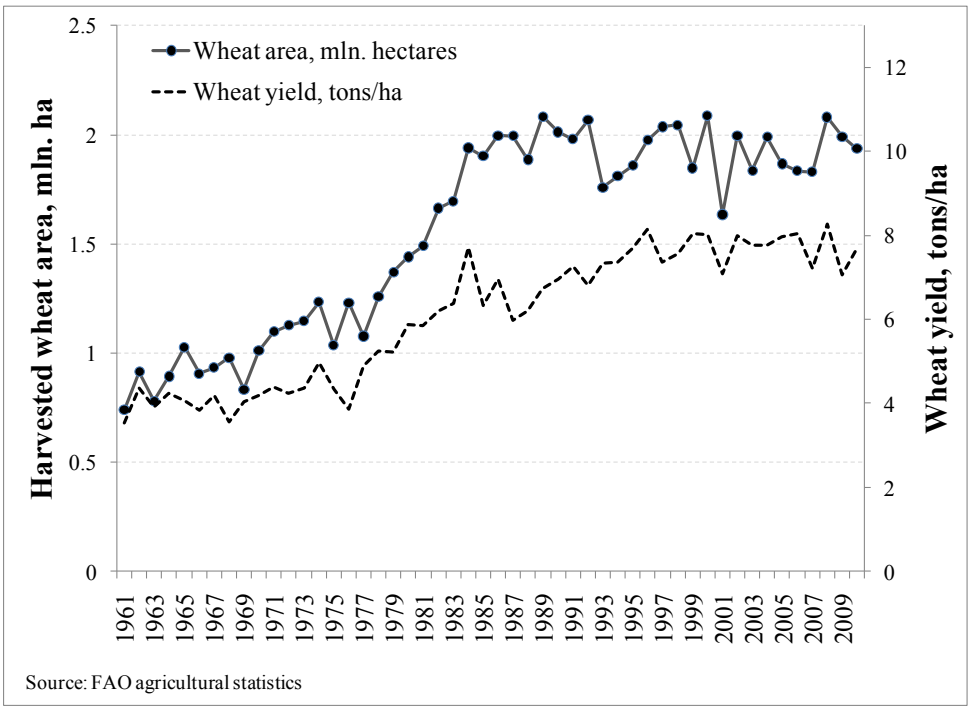


Figure 4: UK wheat Yields and Area 1961- 2009

5.0 Lessons from Privatization

The privatization of wheat research in the UK provides six important lessons for countries who may be contemplating the privatization of public wheat breeding. The outcomes, policy changes, and responses that have occurred in twenty-five years that have elapsed since the sale of PBI provide tangible examples of the outcomes from privatization of wheat research yielding lessons about measures that should be pursued and those actions that should not be repeated.

LESSON 1:

To create a private industry with the scale and scope to be internationally competitive either IPRs must be much stronger than the UK 52.5% farm saved seed royalty, or additional funding mechanisms are required.

The UK royalty collection system operates efficiently with coverage of more than 90% of the acres. Despite this extensive coverage, the pricing effect of the discounted farm saved seed royalty has kept royalty rates at low levels. The result is a very modest royalty stream generating £17 million in royalties of which, approximately £6 million getting reinvested in breeding activities, or about £.40 per tonne of wheat produced. If other countries to create privately financed intensive breeding system, this will require either property rights with even higher royalty rates on farm saved seed or a producer levy system, or both.

LESSON 2:

Modestly sized private breeding industries require significant applied research support in order to be internationally competitive.

The UK experience clearly illustrates that breeding firms with limited budgets cannot afford to make significant investments in plant science or crop science. While the UK government may have anticipated long-term public research savings, the recent level of reinvestment suggests that private breeding activities continue to require significant long term public support.

LESSON 3:

If commercial breeding is removed from the public sector, mechanisms that maintain the linkages between applied public researchers and downstream breeding activities must be put into place.

There was general view among the interviewees that the UK lost 10 to 15 years of wheat improvement by severing public researcher incentives to do applied crop science research. The UK learned the hard way that without incentives to do otherwise, competitively based science funding will attract public researchers toward activities with

academic impact and away from applied research. If there are no clear incentives to work together the links between producers, private breeders, and public scientist weaken. As these linkages become weaker the knowledge flow is impeded, thus further reducing the effectiveness of the upstream public science research. Fortunately the UK also discovered programs that encouraged collaborative research and were quite effective in bringing public scientists and breeders together. Although, it is also worth noting that some tension has continued to persist as the timeframe and reference points for public scientists and breeders differ.

LESSON 4:

Government-mandated five-year funding blocks are a major impediment to long-term strategic research investments. Despite 25 years of post privatization experience, the UK continues to lack a long term strategic plan for wheat innovation.

In the last 13 years, the UK government introduced many new research funding initiatives, (WGIN, LOLA, WISP, STB, etc.) each designed to foster wheat innovation. While these programs have brought much needed research resources to the sector, public researchers and the private breeders lamented the lack of a strategic plan and the inability to develop and fund long-term projects beyond the five-year commitment periods.

LESSON 5:

Mechanisms to enhance knowledge sharing are important. Therefore, transition planning should develop policies to reduce knowledge and research fragmentation.

The sale of PBI and subsequent downsizing resulted in four small and two very small distinct breeding programs. Breeders' rights, mechanisms to share germplasm, genomics research, and other upstream knowledge provide efficient knowledge sharing and keep breeders on a level playing field.

LESSON 6:

Privatization of UK wheat breeding has made it more difficult to train crop scientists and crop breeders.

The UK experience clearly illustrates that breeding and crop science are not a dichotomy. Good crop scientists need to understand breeding and breeders need to understand crop science. Although some training opportunities now exist, the removal of commercial breeding activities from public institutions has made it more difficult to fund and train students with the knowledge of breeding crop science. This suggests a need for the public sector to be involved in at least pre-breeding so that scientists get hands-on experience.

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