The importance of patent status to ‘public’ investment in herbicide use research and development

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Summary  Australian research and development organisations invest substantial funds in herbicides for weed control in broad-acre cropping. Benefits from this research and development (R&D) are distributed between growers, consumers and the agricultural chemical industry, depending on the patent status of the herbicide. The agrichemical industry will preferentially invest in herbicide R&D that increases the use of on-patent herbicides, which may provide the company with the opportunity to charge a price premium above the full cost of supply, including ‘normal’ profits. Hence, grower and/or taxpayer funded (public) investment in herbicide use R&D also may benefit the agrichemical industry where it increases the use of on-patent herbicide. The agrichemical industry would lose though if public R&D decreases the use of on-patent herbicides. The size and allocation of the benefits from R&D into on-patent and off-patent herbicides was analysed using economic surplus techniques. A case study of the returns from R&D into an alternative herbicide for the commonly used off-patent trifluralin is presented. The results from the case studies show that in this case, herbicide patent status does not have important implications for public R&D investment decisions in competitive herbicide markets.

Keywords  R&D evaluation, economic surplus.

INTRODUCTION
The Australian grains industry relies on herbicides for cost-effective weed control, spending nearly $1 billion on them in 2004 (APVMA 2005). Grower and/or taxpayer funded (public) research organisations invest substantial sums in herbicide use R&D to improve the effective and efficient use of herbicides. For many types of agricultural research and development (R&D), including R&D on off-patent, or generic, herbicide use, there is a prima facie case for collective funding because the benefits are widely distributed among many grain growers. However, because such investments also may affect the use of proprietary herbicides, the patent status of the technology must be considered in R&D impact evaluations.

As the producer of a proprietary herbicide will benefit from herbicide use R&D that increased sales of the herbicide, a superficially attractive option would be to rely on the agrichemical company to fund such R&D. However, this may result in market failure involving under-investment in R&D by agricultural chemical companies because their capacity to fully appropriate the benefits is limited. The finite duration of patent protection means they will lose research benefits once the herbicide goes off-patent, and any price premium is eroded by competition from generic manufacturers. In addition, legal and market impediments to practising first degree price discrimination further reduce their ability to capture a return even before expiry of the patent(s). Most importantly, when agrichemical companies charge grain growers a price higher than a competitive market price to use patented herbicides, this will result in under-utilisation of the research results. Consequently, grain growers may not realise all of the benefits potentially available from herbicide use R&D.

Publicly funded research bodies can avoid the twin threats of under-investment in herbicide use R&D, and under-utilisation of the results, by fully funding an optimal level of R&D investment, and making the results freely available. However, this would allow the agrichemical companies to free ride on some R&D initiatives by increasing revenue from sales of patented herbicides, and thereby appropriating some of the R&D benefits. This paper investigates the size of herbicide use R&D benefits, and in particular their distribution between growers, agrichemical companies or consumers.

MATERIALS AND METHODS

Economic surplus technique  Alston et al. (2000) analysed 292 studies that estimated returns to agricultural research to provide a most comprehensive review of research impact assessment. They recommended the economic surplus methods as summarised in Alston et al. (1995) to measure such R&D benefits empirically. The economic surplus approach has been used in a large number of R&D impact studies for many different types of agricultural research, including weed management research (Jones et al. 2005, Sinden et al. 2004, Vere et al. 2004). The economic surplus model has been adapted in this study to incorporate the
unique features of the Australian herbicide industry, including monopoly power for suppliers of patented technologies, agronomic differences between regions and the spill over of technology between regions and globally.

Case study background The hypothetical R&D project involves research into a new alternative to the pre-emergent herbicide trifluralin for the control of annual ryegrass in wheat. Previous and present examples of related work includes WANTFA (2002), Newman (2004), Boutsalis (2006) and Powles (2006).

The loss of post-emergence herbicide options in wheat due to herbicide resistance has led to an increased reliance on pre-emergence herbicides, particularly trifluralin. Resistance to trifluralin is increasing, with new resistant annual ryegrass populations being identified in Western and Southern Australia (Boutsalis 2006, Owen et al. 2005). As the number of cases increases, there is growing recognition of the need for alternative herbicide options, particularly as effective pre-emergence herbicides like trifluralin are very important with the increasing use of soil-conserving cropping systems such as no-till seeding (D’Emden et al. 2006).

The use of Group D herbicides, primarily trifluralin, has grown from 1 million ha in 1990 to approximately 6.9 million ha in 2003 (O’Connell et al. 2004). The generic trifluralin market is highly developed and price competitive, with over 20 registered suppliers in Australia (APVMA 2006). Trifluralin’s cost-effectiveness reduces the short-term incentive for herbicide companies to develop and register a substitute that in the absence of herbicide resistance is not superior to trifluralin. Even though most current alternatives to pre-emergent use of trifluralin in wheat pose a greater risk of crop damage and yield loss, some growers currently choose to use these alternatives as a prophylactic on a fraction of their wheat land.

The R&D project The aim of the R&D project is to identify an existing herbicide that is superior to current trifluralin alternatives but not presently registered for use on Australian broadacre crops. The R&D project is intended to assist commercial release and increase adoption by demonstrating the advantages to growers of the new herbicide relative to existing trifluralin alternatives. In the absence of trifluralin resistance, the new herbicide is assumed to have no advantage over trifluralin other than having a different mode of action. As such, it will only be applied in situations were trifluralin resistance has developed, and alternative herbicides must be used to control weeds.

Because the hypothetical new herbicide is assumed to be safer on the crop and more effective on weeds than existing trifluralin alternatives, it is assumed to provide a 5% wheat yield advantage over current herbicides available to control trifluralin resistant weeds. Furthermore, it is assumed that a product superior to this herbicide will not be released during the analysis period, from 2006 to 2015.

Adoption is assumed to occur among growers who would otherwise be using alternative pre-emergence options for wheat due to trifluralin resistant weeds. Trifluralin resistance is projected to develop such that 2% of Australian wheat production is affected in 2010 and 9% in 2015. After its release in 2008, it is assumed that 50% of wheat production affected by trifluralin resistance is treated with the new herbicide. The R&D investment is assumed to be $150,000 p.a. in 2006 and 2007.

The patent of the new herbicide is expected to be held by the agrichemical company for the duration of the analysis. Patent protection enables the agrichemical company to extract a price premium from the market by monopoly pricing. It is assumed that the price of the new herbicide would be $15 ha⁻¹, which exceeds prices of current alternatives to trifluralin by a 5% margin because it includes a monopoly price premium. Therefore, the overall benefit to growers of the new herbicide is to reduce average costs by 4.82%, comprising a 5% yield advantage partly offset by a greater cost of $0.75 ha⁻¹ due to the price premium. The price premium of $0.75 ha⁻¹ captured by the agrichemical company is, equivalent to 0.18% of average costs for every ha where the new herbicide is applied.

Without the R&D project It is assumed the R&D project does not influence the agrichemical company’s decision to register the new herbicide for use in broadacre cropping, meaning commercial release occurs in 2009 both with and without the R&D project. However, without the R&D project adoption of the herbicide is lower initially as less independent information is available to growers. Adoption is initially 40% of wheat production affected by trifluralin resistance (compared to 50% with R&D), increasing to 50% after five years as growers and agronomists replicate the information produced by the R&D project. Again, benefits and the price premium for use of the new herbicide are the same as for the with R&D project.

RESULTS

Economic surplus The time profile of benefits to Australian grain growers of the alternative to trifluralin with and without the R&D project is shown in Figure 1. The total NPV of benefits to Australian wheat
growers for this period ($7,025,000) can be compared to the assumed total NPV of R&D costs of $279,000 and an agrichemical company benefit of $241,000, Table 1. The benefit: cost ratio of the R&D project for public investment was 25.2, and the internal rate of return 147%, excluding the rest of the world. The agrichemical company would not make this R&D investment because the benefit: cost ratio is only 0.9, and the internal rate of return only 2%.

**Sensitivity analysis** A percentage change in the size of the yield benefit or adoption of the new trifluralin alternative alters the benefits to growers by approximately the same proportion. While the agrichemical company benefit responds proportionally to a change in adoption but there is no change if the grower yield benefit alters. Increasing the price of the herbicide or the price premium gained by the agrichemical company does not alter the total producer benefits from the R&D project but increases the proportion received by the agrichemical company to the detriment of the grower.

**DISCUSSION**
The distribution of benefits between Australian grain growers and agrichemical companies from more effective and efficient use of herbicide is determined by the patent status of the herbicide and the consequential ability of the agrichemical company to extract a price premium from the market. The R&D project analysed was estimated to have high returns, with a benefit:cost ratios of 25.2:1, and internal rate of return of 147%. Australian grain producers were the chief beneficiaries of this R&D, receiving 97% of the benefits due to the R&D project. The agrichemical company was only a minor beneficiary, as they received 3% of total benefit. Australian consumers receive no benefit from the R&D as the minimal increase in wheat production did not cause noticeable price changes.

The distribution of benefits in this case study differs markedly from the findings of Qaim and Traxler (2005) for patented Roundup Ready soybeans, where the patent holder received 34% of the benefit, and consumers received 53%, but grain growers received only 13%. Similarly, Falck-Zepeda *et al.* (2000) estimated that seed and biotechnology firms captured 26% of the benefits from another patented technology, Bt cotton. In the Bt cotton example, grain growers received 50% of the benefits, while consumers received the remaining 24%.

This comparison between the findings of previous studies with our results highlights the very limited extent to which chemical companies have been able to appropriate benefits from public R&D investment in herbicide use in Australia vis-à-vis their share of more recent patented biotechnological innovations. As with other types of agricultural R&D for the grain industry, grain growers not only collectively fund much of the cost of herbicide use R&D, but also capture almost all of the benefits.

Unlike the market for new biotech innovations, the Australian market for herbicides is highly competitive. Alternative methods of weed control, including the large proportion of cheap generic herbicides, are often as cost effective for grain growers as patented herbicides. Hence, the scope for chemical companies to charge significant price premiums for patented herbicides is severely constrained. Second, the fact that Australia exports most of its wheat production explains why grain growers, rather than consumers, appropriate the majority of the benefits from herbicide use R&D.

For these reasons, an agrichemical company is unlikely to make a substantial investment in the type
of R&D projects analysed in this case study given the extremely low prospective rate of return on their investment, 2%. Public and/or collective grower funded investment in such R&D projects is therefore required if grain growers and consumers are to benefit from such projects. There are likely to be many cases where public R&D involving on-patent herbicides is justified in terms of maximising net returns to grain growers though the agrichemical industry may benefit to some small degree from this R&D as well.

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REFERENCES


