Sarah Ann Wheeler

Exploring professional attitudes towards organic farming, genetic engineering, agricultural sustainability and research issues in Australia

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EXPLORING PROFESSIONAL ATTITUDES TOWARDS ORGANIC FARMING, GENETIC ENGINEERING, AGRICULTURAL SUSTAINABILITY AND RESEARCH ISSUES IN AUSTRALIA

Sarah Ann Wheeler
Centre for Regulation and Market Analysis, University of South Australia, North Terrace, SA 5001, Australia.

Abstract

This paper reports the quantitative and qualitative answers of two groups of public agricultural professionals (a general sample and a targeted sample with some knowledge of organic farming) to issues relating to organic agriculture, genetic engineering, sustainability and associated research issues in Australia. It also analyses what influences these professionals' views on the sustainability of conventional agriculture in Australia and other agricultural research issues. Professional views towards organic farming and genetic engineering are explored and analysed for their realism. The advent of genetic engineering has been accompanied by growing concern among many of these professionals about safety, public and private research issues, including intellectual property rights, patenting and private funding of public research.

*Keywords**:** sustainable agriculture, agricultural professionals, intellectual property rights, patenting, organic agriculture, genetic engineering.*

Introduction

In Australia farmers are facing a range of interrelated financial, drought and environmental problems. Australian agriculture has consistently been blamed for contributing to the country's environmental problems such as water pollution and scarcity, increasing carbon emissions, soil salinity, sodicity and acidity, and biodiversity loss (NLWRA 2002). Worldwide there has been a growing sense of responsibility among the public for the wellbeing of the environment and agroecosystems. This has led to increased calls for regulation and support for farmers to adopt more sustainable agricultural practices (Chang & Kristiansen 2006).

Access to accurate and relevant information is a critical component in influencing a farmer's understanding and decision making, including about alternative practices, new technologies and innovations. Public agricultural agencies and their personnel are one of the main sources for such information used by conventional farmers (Van den Ban & Hawkins 1988), particularly in relation to sustainable agricultural practices and innovations. The relationships between access to information and farmers' beliefs about environmental factors are complex, and involve differences in selection of information, receptiveness and perceived relevance. Over the past two decades the nature of public extension provision has changed radically and become more complex. In particular, it has evolved from the provision of advice to farmers to maximise productivity (especially for export earnings) and profit (by using 'controlling' system designs, technologies and inputs, and the most responsive, productive cultivars and varieties) to supporting the adoption of farming systems that address the problems caused by the former systems, and that meet a broader set of goals that include resource and biodiversity conservation, climate amelioration and aesthetic landscapes (Pannell *et al*. 2006). The adoption of more complex and demanding practices and unfamiliar innovations has posed a

Contact Details: sarah.wheeler@unisa.edu.au

range of 'trust' problems for both farmers and extension agents (Pannell *et al*. 2006, Feder & Slade 1985, Lee 2005). Because of this, extension (especially public extension) is required to play an even more important role in teaching and extending sustainable farming practices than traditional agricultural practices. Hill (2006) describes how person-led contact is the most effective instrument of change. The present study helps agricultural professionals fulfil this role of extension, thereby illustrating their understanding of sustainable agricultural issues in Australia.

Sustainable Agriculture

The term "sustainable agriculture" is generally used to imply environmental, economic and social sustainability, and is used to describe a wide variety of practices (Rigby & Caceres 2001, Lee 2005). It is possible that agriculture can never be fully sustainable, in the strictest definition of the term; however it is possible that certain farming systems and innovations can be more sustainable than others. Sustainability in agriculture is often presented as two philosophies, the modern enlightenment philosophy (of which conventional farming and the advent of biotechnology crops are a part) and the post-modern philosophy (of which alternative forms of farming are a part). Forms of alternative farming are often described as systems exhibiting high levels of sustainability (MacRae *et al*. 1990, Tait 2000, Alexandra & May 2004). Stuart Hill has written extensively about the difference between 'shallow' and 'deep' approaches, and has applied this concept to research, to agriculture as a whole, and to alternative agriculture itself. Shallow approaches are those strategies directed at symptoms only, rather than deep approaches that involve the redesign and transformation of systems themselves (e.g. Hill 1998).

How sustainability in farming systems has been characterised, and where each system of farming sits in terms of sustainability issues, is illustrated in Fig. 1. Such a classification should be considered as more theoretical than reflecting actual reality; and the particular order can be debated. The problem with much of the literature on sustainable agriculture is that it can tend to be purely prescriptive, with alternative forms often treated as the ideal to be adopted rather than investigating in full the benefits and costs of various forms of alternative agriculture.

Fig 1. Progressive Phases in Agricultural Sustainability

Low (Shallow) Sustainability

Schools of Thought	Characterised by:
High Input Chemical Intensive Conventional (monoculture) (minimum or zero tillage, chemical banding, genetically engineered crops)	***Low Degree of Self-Sufficiency*** ***High Negative Externalities*** ***External solutions to internal problems***: emphasis on compartmentalisation and control; single, simple, direct short-term physico-chemical, imported curative solutions to local problems ***Increased focus on efficiency and production*** ***Open cycle agrosystems*** ***Monocultures and Losses of Agricultural Biodiversity***
Low input agriculture Ecoagriculture	***Substitution*** of benign inputs
Regenerative Traditional Organic Biological Biodynamic Ecological Permaculture Bioregionalism Wild Harvest (natural)	***Benign Design*** and management ***Low Negative Externalities*** ***Internal solutions to internal (and external) problems***: emphasis on integration, balance and response to feedback; complex, indirect, long-term, bioecological, selective and ecological controls, local approaches to solving both local and global problems. ***High Degree of Self-Sufficiency*** ***Closed cycle agrosystems*** ***Polycultures and retention of agricultural biodiversity*** ***Optimisation of Production***

High (Deep) Sustainability

Sources: Adapted from MacRae *et al* (1990; 77), Hill (1998; 395), Alexandra and May (2004; 5), Tisdell (2005; 8)

Although the concept of sustainable agriculture generally describes the whole agricultural system or way of farming, much of the sustainable agricultural academic literature is concerned with the adoption of certain sustainable agricultural techniques (Lee 2005). Typical sustainable agricultural techniques and management practices are listed in Table 1.

Conventional agriculture tends to be capital intensive and large-scale. It is a highly mechanised form of agriculture with extensive use of synthetic fertilisers, herbicides and pesticides. Cropping tends to be monocultures and animal husbandry intensive, and it can adopt most or all of the techniques cited in Table 1. There are few, if any, sustainable farming practices that cannot be used on conventional farms. The difference between conventional and sustainable farming is the emphasis on approach, namely a 'shallow' or 'deep' approach.

Table 1. Sustainable Agricultural Techniques

Crop rotations, including grain-legume rotations	Soil Fertility Management
Agroforestry systems	Mulching
Intercropping and polycultures: mixed, row, strip, relay	Drip irrigation
Legume intercropping	Trash lines
Introduction of improved crop varieties	Ditches
Improved fallow management	Improved water efficiency
Hedgerows and live barriers	Use of inorganic/organic fertilisers
Alley farming	Cover crops and green manures
Rainfall harvesting and storage, micro and macro catchments	Weed management, minimisation or elimination of chemicals
Zero tillage, reduced tillage, minimum tillage, deep tillage	Integrated pest management
Improved use and efficiency of animal manures	Soil aeration
Improved forage and grazing management	Contour farming
Grass strips	Improved drainage
Raised beds, raised fields	Windbreaks
Precision farming	Terraces
Stone and soil bounds	Seed conservation and seed banks

Sources: Adapted and modified from Lee (2005; 1326) and FAO (2001).

Evaluating the effectiveness of sustainable agricultural systems is much harder than evaluating the effectiveness of the adoption of one sustainable technique (such as minimum tillage). Farming systems are notoriously difficult to compare, because they incorporate different concepts and systems. For example, organic farms may have a wide range of outputs rather than a single output, with a main goal of self-sufficiency. Also, how can one system be classified as 'better' than the other? The classification of 'better' depends on the objectives of: a) researchers; b) operators of the system; and c) society or other interested parties.

Organic agriculture is one of the most well-known and largest forms of sustainable agriculture (Lampkin 1994), although some disagreement over its sustainability persists (e.g. Avery *et al*. 2005). Genetic engineering (GE) is a newcomer to the literature on sustainable agriculture; with many believing that it will become the 'doubly green revolution' in the next 10 years and provide immense social benefits (Robinson *et al*. 2000). Other scientists (though probably fewer) disagree about the benefits to be derived from genetic engineering (Independent Science Panel 2003). To a large extent, these two innovations (organic agriculture and GE) represent different ends of schools of thought within the farming spectrum, as illustrated in Figure 1. Whereas modern biotechnology is part of the modern 'enlightenment philosophy' of sustainable agriculture, and generally involves the adoption of a single innovation and hence can be described as a shallow approach, organic agriculture is part of the post-modern philosophy and involves applying deep approaches to farming. Organic agriculture involves a composite adoption, as a series of sustainable agricultural techniques have to be adopted as a whole. In this sense, it is a single innovation, but one that is generally more complicated than the adoption of techniques such as minimum tillage or *Bt* cotton. The additional complexity of the adoption of sustainable systems means that information through public agents is likely to play a greater role in their adoption by farmers.

Agricultural professionals play a key role in designing, researching and advocating sustainable agricultural innovations. Many have questioned the commitment of agricultural scientists to true sustainability in agriculture, and believe that there has been a failure by professionals' to speak out on environmental issues (Hill 1998). MacRae *et al*. (1989) argued that scientists who worked within sustainable agriculture were vastly different from scientists who worked within conventional agriculture in terms of goals, emotions, beliefs, worldviews and actions. In particular, MacRae *et al*. suggest that biotechnological researchers are likely to suffer from the problems associated with conventional scientific inquiry; because of this, the nature of genetic engineering research distracts our attention from the real cause of the agricultural problem and the need for redesign and transformation of systems.

Krimsky and Wrubel (1996) suggest that a scientist who is traditional, positivist, works in private industry and/or is sponsored by government or industry will tend not to become involved in advocating or supporting environmental or health hypotheses. A survey of 70 Australian environmental scientists found that over half of them (54%) believed that their career prospects or research funding would be jeopardised by speaking out on environmental issues (29% were unsure), while 11% had been directly disadvantaged because of their outspoken environmental views (Wilson & Barnes 1995). The present paper investigates the degree to which professionals are outspoken about Australian agricultural sustainability issues and, in particular, about their views on organic agriculture and genetic engineering.

Agricultural Research Issues

Both public and private agricultural research is becoming more dominated by intellectual property rights and patents. Traditionally, public agricultural research organisations did not pursue R&D in activities where market incentives were sufficient; however, there is an increasing trend to commercialise public agricultural research (Wong *et al.* 2002). Major problems are arising for public agricultural research concerning overlapping patents, infringements, excessive breadth, litigation costs, lockouts and issues with freedom to operate (Huffman 2001, Phillips & Dierker 2001). Some authors suggest that patented inventions and intellectual property rights favour knowledge associated with conventional agriculture, hence distorting private research and causing follow-on effects with publicly funded agricultural research (Phillips & Dierker 2001). On the other hand, some prominent Australian scientists have argued that there are no serious problems associated with patenting, intellectual property rights, and with the increasing involvement of private companies in public research (Peacock 1993).

The debate has sparked a new term in the academic literature, namely the “anti-commons effect” (coined by Heller & Eisenberg in 1998). Unlike the “commons effect”, where a lack of property rights resulted in over-exploitation of a resource, the “anti-commons effect” from privatising scientific knowledge is said to result in limiting scientific progress. Empirical evidence is scanty and contradictory (Walsh *et al.* 2003, Murray & Stern 2005).

There is also strong argument in the literature over the influence of private funds on research outcomes (Drahos 1996, Huffman & Tegene 2002). Universities cannot be ‘open’ if their funding or research agenda has been captured by a number of large companies and if the information gained is controlled under contractual terms. Lawrence and Norton (1994) found that of the Australian agricultural scientists they surveyed (n=278), 76 per cent believed that commercial linkages were necessary for the continued development of the industry, but 76 to 78 per cent were concerned that openness in research, and especially basic or fundamental research, would suffer. In addition, 68% believed that there was a need to be concerned about corporate funding of public research because it may unduly influence the research being conducted.

Hence, there is rising unease among many scientists over whether intellectual property rights have gone too far. In particular, some have claimed that research in areas such as sustainable agriculture will suffer progressively more as a consequence of the unpatentability of the innovations (e.g. Jennings 1997).

This study highlights agricultural professionals’ concerns with intellectual property rights and private funding of agricultural research, and attempts to assess how their views might have changed over the past decade.

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Methodology

A telephone survey was conducted in mid-2004 to elucidate a range of agricultural professionals' views on organic farming and genetic engineering. An agricultural professional was strictly defined as someone either providing agricultural advice to farmers; conducting agricultural specific farm research; or teaching agricultural courses at university. The sample frame for the survey consisted of two groups: general and targeted. The general group of agricultural professionals was limited to State and Commonwealth bodies based in South Australia, namely Primary Industries and Resources South Australia (PIRSA), Rural Solutions South Australia (extension arm of PIRSA), the South Australian Research and Development Institute (SARDI), the University of Adelaide, CSIRO Land and Water and CSIRO Plant Industry. The targeted group was randomly sampled from a constructed database of professionals employed within public bodies across Australia who had some actual organic agriculture experience. This supplementation was needed to allow comparisons between professionals with organic experience with those who, in general, do not have that experience. This database was constructed using sources such as attendance at organic conferences; articles and reports published on alternative agriculture; suggestions by researchers working in the area; and the RIRDC website of organic research. It is possible that not all relevant professionals were identified, but my aim was that the majority and the most prolific people would be included. The targeted group was from across Australia; in addition to the above organisations, professionals were surveyed from: University of New England, University of Western Sydney, DPIWE Tasmania, DPI Victoria, DPI Queensland, NSW Agriculture and Department of Agriculture WA.

Survey personnel were randomly selected from each database until the minimum sample sizes were reached. The aim was to survey at least 20-30% of each organisation's population to obtain a minimum sample size (which was calculated using Yamane's [1973] simplified formula). A level of confidence was set at 95%, with a maximum degree of variability in the population of 50% (hence this requires a more conservative sample size, that is, the sample size may be larger than if the true variability of the population attribute were used [Miaoulis & Michener 1976]). It is possible that agricultural professionals are, in fact, a more homogeneous group (hence permitting a decrease in the sample size needed); however, for conservative reasons maximum variability was assumed. A 7% level of precision (also known as confidence interval) was used. Respondents were randomly selected from each database for a telephone interview (those not available, but who were at work, were phoned back later until they were reached). Once contact was made, an introduction was read out and professionals were asked if they would participate in the survey at a time convenient to them. Before the survey commenced, a statement on ethics clearance, approval from the relevant head of organisation, confidentiality issues and definitions of organic agriculture and genetic engineering was provided to the respondent. Surveys continued until the minimum sample size was reached, which resulted in interviews with 119 professionals in the general sample and 66 professionals in the targeted sample. Overall, the 185 interviews conducted with professionals had a response rate of 96%.

This study reports the answers (and comments made) by these professionals to 15 questions about current issues in Australian agriculture; this formed the last section of the survey. Their responses to the questions are shown in Table 2 (the specific questions asked are provided in the first column). The purpose of these questions was to gain some common understanding of professionals' views towards sustainable agriculture, organic agriculture, genetic engineering, and key agricultural research issues. Some questions were worded positively and some were worded negatively. Respondents were asked if they "Strongly Disagreed", "Disagreed", "Agreed", "Strongly Agreed", or "Remained Neutral" with respect to each statement. "Don't Know" responses were allowed, and professionals were free to comment on each question as freely as they wished. An average score for each sample was calculated (the above answers were coded into a five point Likert scale [with mid-way answers allowed], with "Strongly Disagree" one and "Neutral" three). Some comments made by professionals have been detailed to help provide more information and understanding of the responses made. Comments have been selected on two grounds: the first is to ensure that comments were selected from a wide range of professionals; and the second was to provide especially interesting comments made by professionals. The provision of qualitative comments has not followed any strict scientific methodology; rather it aimed to provide some additional information and 'flavour' to the quantitative data. Whether the comment came from someone in the general sample (GS) or targeted sample (TS) was recorded. Based on these research results, I have provided some commentary on how much professionals' beliefs seem to be grounded in actual reality.

In interpreting these data, it is important to bear in mind from where these professionals received their information. I (Wheeler pending) have also analysed the responses of these professionals towards genetic engineering and organic farming by their source of information. I found that there was a clear difference between the information sources on organic farming used by general respondents, and the information sources used by targeted respondents. General respondents consistently named the media/internet as their main source of information on organic farming, followed by scientific sources. Targeted respondents named significantly different information sources, namely the organic industry, scientific sources and organic farms and farmers as their main sources. On the other hand, little significant difference was found between the information sources used by general and targeted respondents on genetic engineering. Both samples consistently named scientific sources and the media and internet, followed by their peers, as their main sources of information on genetic engineering.

Results

Environmental sustainability in agriculture

The first question asked of professionals assessed their overall views on the current sustainability of Australian agriculture (first row in Table 2). Note that this version of sustainability focussed primarily on environmental aspects. Around half of all respondents believed that conventional farming in Australia was generally not environmentally sustainable (Table 2). Targeted respondents were slightly more likely to 'agree' that conventional agriculture was not environmentally sustainable than general respondents, although their average score was not significantly different. Correspondingly, a significant proportion of all agricultural professionals (over one third) believed that, in general, conventional farming is environmentally sustainable in Australia. A range of responses included:

> *"We do need increased sustainability in conventional agriculture". (Respondent 179 - TS).*
> *"There is nothing wrong with conventional agriculture in Australia; we are clean and green". (Respondent 15 - GS).*

Within the survey, unlike the definitions provided for genetic engineering (biotechnology) and organic farming, there was no definition of 'environmental sustainability' provided. Indeed, other aspects of sustainability, such as social and ethical considerations, were not included (due to space and time restrictions in the survey). Consequently, professionals used their own definitions of the term. There was definite resistance from many professionals to the idea that agriculture in general needed to change; although whether this came from their own entrenched beliefs or other influences was not determined. In this world of declining water quality and quantity, soil erosion, biodiversity losses and rising emissions, much of which is significantly influenced by agriculture, the idea that current practices are environmentally sustainable seems foreign to say the least. However, many of the attitudes of professionals arise from their beliefs that just a few practices here and there need to change for sustainability to be achieved. My attempt to model the influences on beliefs about conventional agriculture's current environmental sustainability is provided in Appendix 1. Women were slightly more likely than men to agree that Australian agriculture was not environmentally sustainable (however, this was only weakly significant). Professionals who worked in broadacre and/or grazing were much more likely to agree that conventional agriculture was environmentally sustainable. This result most likely reflects the fact that most professionals in this area have traditionally been focussed on yield increases as their main goal in research and extension (Harp & Sachs 1992), and hence do not care as much about other consequences of agricultural production. Finally, the most significant influence on

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attitudes towards the conventional sustainability of agriculture was believing that organic farming was environmentally superior to conventional agriculture. Those who believed genetic engineering products were more environmentally superior to conventional agriculture did not play a significant influence on beliefs towards the sustainability of conventional agriculture, indicating that professionals who are concerned about sustainability issues do not regard genetically engineered crops as helping to address the problems.

Organic agriculture and genetic engineering

The next 14 questions in Table 2 addressed specific issues that have been raised in the literature about organic farming and genetic engineering, namely: environmental friendliness, profitability, food quality, innovativeness, policy support, and research needs. In response to statements 2 to 4, half of all respondents disagreed that modern biotechnology was more environmentally friendly than conventional agriculture, with targeted respondents much more likely to disagree than general respondents; while most respondents believed that organic farming was environmentally superior to conventional agriculture (68%) and to genetic engineering (58%).

In terms of profitability (statements 5 and 6), almost half of the respondents were undecided or did not know whether there are financial benefits to be gained from genetic engineering relative to conventional agriculture. Targeted respondents were more likely than general respondents to believe that there are less financial benefits; while most respondents (69%) agreed that conventional agriculture is more financially profitable than organic agriculture.

Most respondents (57%) disagreed with statement 9 that genetic engineering produces better quality food than conventional agriculture. Targeted respondents were much more likely to disagree than general respondents. There was no common consensus over whether organic farming produces better quality food than conventional farming (statement 10), though slightly more disagreed (40%) than agreed (37%), with targeted respondents much more likely than general respondents to agree.

I (Wheeler 2008) have also examined the impact of professionals' knowledge on their beliefs about the net social benefits (financial and non-financial) of organic farming. I found that the higher the level of knowledge professionals had about organic farming, the more positive their attitude towards the system. In terms of the views expressed above, the most positive significant impact on overall beliefs was professionals' favourable views on the environmental sustainability of organic farming, followed by their favourable views on food quality and the innovativeness of organic farming (discussed below).

There was no clear consensus either way as to whether genetic engineering will be the dominant form of agriculture in the future (statement 7), though targeted professionals are more inclined than general respondents to believe that it will not be dominant. It is important to note that genetic engineering itself is not a 'form of agriculture'; there is a difference between the science of agricultural biotechnology (i.e. plant genetics) and the technology of biotechnology (application of scientific knowledge resulting in new innovations). The statement provided to the professionals was worded to try and obtain information about the potential spread of adoption of genetic engineered products and research techniques in the future; and the professionals did seem to respond to the question in that way. On the other hand, most respondents (78%) disagreed quite strongly with statement 8 that organic agriculture is a return to pre-1950s agriculture, with targeted professionals more inclined than general respondents to disagree. The following two contrasting responses are typical:

> *"Organic agriculture is more like a return to pre-1750 agriculture" (Respondent 94 – GS).*
> *"In a sense this statement is correct, but organic agriculture has got the potential for increased sophistication and positive impact on conventional agriculture". (Respondent 41 – GS).*

This strongly worded question (8) was included in the survey as the innovative nature of organic farming has been debated by many scholars. Is organic farming a pre-modern technology or a technology for the modern world? Strong critics tend to characterise it as a pre-modern technology (e.g. Avery 1995), but it has generally been accepted that it a viable social and technological alternative to conventional agriculture (Beauchesne & Bryant 1999). A number of professionals (even those who are negative overall towards organic farming) seemed to agree with the idea that it is not a return to past agriculture, and hence may agree with the idea that it is an innovation that opposes some forms of modernity, with visions of returning farming to certain pre-modern structures, as well as being an innovation that provides new ways of farming. A small number of professionals (who were positive to organic farming overall) agreed with this statement, because they viewed pre-1950s agriculture as concentrating on soil and biological solutions, which is a fundamental concept of organic farming.

Literature suggests that scientists who support alternative paradigms are more likely to be vocal in advocating new positions (Kuhn 1970, Krimsky 2003). Statements 11 and 12 addressed the further involvement of government in the promotion of either biotechnology or organic farming, and as such they are a proxy for evaluating the outspokenness of professionals. It is suggested that given the above, those professionals who are advocating stronger involvement from government are more likely to be favourable towards alternative paradigms, because scientists within mainstream science are unlikely to feel a need for the *status quo* to be disturbed. Most respondents (53%) disagreed with statement 11 that the government should be taking a more proactive stance in promoting genetic engineering, with targeted respondents much more likely than general respondents to disagree.

> *"I do not know how many more millions of dollars could go into government support of biotechnology… You only have to look at the amount of students funded in this area at Roseworthy…" (Respondent 131 - TS).*
>
> *"Biotechnology is pushed by government and big money, in order to make money. CSIRO is seriously compromised by the agreements it has in place with companies. Government has a very pro-active attitude towards biotechnology and is putting a lot of effort into it because it is seen to be good and sexy for the nation". (Respondent 116 - GS).*

Those that agreed with statement 11 were most likely to support programs to promote awareness and 'educate' the public about the benefits of genetic engineering. The issue of education and information on genetic engineering is more fully addressed in Wheeler (2008a). That study concludes that consumer studies have never found a positive significant link between a person's actual knowledge of genetic engineering and their attitudes towards the innovation. Furthermore, I (Wheeler 2008a) also found that this premise held true for professionals, indicating that factors other than knowledge are influencing agricultural professionals' views towards genetic engineering. The media was constantly blamed for providing biased and negative reporting; however, I found that the media coverage in Australia is overwhelmingly positive (see Wheeler 2008). There is no easy way to estimate how much current government support each type of system receives in Australia. However, it is clear that we are investing strongly in biotechnology. In 2002-03, public sector related R&D biotechnology investment in agricultural, vet and environment was $345.2 million, representing 35% of total R&D expenditure in these fields (Hopper & Thorburn 2005). The size of this investment indicates that government has already taken a more than enough proactive stance in promoting genetic engineering and, indeed, it is probably to the detriment of other research programmes.

Most respondents (62%) agreed with statement 12 that the government should be taking a more proactive stance for organics, with targeted respondents much more likely than general respondents to strongly agree, as is evident in the following statements.

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Table 2 Professionals' Answers to Questions on Sustainable Agriculture and Research Issues.

	Statement	*Sample*	*Strongly Disagree*	*Disagree*	*Neutral*	*Agree*	*Strongly Agree*	*Don't Know*	*Average Score*
1.	Conventional farming in Australia is generally not environmentally sustainable	*General*	10%	33%	12%	35%	9%	2%	3
		Target	5%	23%	12%	49%	11%	2%	3.3
		Total	8%	29%	12%	40%	9 %	2%	3.1
2.	Biotechnology is more environmentally friendly than conventional agriculture	*General*	5%	38%	21%	17%	1%	19%	2.1
		Target	20%	42%	17%	8%	0%	14%	1.8[A]
		Total	10%	40%	20%	14%	1%	17%	2
3.	Organic agriculture is more environmentally friendly than conventional agriculture	*General*	3%	14%	21%	48%	13%	1%	3.5
		Target	2%	11%	8%	58%	21%	2%	3.8
		Total	3%	13%	16%	52%	16%	1%	3.6
4.	Organic agriculture is more environmentally friendly than biotechnology	*General*	2%	16%	17%	40%	9%	17%	2.9
		Target	0%	8%	6%	53%	23%	11%	3.6
		Total	1%	13%	13%	44%	14%	15%	3.1
5.	Biotechnology is more financially profitable than conventional agriculture	*General*	2%	19%	14%	31%	1%	33%	2.1
		Target	8%	32%	18%	15%	0%	27%	1.8[B]
		Total	4%	24%	16%	25%	1%	31%	2
6.	Conventional agriculture is more financially profitable than organic agriculture	*General*	0%	7%	13%	56%	17%	8%	3.6
		Target	3%	18%	12%	53%	9%	5%	3.3
		Total	1%	11%	12%	55%	14%	7%	3.5
7.	Biotech farming will be the dominant form of agriculture in the future	*General*	3%	24%	11%	45%	1%	16%	2.7
		Target	9%	35%	14%	23%	2%	18%	2.2[A]
		Total	5%	28%	12%	37%	1%	17%	2.5
8.	Organic farming is a return to pre-1950s agriculture	*General*	11%	61%	5%	20%	3%	1%	2.4
		Target	30%	58%	5%	5%	2%	2%	1.8[A]
		Total	18%	60%	5%	15%	2%	1%	2.2
9.	Biotechnology produces better quality food than conventional agriculture	*General*	7%	40%	20%	14%	0%	19%	2
		Target	17%	58%	8%	3%	0%	15%	1.6[A]
		Total	10%	47%	16%	10%	0%	17%	1.9

Table 2. Professionals' Answers to Questions on Sustainable Agriculture and Research Issues (continued).

Statement	***Sample***	***Strongly Disagree***	***Disagree***	***Neutral***	***Agree***	***Strongly Agree***	***Don't Know***	***Average Score***
10. Organic agriculture produces better quality food than conventional agriculture	*General*	7%	42%	15%	24%	5%	7%	2.6
	Target	0%	24%	20%	36%	12%	8%	3.1[A]
	Total	4%	36%	17%	29%	8%	7%	2.8
11. Government should take a more pro-active stance for biotechnology	*General*	3%	40%	12%	34%	5%	7%	2.8
	Target	24%	47%	9%	14%	3%	3%	2.1[A]
	Total	11%	42%	11%	27%	4%	5%	2.5
12. Government should take a more pro-active stance for organic agriculture	*General*	1%	33%	11%	47%	5%	3%	3.1
	Target	2%	11%	8%	46%	32%	3%	3.8[A]
	Total	1%	25%	10%	47%	15%	3%	3.4
13. There needs to be more research on the long-term consequences of biotechnology products before further general release	*General*	0%	12%	10%	50%	27%	1%	3.9
	Target	0%	3%	2%	47%	47%	2%	4.3[A]
	Total	0%	9%	7%	49%	34%	1%	4.1
14. The increased use of intellectual property rights and patenting activity is a good thing for agricultural research	*General*	19%	28%	10%	30%	4%	8%	2.5
	Target	12%	47%	8%	26%	0%	8%	2.3
	Total	17%	35%	9%	29%	3%	8%	2.4
15. Private funding of agricultural research does not influence research outcomes	*General*	13%	51%	8%	20%	2%	6%	2.3
	Target	26%	50%	6%	5%	12%	2%	2.0[B]
	Total	18%	51%	7%	17%	2%	5%	2.2

Notes: Significance is only tested with the average score.
A Significantly different to general sample at 1% level with a two tailed t test
B Significantly different to general sample at 5% level with a two tailed t test

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"Organic agriculture needs a voice and more support. The Organic Federation of Australia are trying to pull things together more, but currently the support to genetic engineering and organics is out of balance. Organic agriculture needs to be recognised as a valid form of agriculture and accepted by departments". (Respondent 152 - TS).

"I think the Australian Government does need to take a stand and say who they support (biotechnology development or organic). It makes it hard for those on the ground to tailor how we structure our work plans if there is not a clear policy stance. For example, two years ago I could not mention the word 'organic agriculture' in a tender and expect to be funded, but now I can use it and receive funding" (Respondent 153 - TS).

It is also clear that organic agriculture in Australia receives very little government research or extension support. In 2000-01, $401,000 worth of organic research was conducted, which was estimated to be at least 40% less than the amount collected from organic farmers' contributions to R&D (Wynen 2003). This represented 0.0004% of R&D expenditure in agriculture, vet and environmental science in 2002-03 (Hopper & Thorburn 2005), which is significantly less than the current adoption of organic agriculture. The smallness of such figures supports professionals' views that the government should take a more proactive stance for organic farming.

There was an overwhelmingly strong agreement (83%) from all respondents to statement 13 that there should be more research on the long-term consequences of genetic engineering before further release, with targeted respondents much more likely to agree than general respondents.

"We do need much more long-term research on biotechnology; there are many things that are unknown". (Respondent 63 - GS).

"We need long-term applied research to look at various systems of agriculture – and long-term does not just mean three years! For every action within a complex interactive system, there are complex inter-reactions. The shorter the timeframe looking at the system, then the less unintended results one finds". (Respondent 118 - TS).

Some respondents believed that long-term research would lead to increased acceptance of biotechnology products, whereas others believed that it would lead to confirmation about negative consequences. Although long-term research on genetic engineering would most likely be supported by organic farming advocates, the question remains as to where the money for such research would come from, whether it would be drawn from existing funds (hence cutting the amount of exploratory research that could be undertaken) or from other programmes, which may not be a desirable outcome if sustainable agricultural funds are decreased correspondingly.

Intellectual property rights and research concerns

The final two statements (14 and 15) attempted to address research concerns about intellectual property rights and private funding. A slight majority of respondents (52%) disagreed with statement 14 that the rise in intellectual property rights and patenting activity was a good thing for agricultural research. Many related their comments back to the innovations of organic agriculture and genetic engineering:

"Organic agriculture is a free good; it has public benefits, and hence this is why it is not funded. It is about public domain for public benefit. Biotechnology can be privately owned; and its approach is a furthering illusion of control... (it is a part of linear causal systems). Of course, there are exceptions to this rule, such as CAMBIA…". (Respondent 146 - TS).

> *"There are generally no intellectual property rights in organic agriculture because of the nature of its public benefits rather than private benefits, hence it cannot be patented. You cannot make money out of soil biology". (Respondent 180 – TS).*

Organic farming is clearly not a free good, but the supply of organic farms may be far from socially optimal because of market failure issues, one of which includes its public good nature. For example, inputs in organic agriculture have much more of a public good nature due to their being knowledge based and based on soil and biological solutions rather than on the private goods used in conventional agriculture (fertilisers, pesticides, genetically-engineered products) (Wynen 1989). Organic farming is also more likely to generate positive externalities (environmental, health and social). Externalities in general are harder to patent, and research in organic farming may suffer as a consequence due to their unpatentability (e.g. Jennings 1997).

Most respondents (69%) disagreed with the statement that private funding did not influence agricultural results, with targeted respondents much more likely to disagree than general respondents. This question generated much discussion among respondents. Comments made by those who disagreed included:

> *"…I strongly disagree, as research outcomes can be decided prior to the commencement of the research". (Respondent 137 - TS).*
>
> *"…companies have vested interests in research" (Respondent 126 – GS).*
>
> *"…private companies want what they want and they get it". (Respondent 50 - GS)*
>
> *"Research is skewed by research funding and therefore driven by private companies. Research follows the dollars, not a pure, objective science". (Respondent 164 - TS).*
>
> *"…private funding of agricultural research does influence research outcomes, but it is not a blatant misrepresentation. One result is that it takes it in a certain direction; but on the other hand some companies are doing public good research. For example, the company Syngenta has a whole biological control division. Such a division does not adhere to a complete worldview, but they are looking at complex organisms and they are doing things in all areas.... It is hard to say the effect of private funding on research overall". (Respondent 42 - GS).*

A few professionals who agreed (or remained neutral) that private funding does not influence agricultural research outcomes still voiced some ambiguity in their responses. For example:

> *"… I'd like to say no there is no influence". (Respondent 150 - TS)*
>
> *"…I'd like to think that it does not. There are not a lot of private funds in our research anyway". (Respondent 114 - GS).*
>
> *"… I'd say mostly no to the question of whether funding influences outcomes". (Respondent 83 - GS).*
>
> *"Agricultural research can only meet objectives that are asked for. Therefore, it is easy for some questions to be ignored and some areas under funded; mostly those that have public good aspects". (Respondent 115 - GS).*

There seems to be some consistency between the findings of this study and that of Lawrence and Norton (1994), in terms of the percentage of respondents concerned about corporate funding of public research (69% in this study vs. 68% in the previous study on this issue). In one sense this is reassuring, as it seems that concerns of Australian professionals towards the influence of private funds have not risen over the past decade, although arguably private research in organisations has increased. I (Wheeler 2007) also found that there seemed to be no fundamental change in professionals' views towards genetic engineering over the past five years, reinforcing the above conclusion. There is also a question concerning to what extent respondents had experience and knowledge of the issues raised. Models 2 and 3 in Appendix 1 attempt to quantify what factors influence professionals' beliefs about intellectual property rights and private research funds. There are no common influences in the two models. Beliefs about the two issues seem to be driven by completely different factors. Based on the following factors, professionals are more likely to agree that the increased use of intellectual property rights and patenting activity in agriculture is a good thing: the longer they have worked in their area; the lower their salary; the higher their genetic engineering knowledge (only weakly significant); if they are not working in the field of broadacre or grazing; the lower their research relevance on genetic engineering; and the more they believe private research funds do not influence research outcomes. One could argue that professionals who would know most about (or have the most experience with) intellectual property rights and patenting are those working in the genetic engineering field. On the one hand, professionals who believe that they have a high knowledge in the area are more likely to believe that the increased use of intellectual property rights and patenting in agriculture is a good thing. On the other hand, however, professionals who cited a higher percentage of their research as working on genetic engineering issues were more likely to believe that the increased use of intellectual property rights and patenting was not a good thing; maybe because they had already incurred problems or suspected that they would in the future.

Based on the following factors, professionals are more likely to agree that private research funds do not influence research outcomes: the younger they are (and once they are aged over a certain threshold); if they are male; and if they agree that increased intellectual property rights and patenting activity in agriculture is a good thing. Interestingly, these are the only models on professional beliefs (e.g. Wheeler 2008, 2008a) in which gender was found to have a significantly strong influence. Women seem to be more suspicious of the consequences of private research funds than males, and are also slightly more likely to believe that conventional agriculture needs to change, but their beliefs were not significantly different in any other comparison.

Along with the quantitative results in this paper, the qualitative comments made in the survey do support some of the concerns raised in the academic literature over the past two decades over the rise of intellectual property rights, patenting and private research funding, and further research on this topic in general will be required.

Additional Professional Concerns

At the end of the survey, professionals were asked if there were any other comments that they wished to make. A number of professionals took the chance to comment about the adoption of both genetic engineering and organic farming, with some believing that co-adoption was not possible, whereas others considered it as possible. For example:

> *"Organics and biotechnology are incompatible – they cannot coexist. Because of this, there is a clear need for establishing property rights". (Respondent 155 - TS).*
>
> *"The two sides (organic agriculture and genetic engineering) are at war". (Respondent 116 - GS).*
>
> *"My feeling is that we need a merging of technologies (genetic engineering and organics) to create a sustainable agriculture. Biotechnology offers pest resistant solutions for organics (but this assumes of course that the long-term aspects associated with biotechnology are resolved before merging)". (Respondent 179 - TS).*
>
> *"Increased adoption of both is possible (though some would see this as contradictory). They both need to be appropriately researched, taking into account all problems and community concerns. There is a lot yet that can be done". (Respondent 42 - GS).*

The issue of co-adoption is clearly one that causes wide debate. One of the main points of debate is the different interpretations of biotechnology, with some farmers wanting the ability to use techniques such as marker selection (e.g. Lammerts van Bueren & Østergård 2005), which is potentially possible to adopt without any negative externalities. Others believe that a clear stance on all aspects of genetic engineering must be taken, and the preferred option is banning any genetically modified organisms (IFOAM 2002). The problem with co-adoption can be that techniques are not adopted in isolation – they can have externalities (positive or negative) present. The clear example of this is genetically engineered canola, which is highly likely to transfer from its original location, increasing costs and difficulties for farmers who never originally planted the seed. The problem related to this negative externality is difficult to resolve as there is no clear property rights that exist. Although there may be a strong moral argument that companies or farmers who planted the seed should bear the costs of any negative externalities caused, there is no current move to make these property rights clear. Clearer property rights will be needed to establish the rights of sustainable farmers. Those who support co-adoption of organic farming and genetically modified crops are clearly not worried about the extent of these particular negative externalities or about the potential for a decrease in consumer demand for organic produce as a result. Empirical studies find that consumer attitudes towards genetic engineering are a significant predictor in their willingness to pay for organic produce, and vice versa (James & Burton 2003). This suggests that consumers are more than likely to prefer organic produce that remains free of any genetically engineered products or processes; and if they were accepted into organic farming practices, then consumers would probably demand to pay less for organic produce.

Many of the targeted professionals from the survey wanted to make additional comments regarding the need for conventional agriculture to become more sustainable, but not necessarily to convert to organic agriculture. Many professionals strongly supported the concept of low input sustainable agriculture, but did not believe that sustainability in Australian agriculture would be achieved with a full-scale adoption of organic systems. For example:

> *"Organics is only accepted on the fringe currently. If it is to go mainstream, then it needs to be repackaged as low-input, and therefore parts of organics can be adopted by farmers". (Respondent 153 - TS).*

> *"Pragmatism is what is needed when it comes to the decision of what farming system to adopt. You need to look at everything that is offered, and choose what is right for the environment you are in". (Respondent 71 - GS).*

> *"I think that many conventional farmers believe that agriculture in general, the environment and consumers would all be better off if every farm was organic. Conventional farmers would love to go organic, but there are too many barriers for them to do so. These barriers should be lowered. I do not think it is an impossible dream to predict further increases in organic agricultural adoption; however I believe that the groundswell within farmers generally will be to go towards lower input systems and hence increased sustainability". (Respondent 165 - TS).*

> *"Biotechnology and organic agriculture are perceived as being far ends of the farming spectrum and cannot be adopted together, but in reality they can live together" (Respondent 185 - GS).*

> *"There needs to be more cross-fertilisation of both cultures (conventional agriculture and organic agriculture). For example, look at the benefits of no-till agriculture; we need some application of both for a truly sustainable agriculture". (Respondent 183 - TS).*

> *"Organics as a system has a limited market size and production; you could not have all Australian farmers go organic. But, organic agriculture offers an enormous amount to conventional agriculture in terms of some of its management systems, i.e., trees, companion plantings etc... A hybrid of conventional and organic systems is what we want". (Respondent 154 - TS).*

Such views may reflect the relatively small adoption of organic farming in Australia. These views may not be held by professionals in other countries where organic farming has reached a much higher percentage, and hence is currently being regarded as a real alternative. At the moment in Australia, the adoption of organic farming is not regarded as an alternative to conventional agriculture by many agricultural professionals, even by professionals who have more experience in the area; perhaps because of problems that are currently perceived to be associated with the system (e.g. Wheeler 2007). This view seems prevalent, even though organic farming is considered by many of these professionals to be the more sustainable system. The problem seems to lie with their beliefs that other conventional farmers in Australia will not adopt organic farming as it stands now; and that either the standards for organic farming need to change or conventional agriculture needs to 'cherry pick' certain techniques to increase their sustainability. Such beliefs may be true to some extent, however, it ignores the fact that the organic market has continued to grow and consumer demand will drive further farmer change in the future. In addition, as more and more new farmers enter the industry, they are more likely to fully consider adopting alternative forms of farming as they are not caught up in any traditional ways of farming in the past, or have mindsets against organic farming. The existing stance also ignores the findings that organic farms may provide very important positive externality effects, as found by Lohr (2005). Lohr sought to measure the overall spill-over effects of organic farming in the USA. In her unique analysis, she compared 36 indicators of economic, social and environmental benefits in counties with organic farms (1,208 counties) and counties without (1,870). She found that counties with organic farms compared better on 26 out of 36 indicators, whereas counties without organic farms compared better on only 3 indicators, and 7 were neutral. Lohr suggests that this analysis may suggest broader sustainability benefits from organic farms, i.e., that organic farm are influencing the practices of conventional farms around them. Hence, there is more to be gained from farmers going organic than may be originally thought.

My survey indicates that there is strong support amongst Australian agricultural professionals for a greening of Australian agriculture, incorporating some of the best techniques and products from both genetic engineering research and organic farming, although most consider that the adoption of these techniques needs to be balanced. There is little support for a complete reorientation or deepening of Australian farming systems at this point in time, although those taking this stance do not seem to be aware of the wider literature on organic farming or of how organic farming has developed to this point.

Discussion and Conclusion

Over half the agricultural professionals surveyed believed that Australian agriculture was not environmentally sustainable, although on the whole they were not convinced about pursuing what is regarded by some as 'extreme' measures to obtain sustainability (namely organic farming). Belief that conventional agriculture in Australia is unsustainable is influenced primarily by positive views on the environmental benefits of organic farming, gender and the field of agriculture in which the professional works.

Professionals who are seeking a real alternative to current farming systems do seem to regard organic farming as such a system, although they do not regard genetic engineering as a possible solution to environmental problems. From the general survey responses, other professionals believe that both organic farming and genetic engineering have much to offer Australian agriculture; and that the two innovations can coexist and work together to help improve agricultural sustainability. A smaller minority of professionals surveyed, and organic farmers and the organic industry in general, believe that coexistence is not possible, and that a complete reorientation (or deepening) of farming systems is needed to achieve sustainability in Australian agriculture. In general, the targeted sample of agricultural professionals (who were more knowledgeable about organic farming) was much more likely than general respondents to believe that organic farming offers environmental, innovative and food quality benefits. Consequently, targeted respondents are much more supportive of further government support for organic farming, but are less approving of government support for genetic engineering. In addition, targeted professionals were more likely to agree that biotechnology products need to be researched for longer time periods before further commercial release, although most professionals from the general sample also agreed with this principle. There is no doubt that many professionals in the general survey were ignorant and ill-informed about organic farming. Most, for example, could not name a single organic farming certifying body. Negative attitudes towards organic farming may be symptomatic of institutional bias. Ways that such institutional bias could be addressed include: changing the agricultural curriculum; encouraging multi-disciplinary research; spreading research dollars; funding a variety of research programmes; and increasing professional exposure to systems thinking, redesign approaches, and alternative farming systems. A new generation of agricultural professionals would in this way be provided with information and knowledge about sustainable agriculture that will probably (but not always) influence their views. Encouraging increased contact with organic farmers and visits to organic farms (along with an increased recognition of the extensive scientific literature on organic farming) could also play a role in changing the perceptions of some agricultural professionals.

Professionals do hold concerns about the future direction of agricultural research. They are concerned about the rise of intellectual property rights and patenting in agricultural research, although these concerns seem to be stable and have not increased in the past decade or so. Professionals' positive attitudes towards intellectual property rights and patenting are mainly influenced by their working age, salary, field of agriculture, the lower their research relevance on genetic engineering, and positive attitudes about the influence of private funds on research. In general, most respondents seem suspicious of the influence of private research funds on research outcomes. The main influences on professionals' beliefs that private research funds do not change research outcomes are age, gender and positive attitudes towards intellectual property rights. These results could be interpreted to support, to some extent, the conclusion of authors who argue that intellectual property rights, and patenting in general, have gone too far, and that patenting rights should play more of a role in maximising society's benefits, not individual producer benefits. As a result research in areas such as sustainable agriculture, and in particular organic farming, may suffer comparatively.

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APPENDIX

A binary probit model was used to evaluate the factors that influenced beliefs towards the sustainability of conventional agriculture; intellectual property rights and patenting; and the influence of private research funds. The dependent variables used are the respondents' answers to the three questions where the answers were reclassified as dummies (i.e. if professionals agreed/strongly agreed with the statement they were coded as a one, and any other answer was coded as a zero). The methodology of the binary probit regression model is not explained in full here due to space restrictions, however, it is available from the author upon request; or see Greene (2003) or Wheeler (2008) for further detail.

Due to the comprehensive nature of the surveys, there were many variables that could be included in the models of beliefs, namely: socioeconomic and demographic variables (age, years spent working in a professional area, farm background, gender, income, education, ethnicity); occupational variables (leadership, being a scientist, being an extension officer, working in a state organization, working for CSIRO, working within the area of NRM, working within the area of broadacre and/or grazing); knowledge and experience variables (self-perception of their organic and biotechnological knowledge, part of targeted sample, percentage of time spent research organic farming and genetic engineering); and attitudes to other research issues (namely including professionals' views on the overall benefits of organic farming and genetic engineering, the current environmental sustainability of conventional agriculture, attitudes towards intellectual property rights and patenting, and attitudes towards the influence of private research funds in agricultural research).

An explanatory list of variables is provided in Table A.1, and the results in Table A.2.

Table A.1 Explanatory Variables for Professionals' Beliefs towards Research Issues

Variable	Explanation
Socio-Economic Characteristics & Demographics	
Age	Actual age in years
Age^2	Age^2 = age squared
Leader	Dummy variable, 1 = leader, 0 = non-leader
Working Age (WKAGE)	Years spent working in current agricultural area
Farm Background (FARM)	Dummy variable, 1 = farm background, 0 = otherwise
Female	Dummy variable, 1 = female, 0 = male
Ethnicity	Dummy variable, 1 = non-European, 0 = European
Salary	Dollar salary of professionals
Tertiary Education (EDUCYRS)	Years of post-secondary education
Occupational Influences	
Extension	Dummy variable, 1 = extension role, 0 = scientist, researcher, academic
Scientist	Dummy variable, 1 = scientist, 0 = other
CSIRO	Dummy variable, 1 = employed at CSIRO, 0 = RSSA, Uni Adelaide, SARDI, PIRSA, other organisations
STATE	Dummy variable, 1 = employed in state organisations, 0 = other
Working in Natural resource management (NRM)	Dummy, 1 = NRM, revegetation, land management, soils, entomology, ecotoxicology, salinity, 0 = dairy, livestock, biotechnology, irrigation, plant pathology, horticulture, viticulture, broadacre/grazing
Working in broadacre and/or grazing (BROADGRAZ)	Dummy variable, 1 = broadacre/grazing, 0 = other
GE research relevance (GERESREL)	% indicating the genetic engineering research relevance
OA research relevance (OARESREL)	% indicating the organic farming research relevance
Knowledge, Experience and Informational Influences	
Genetic engineering knowledge (GEK)	Scalar variable of genetic engineering knowledge, where 1= no knowledge and 5 = detailed and practical knowledge
Target	Dummy variable, 1 = targeted sample, 0 = otherwise
Attitudinal Influences	
Beliefs on conventional agriculture's sustainability (CAENV)*	Scalar variable of response to "Conventional agricultural farming in Australia is generally not environmentally sustainable", where 1= strongly disagree and 5 = strongly agree
Beliefs on agricultural intellectual property rights and patents (IPUSE)	Scalar variable of response (1 to 5) to "the increased use of intellectual property rights and patenting activity is a good thing for agricultural research"
Beliefs on private funding effects (PRIVATEFUNDS)	Scalar variable of response (1 to 5) to "private funding of agricultural research does not influence research outcomes"
Beliefs on GE environmental sustainability (GEVSCAENV)	Scalar variable of response (1 to 5) to the statement that "GE is more environmentally friendly than conventional agriculture"
Beliefs on OA environmental sustainability (OAVSCAENV)	Scalar variable of response (1 to 5) to the statement that "OA is more environmentally friendly than conventional agriculture

Notes: * Attitudinal variables were also coded as dummies as explained in the text for use as dependent variables.

Table A.2 Binary Probit Regression Models of Influences on Beliefs towards the Sustainability of Conventional Agriculture, Intellectual Property Rights and Patenting and Private Research Fund Influences

	1. Beliefs Towards Environmental Sustainability of Conventional Agriculture			***2. Beliefs towards Intellectual Property Rights and Patenting***			***3. Beliefs towards the influence of Private Research Funds***		
	Coef.	z	P>|z|	Coef.	z	P>|z|	Coef.	z	P>|z|
age	-0.02	-0.22	0.83	0.08	0.94	0.35	-0.18	-2.28	0.02
age2	0.00	0.53	0.59	0.00	-1.24	0.22	0.00	2.32	0.02
wkage	-0.03	-1.58	0.12	0.04	2.91	0.00	0.01	0.75	0.45
ethnic	0.06	0.11	0.92	-	-	-	0.07	0.13	0.89
gender	-0.51	-1.92	0.06	0.24	0.94	0.35	0.62	2.15	0.03
farm	-0.04	-0.19	0.85	-0.17	-0.74	0.46	0.24	0.99	0.32
educyrs	0.08	1.25	0.21	0.01	0.14	0.89	0.06	0.81	0.42
salary	0.00	-0.26	0.79	-0.00	-3.50	-0.00	0.00	0.33	0.74
scientist	0.04	0.17	0.87	-0.25	-0.92	0.36	0.09	0.31	0.76
leader	0.19	0.56	0.58	0.12	0.33	0.74	-0.12	-0.31	0.76
extension	0.03	0.11	0.91	-0.06	-0.22	0.83	-0.16	-0.58	0.56
target	0.05	0.19	0.85	-0.25	-0.85	0.40	-0.16	-0.47	0.64
nrm	-0.18	-0.68	0.50	-0.31	-1.20	0.23	-0.16	-0.51	0.61
broadgraz	-0.70	-2.50	0.01	-0.60	-2.07	0.04	-0.39	-1.29	0.20
csiro	-0.24	-0.47	0.64	-	-	-	0.41	0.76	0.45
btk	-0.02	-0.15	0.88	0.24	1.67	0.09	0.15	1.08	0.28
oak	0.09	0.68	0.50	-0.09	-0.64	0.52	-0.04	-0.29	0.77
btresrel	-0.01	-1.44	0.15	-0.01	-2.16	0.03	0.00	0.29	0.77
oaresrel	0.00	0.31	0.76	0.00	0.60	0.55	0.00	-0.68	0.49
ipuse	-0.03	-0.27	0.79	-	-	-	0.32	3.00	0.00
privatefunds	-0.16	-1.44	0.15	0.28	2.66	0.01	-	-	-
caenv	-	-	-	0.06	0.65	0.52	-0.16	-1.63	0.10
oavscaenv	0.57	4.26	0.00	-	-	-	-	-	-
btvscaenv	0.18	1.38	0.17	-	-	-	-	-	-
_cons	-1.82	-0.85	0.40	-1.2441	-0.68	0.5	1.26	0.70	0.48
N	185			185			185		
Wald chi2	41.54			41.37			44.64		
Prob>chi2	0.01			0.0022			0.002		
Pseudo R2	0.25			0.1671			0.163		
Log pseudo likilihood	-99.40			-95.83			-77.51		

Notes: All models calculated with Huber/White heteroskedasticity-consistent standard errors and covariance. Due to collinearity problems, not all models could be fully estimated with all variables. Other variables such as overall attitudes to organic farming or genetic engineering are not included due to possible endogeneity issues. Attitudes towards the environment credentials of genetic engineering and organic farming are only included in the first model (not included in other models due to non-relevance).

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