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TOWARDS A COMPARISON OF CHEMICAL-FREE AND CONVENTIONAL FARMING IN AUSTRALIA

ELS WYNEN and GEOFF EDWARDS*
La Trobe University, Bundoora, Vic. 3083

The classes of benefits and costs, private and external, arising from a partial movement from conventional to chemical-free farming are considered. A report is provided on a comparison of physical and financial characteristics of chemical-free and conventional cereal/livestock farming in south-eastern Australia. A key finding is that private net returns were similar for the two types of farmers. A favourable change in net externalities could be expected from a movement towards chemical-free farming. Policy implications relating to the taxation of chemical use in agriculture, and to research, extension and marketing are discussed.

Until the middle of last century, a successful agricultural management system was largely dependent upon the maintenance of an ecological balance on the farm. This was achieved through employing practices including certain crop rotations, cultivation, and the use of livestock. Such management practices enabled agriculture to be sustained for many centuries.

In more recent times, scientific advances have allowed increased productivity per unit of land and of labour by the use of synthetic fertilisers and pesticides.[1] This new technology was widely adopted by farmers in the western world, and is referred to here as conventional agriculture. Although the productivity of land has increased in the short term, concern exists that modern agriculture may not be sustainable in the long term. Central to this concern are such phenomena as pest resistance to pesticides (see, for example, Debach 1974) and soil degradation through erosion, acidity, salinity and compaction (see, for example, Department of Environment, Housing and Community Development 1978; Hodges 1981; Hodges and Arden-Clarke 1986). Some of the unwanted effects of conventional farming occur on-farm. Others are experienced off-farm as external diseconomies.

Non-conventional farming is referred to under many names, including alternative, organic, biological, ecological, natural and sustainable. The National Association for Sustainable Agriculture, Australia (NASAA) (1986) defines sustainable agriculture as:

> 'A system of agriculture able to balance productivity with low vulnerability to problems such as pest infestation and environmental degradation while maintaining the quality of land for future generations.
>
> In practice this involves a system which avoids or largely excludes the use of synthetically compounded fertilisers, pesticides, growth

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[1] The word 'pesticides' is used here as an umbrella word referring to all agricultural biocides such as insecticides, herbicides, fungicides and nematocides.

regulators, livestock feed additives and other harmful or potentially harmful substances. It includes the use of technologies such as crop rotations, mechanical cultivation and biological pest control; and such materials as legumes, crop residues, animal manures, green manures, other organic wastes and mineral bearing rocks.'

Similar definitions have been provided by others (for example, United States Department of Agriculture 1980).

Because of contention about the sustainability of conventional agriculture (for example, Tisdell 1988), the word chemical-free is used in this paper to indicate the type of agriculture defined by NASAA as sustainable. The description chemical-free conveys the absence of some inputs more clearly than it does the presence of certain management techniques. However, there appears to be no clearly superior short description of the type of agriculture under consideration. Although it has few practitioners, there is evidence of increasing interest in chemical-free agriculture by farmers and researchers (Youngberg 1987).

Chemical-free agricultural practice does not necessarily ensure that farmers' produce is chemical-free. Spray-drift, and residuals from chemicals used on their farms in the past, are two reasons for this. Further, products might not be chemical-free if chemicals are applied in the marketing process.

Private costs and benefits of chemical-free agriculture have been assessed by some (see, for example, Klepper *et al.* 1977; Vine and Bateman 1981). It is more difficult to find literature on the external costs and benefits in quantitative terms. An estimate of the external cost of the use of pesticides in The Netherlands amounted to f. 300m–f. 550m, with total expenditure on chemicals of f. 700m per year (Van der Vaart 1987).[2] We are not aware of any estimates of external costs of pesticide use in Australia. Because of the relatively small role of intensive crop and animal production in Australia, it is likely that external costs are correspondingly low in comparison with those in other countries with intensive agricultural systems.

In this paper, the social costs and benefits of a partial movement from conventional to chemical-free farming are considered. The classes of private and external costs and benefits are outlined in the second section. In the third section a comparison is made of physical and financial characteristics of chemical-free and conventional cereal/livestock farming in south-eastern Australia for the cropping year 1985–86. The survey on which this section is based should be viewed as an initial study. Policy issues are discussed in the fourth section, with emphasis on implications of some of the externalities identified in the second section.

Benefits and Costs of a Movement from Conventional to Chemical-Free Farming

A movement towards chemical-free farming is expected to involve private and external benefits and costs. Together, these comprise social benefits and costs. Private benefits or costs are defined as those initially

[2] $A1 = f. 1·28; 29 January 1988.

TABLE 1

Benefits and Costs of a Movement from Conventional to Chemical-Free Farming

Item	Private	External
A. Benefits		
1. Increased availability of some products, e.g. chemical-free cereals	*	
2. Decreased use of some inputs, e.g. synthetic fertilisers, pesticides	*	*
3. Improved soil quality		
On-farm, e.g. improved soil structure	*	
Off-farm, e.g. decreased erosion		*
4. Improved water quality	*	*
5. Improved human health		
Farmer and farmer's family, due to, e.g., reduced handling of pesticides	*	*
Farmer's neighbours, due to, e.g., reduced exposure to spray drift		*
Consumers, due to, e.g., reduced exposure to pesticide allergens		*
6. Reduced risk of pest adaptation to farm management techniques	*	*
7. Reduced susceptibility to harsh seasons	*	
8. Reduced potential loss from rejection of exports of conventional products	*	
9. Increased personal satisfaction, due to, e.g., provision of 'clean' food	*	
10. Decreased need for research related to conventional farming technologies	*	*
B. Costs		
1. Decreased availability of some products of conventional farming	*	
2. Establishment and operation of a marketing system for chemical-free products	*	
3. Increased use of resources that substitute for synthetic fertilisers and pesticides, e.g. green manures	*	
4. Increased uncertainty about farming, due to, e.g., more limited knowledge of technologies	*	
5. Decreased personal satisfaction, due to, e.g., social pressures	*	
6. Increased need for research related to chemical-free farming	*	*

accruing to, or borne by, those farmers, or their families, who adopt chemical-free farming. Ultimately these benefits and costs, or parts of them, may be passed on to others through changes in market prices. External benefits and costs include conventional externalities experienced by other firms or individuals when a farmer shifts from conventional to chemical-free farming. With the definitions used here, changes that a movement to chemical-free farming cause in government payments/receipts for inputs or outputs subject to policy-induced distortions also represent externalities.[3] Examples are fertiliser subsidies and subsidised medical services. This approach of defining externalities more broadly than is usually done (but see Buchanan and Stubblebine 1962, p. 381; Baumol and Oates 1988, pp. 16–7) is

[3] The alternative approach, which gives the same net result, would be to value inputs and outputs at their undistorted prices at the farm level. However, that approach would not indicate the private costs and benefits to farmers of a movement to chemical-free farming.

reasonable in the context and saves words. Our attempt to identify the benefits and costs, private and external, of a movement towards chemical-free farming is summarised in Table 1.

As in all benefit–cost analyses, it is necessary to decide on the perspective of the study. The approach taken is the commonly used one of including all benefits and costs accruing to the nation, and ignoring benefits and costs experienced outside Australia. See Mishan (1982, pp. 74–5) for support of this approach. The following comments are specific to particular items in Table 1.

It is doubtful whether increased supplies of chemical-free produce (item A.1) can be viewed as a clearcut private benefit unless marketing arrangements exist allowing such produce to be distinguished from the products of conventional farming. Because smaller volumes of chemical-free produce would be expected for a long time, and because it is costly to ensure that products presented as chemical-free are so, marketing costs will be higher for these products than for the products of conventional agriculture. This difference in marketing costs for the two classes of products needs to be included in item B.2.

External benefits would accrue from a decrease in the use of those inputs which caused external diseconomies, such as fertilisers and pesticides (item A.2). When a subsidy applies to the input (as for fertilisers until 30 June 1988) a decrease in the subsidised input also causes, with our taxonomy, an external benefit to taxpayers.

Improvements in the health of farmers and their families (item A.5) arising from a movement to chemical-free farming generate external benefits, as well as private ones. The reason is that users of medical services typically pay less than the social costs of providing them (for example, see Clements 1983).

Chemical-free food (item A.1) and improved water quality (item A.4) are valued partly for their contribution to improving human health (because of the absence of chemicals and, for food, because of other qualities such as nutritional benefits). That is, the demand for chemical-free food and for better water is partly derived from the demand for improved health: it is inappropriate to double-count. However, food grown on chemical-free farms and cleaner water are also valued for other reasons, for example, perceived superior taste.

Pests (including weeds, insects and diseases) are less likely to adapt to pest management measures in the chemical-free than in the conventional sector (item A.6) for several reasons. These include the emphasis on preventing the occurrence of pests (as opposed to the treatment of the pest when it occurs), and a greater diversity of techniques in chemical-free farming (for example, use of crop rotations, trap crops, mechanical cultivation and manipulation of planting dates).

Reduced susceptibility of farm income to harsh seasons with chemical-free farming (item A.7) is attributable to two factors. First, cash costs in chemical-free farming can be expected to be generally lower than in conventional farming, giving lower cash losses in climatically adverse years. The second factor is less obvious. Soils on chemical-free farms are sometimes less susceptible to dry conditions (possibly due to relatively high organic matter content), with consequences for yields (Klepper *et al.* 1977). In dry years, crops on chemical-free farms suffer from drought-stress later than on conventional farms. In years of extreme drought this may not help.

Changes in personal satisfaction or psychic income resulting from a switch to chemical-free farming reflect a range of personal and social factors specific to each individual or family. It can be expected that the net effect of these would be positive for some farmers (item A.9) and negative for others (item B.5). As in other contexts, estimation of these items *ex-ante* would be exceedingly difficult. However, since they involve private effects, it can be expected that individuals will allow appropriately for them in making decisions on type of farming.

Since the size of an industry or sector is a key determinant of the national benefit from research (Edwards and Freebairn 1981), reduction in the size of the conventional farming sector would cause a fall in the nationally optimal research effort for this sector. (The relevant measure of the decrease in size of conventional farming is not the change in absolute size, but the decrease compared with its size in the absence of the movement to chemical-free farming.) It is hypothesised that the actual research effort would also be reduced.[4] A reduction in allocation of resources to research into conventional farming (item A.10) is treated partly as a private benefit because farmers undertake some experimentation directly and because the cost of some research, mainly in the private sector, is paid for by farmers in input prices. Savings in the bigger (in Australia) public sector contribution to agricultural research would, with the taxonomy used, be an external benefit of a shift towards chemical-free agriculture.

At least two interesting points emerge from Table 1. The first is that a large number of items need to be considered in a complete benefit–cost analysis of a shift towards chemical-free farming. These relate to changes not only in outputs and inputs, but also in resource quality, risk, personal satisfaction and research.

The second point concerns the relationship between the private and external impacts of a movement towards chemical-free farming. On the costs side, if policy-induced distortions are absent, all impacts other than a component of research into chemical-free farming can reasonably be viewed as private costs.[5] The fact that mainly private costs are involved makes estimation of the magnitudes easier.

On the benefits side, however, Table 1 has ten entries for private benefits and eight for external ones. This suggests that valuation problems are likely to be greater for benefits than for costs, a situation common in benefit–cost assessments. It points also to the likelihood that not all benefits are taken into account by those considering the adoption of chemical-free farming. This raises questions about the desirability of government intervention, which are taken up in the fourth section.

[4] If there is underallocation of resources to agricultural research, as is widely accepted to be the case (for example, Ruttan 1982), it may be efficient for *actual* research for conventional agriculture to increase, even if this sector becomes smaller. However, holding research policy constant, a fall in research into conventional agriculture would follow a fall in size of this sector. If, on the other hand, the real research effort for conventional agriculture were held constant with a movement towards chemical-free farming, this could make research closer to its nationally optimal level, enhancing the attractiveness of the movement in benefit–cost terms.

[5] The absence of policy-caused divergences is probably most questionable in relation to the reduction in output of conventional farming (item B.1). However, with generally low rates of assistance for the cereal industry, any policy-induced divergences are likely to be small.

Evaluation of all the benefit and cost items listed in Table 1 is a task beyond us. The task attempted is a much simpler one. In the third section, a survey of the private financial benefits and costs of chemical-free and conventional cereal/livestock farming in south-eastern Australia is reported. In the fourth section some policy issues are considered, including the merits of different policies for reducing the externalities identified in Table 1.

A Comparison of the Private Costs and Benefits of Chemical-Free and Conventional Farming[6]

Introduction

Studies of chemical-free farming in Europe and the USA have been reviewed by Lampkin (1984) and Wynen and Fritz (1987). In these studies, variable costs, gross margins (production times price minus variable cost) and net margins (gross margins minus fixed costs) were considered. Although results varied, in general, variable costs were lower on chemical-free than on conventional farms. Gross and net margins were lower in some studies, and higher in others, on chemical-free farms.

Data on chemical-free agriculture in Australia are almost non-existent. To enable a comparison of the private costs and benefits of chemical-free and conventional farming a survey was conducted of chemical-free farmers and a conventional farmer counterpart for each of those farmers, for the cropping year 1985–86. To obtain a population list for the survey, a preliminary survey was initiated in November 1984. The names of farmers were obtained in many different ways. Participants in organic conferences and festivals were made aware of the intended research. Letters were written to the editors of all major rural papers in south-eastern Australia, and to organic growers' organisations. Retailers of chemical-free produce were approached for names of commercial suppliers. Farmers listed in Conacher and Conacher (1982) or in the Willing Workers On Organic Farms programme, if appearing to be commercial, were sent a letter. On the survey schedule itself a question was asked about names of other chemical-free farmers.

Main survey

As big differences may occur in input and output mixes and in the level of output prices across enterprises, it was decided to concentrate on one agricultural industry. The broadacre cropping industry was chosen for two main reasons. One, it was considered desirable to study a cropping enterprise, because it is in cropping that differences between the two systems are most pronounced. These differences exist both in use of inputs, and in the effect on the long-term productivity of the farm, through the system's effect on the soil. The second reason was that the cereal/livestock industry is a major agricultural industry in Australia.

[6] The survey described in this section was financed from CTEC funds obtained by Rob Dumsday and John Kennedy for a project on the long-term utilisation of land and water resources.

The main survey was carried out in October 1986 (Queensland and New South Wales), and in February 1987 (Victoria and South Australia). All farmers who were known from the preliminary survey and who were judged to be possibly farming in a chemical-free way were interviewed. The first criterion for inclusion in the survey was that no synthetic fertilisers or pesticides were used in cropping. In addition to the non-use of these inputs, there had to be clear indications of the use of other techniques in the management system, to handle soil fertility and pest problems. Such techniques could include, for example, the practice of a crop rotation which allows build-up of organic matter in the soil and use of livestock and farm equipment for weed management. Only farmers with 50 per cent or more of their total income originating from farming were included. The third criterion was that the farm had been under chemical-free management for at least 5 years. This was to avoid the transition period during which adjustment problems might occur. On average, the included producers had been farming chemical-free for 20 years.

Of the 19 farmers meeting the three criteria, eight were judged to be fully chemical-free, five semi-chemical-free, and the rest farmed in such a way that differentiation from the conventional system was not warranted. The fully chemical-free farmers are reported upon here.

The chemical-free farmers interviewed were compared with conventional farmers in their proximity. These conventional producers were also broadacre cereal growers. Local officers of the Department of Agriculture assisted in finding suitable counterpart conventional farmers. In each case, the conventional farmer chosen was at least as good a manager as the chemical-free farmer in the opinion of the Department of Agriculture officer. Other characteristics on which conventional farms were chosen were similarity of soil type, local climate, and size to that of the chemical-free farm. As it was very difficult to find conventional farmers who were good managers, and whose farms were similar in all the other aspects (soil type, climate and size), farm size was usually the first criterion to be dropped.

The main part of the survey consisted of questions on physical and financial characteristics of the farms. These questions were taken from the Australian Bureau of Agricultural and Resource Economics' (ABARE) farm survey and were supplemented with questions considered important in the context of the present study.

Tests were carried out to investigate the differences between chemical-free and conventional farming for a number of variables. As the conventional farmers were chosen on the basis of similarity of certain characteristics to chemical-free farmers (such as climate and soil type), the tests used are those appropriate for 'paired samples'. If the observations in a sample are normally distributed, a Student t-test is often used to examine whether differences are statistically significant. When a sample is small, the assumption of a normally distributed sample is less likely to hold. For this reason the non-parametric Wilcoxon test, for which normality does not need to be assumed, was used. This test might be marginally less powerful than a Student t-test if the underlying distribution is normal. *Ceteris paribus*, the smaller the sample the less likely it is that differences between samples can be shown to be statistically significant. However, where differences are indicated, these are likely to be detected also in larger

samples. Since it is thought that most chemical-free farmers were included, enlarging the sample would not have been easy.

The p-values in the tables in the third section are the individual p-values for the variables (that is, the problem of multiple testing, while recognised, is ignored). Averages shown in these tables are unweighted averages, and were calculated including only those farms where both of a pair engaged in the activity under consideration (for example, production of wheat or livestock). This was because the eight farms were located in widely different areas, so that weighting according to area operated, or the inclusion of only one of a pair, might bias the result.

Results

The physical characteristics of the eight chemical-free farms and the conventional counterparts are shown in Table 2. No statistically significant difference between the chemical-free and conventional farms was shown for total area operated ($p = 1 \cdot 0$), or for arable area as a percentage of the total area ($p = 0 \cdot 107$).

Fertility of the soil can be manipulated by crop rotations. As chemical-free farmers do not add nutrients to the soil in the form of synthetic fertilisers, a difference in crop rotations between the two systems can be expected. One way of measuring this is to measure the area cropped in a particular year as a proportion of the arable land on the farm. In 1985–86, the difference was significant ($p = 0 \cdot 007$). Each of the eight chemical-free farmers cropped a lower percentage of arable land than their conventional counterparts.

Another way to manipulate soil fertility, and to manage weed problems, is to keep livestock. Of the eight conventional farmers, three did not keep stock at all. However, on the remaining five conventional farms the stocking rate per grazed hectare (defined as number of sheep and goats plus eight times the number of beef cattle, divided by operated area minus cropped area) was similar to that of the chemical-free counterparts ($p = 0 \cdot 418$).

The effect of the farming system on soil fertility and pest problems can be assessed by measuring crop yields. Wheat was grown by all but one of the conventional farmers; the exception regarded wheat production as uneconomic because of the costs of controlling nematodes with pesticides. The average wheat yield on the other seven

TABLE 2

Some Physical Characteristics of Chemical-Free and Conventional Farms in South-Eastern Australia: 1985–86

	C-F[a]	Conv.[a]	Difference[b]
Total area operated (ha)	755	928	−173 (1·000)
Arable area (% of total area oper.)	74	82	−8 (0·107)
Cropped area (% of arable area)	47	77	−30 (0·007)***
Stocking rate (unit/grazed ha)	4·6	3·1	1·4 (0·418)
Wheat yield (t/ha)	2·4	2·5	−0·1 (0·673)

[a] C-F = average of chemical-free farmers; Conv. = average of conventional farmers.
[b] Figures in parentheses are p-values. *Significant difference at the 90 per cent confidence level; **significant difference at the 95 per cent confidence level; ***significant difference at the 99 per cent confidence level.

pairs of farms was similar ($p=0\cdot673$). On chemical-free farms the absence of synthetic fertilisers was compensated for by the use of mineral rock, the keeping of livestock partly for manure production and by the manipulation of the rotation system. Typically, chemical-free farmers grew less cash crop, and more green manure or pasture. Weedicides used on conventional farms were replaced by practices such as timely cultivations, and use of livestock.

Although not verified, some chemical-free farmers claimed that the quality of their produce was better than that of conventional farmers as expressed, for example, in protein content. This aspect is discussed extensively in Balfour (1975).

Expenditure on the main inputs per hectare operated is shown in Table 3. Apart from credit and labour, expenditure on all inputs was significantly higher on the conventional than on the chemical-free farms ($p<0\cdot1$).

The fertilisers used by chemical-free farmers consisted of those allowed under the Organic Standards set by NASAA (undated). Pesticides used by chemical-free farmers were those allowed by the same Standards on field crops (with two minor exceptions), and included allowable and non-allowable pesticides on stored crops and on livestock.

Six of the eight chemical-free farmers had interest repayments of less than $5 per hectare operated, compared with four of the conventional farmers. Fuel use is sometimes expected to be greater on chemical-free farms due to possibly more extensive cultivations to manage weeds. However, per hectare cropped there was no difference between the two systems for this input ($p=0\cdot800$; not shown in Table 3). Expenditure per hectare operated was higher on conventional farms than on chemical-free farms ($p=0\cdot030$).

The same picture emerges for depreciation of machinery and equipment. Although no difference can be shown for this input between the two systems per hectare cropped ($p=0\cdot624$), a difference does exist when calculations are carried out per hectare operated ($p=0\cdot080$). As conventional farmers crop a larger area than chemical-free farmers, lower depreciation values per hectare cropped on conventional farms (due to economies of size) would not have been surprising. On the other hand, the relatively large areas in one crop on conventional farms might indicate a need for relatively large and new

TABLE 3

Expenditure on Main Inputs on Chemical-Free and Conventional Farms in South-Eastern Australia ($ per Hectare Operated): 1985–86[a]

Input	C-F	Conv.	Difference
Fertilisers	3·0	19·1	−16·1 (0·018)**
Pesticides	0·4	14·1	−13·7 (0·007)***
Interest	5·0	16·2	−11·2 (0·363)
Fuel	11·5	21·4	−9·9 (0·030)**
Machinery and equipment	31·3	73·8	−42·5 (0·080)*
Labour	34·9	40·9	−6·0 (0·363)
Improved capital value	1011	1038	−28·0 (0·726)

[a] For explanation of symbols, see Table 2.

machinery to ensure timeliness of operations; this would result in relatively high depreciation costs.

Labour requirements are sometimes expected to be higher on chemical-free than on conventional farms due to weed problems when no pesticides are used. Although it is possible that this is true for some enterprises, there was no indication of it on the surveyed farms ($p=0\cdot363$).

Since similar soil type and location were the important considerations in the choice of conventional counterparts, unimproved capital values of the two types of farms were similar per hectare operated ($p=0\cdot363$). The same was true for the improved capital value ($p=0\cdot726$).

In summary, the difference in input use between the two agricultural production systems is the relative importance of physical input-demanding practices (for example, application of fertilisers and pesticides) in conventional farming, and of knowledge-demanding practices (for example, crop rotations for reducing pests; use of stock for manure production and weed control) in chemical-free agriculture.

The financial returns, shown in Table 4, were calculated in the same way as in ABARE calculations, and as explained in Campbell (1981). The total cash costs and the total cash receipts take into account only the cash aspects of farming. Depreciation, family labour and stock accumulated or depleted over the year are not accounted for in that measure. To calculate the returns to capital and management, estimates of these non-cash costs are subtracted from, and of returns added to, the farm cash operating surplus. The resulting amount is divided by the value of all assets on the farm (improved capital value of the land, value of machinery and equipment and of livestock). The interest and rent paid could be considered not to be a cost of the farming system itself. If these are deducted from returns to capital and management, the adjusted returns result. Premiums for chemical-free produce, where received, were included in the results.

The total cash costs, which include interest, were significantly lower on chemical-free farms ($p=0\cdot021$). However, all other financial measures were similar ($p>0\cdot1$). This was the case also when average prices received by the conventional farmers per tonne of wheat (the main crop) were imputed for all farms, that is, when premiums were excluded. The general picture remained the same when five semi-chemical-free farms were included (see Wynen 1988).

The range of the adjusted returns to capital and management was

TABLE 4

Financial Costs and Returns per Hectare Operated on Chemical-Free and Conventional Farms in South-Eastern Australia: 1985–86[a]

Input	Unit	C-F	Conv.	Difference
Total cash receipts	($)	181	262	−81 (0·141)
Total cash costs	($)	76	128	−52 (0·021)**
Farm cash operating surplus	($)	105	134	−28 (0·944)
Returns to capital and management	(%)	3·03	1·17	1·86 (0·183)
Adjusted returns to capital and management	(%)	3·39	2·18	1·21 (0·441)

[a] For explanation of symbols, see Table 2.

considerable. For chemical-free farmers this was from −1·3 to +14·1 per cent, and for the conventional farmers from −6·3 to +11·2 per cent. The higher values of the range were for two farmers of the same pair. The lowest value for the chemical-free farmers coincided with the second-lowest value for the conventional farmers.

Summary

In summary, the survey suggests that at recent levels of input and output prices, established chemical-free cereal/livestock farmers can operate as profitably as conventional farmers in parts of south-eastern Australia. The results of further research comparing the private economics of the two farming systems will be of considerable interest.

Policy Issues

Introduction

With potential private net benefits from chemical-free cereal/livestock farming similar to those from conventional farming in parts of south-eastern Australia, and the net external effects of moving towards chemical-free agriculture likely to be positive, such a movement might be expected to increase social welfare. Does this mean that there is an economic case for government to discourage conventional farming or to encourage chemical-free farming? If there is, what policies would be appropriate? The approach taken here is to consider one at a time a number of possible impediments to the adoption of chemical-free farming. In the main it is considered that any impediment can be viewed in isolation. That is, it is assumed that there are no *other* departures from efficiency in the economy which have significant second-best-type implications for policy concerning the particular impediment to chemical-free farming. In this situation, the distinction between first-best policies (which remove the impediment without generating adverse side-effects) and other policies is helpful (Corden 1974). However, some second-best issues and their possible implications for efficient intervention are noted.

Agricultural chemicals

External environmental and health costs resulting from use of chemicals in agriculture are instances of non-point pollution; the contributions of individual farmers to those costs are unknown. This rules out the first-best policy of taxing polluting farmers according to the external damage they cause. The best feasible policy depends on the circumstances of the case, and may involve fiscal measures or regulation (for example, Chisholm 1987). Internalisation of externalities from chemicals requires, however, that use of chemicals in agriculture be directly or indirectly taxed.[7]

[7] The optimal rate of tax will vary with physical conditions, management practices and other factors influencing the external damage arising from use of chemicals. The rule of one price and the Australian Constitution both prevent varying the tax on chemical purchases with the external damage caused by use of the chemical in the purchaser's situation, even if that were known. To improve upon the crude approach of taxing all use of a chemical at a uniform rate, taxes, subsidies or regulations could be applied to other inputs or practices which influence the external costs of using the chemical. However, lack of information may make it difficult to set up and administer an approach that was superior to a crude uniform tax on chemicals.

While it is unclear which approach would be most effective for making farmers pay the social costs of chemical use, it is clear that the longstanding Australian policy of subsidising the use of phosphatic and nitrogenous fertilisers (terminated in 1988) was inconsistent with that objective. Chemical-free farmers did not receive a subsidy for their alternative source of nutrients (for example, rock phosphate). In this way, chemical-free farmers were disadvantaged compared to many conventional farmers.

The policy of subsidising use of fertilisers is widely acknowledged to cause inefficiencies in the use of inputs and in the mix of conventional agricultural outputs produced (see, for example, Rose, Moir, Farquharson and Vanzetti 1984). The disincentive provided to the development and use of alternative agricultural systems that economise on fertiliser inputs, including systems that dispense with them totally, is an additional source of inefficiency in fertiliser subsidy policies. It is unlikely that equal treatment of the two farming systems was a consideration in abolishing the subsidies. With governments in Australia showing increased interest in chemical-free agriculture, it is important to recognise the discrimination against this system of any re-introduction of fertiliser subsidies in the future.

Although pesticides do not attract a subsidy, it is likely that not all the costs of this input are paid for by farmers (see, for example, Pimentel *et al.* 1980; Van der Vaart 1987), and that society subsidises pesticide use indirectly by being subject to negative external effects. The result is a further distortion of resource use away from chemical-free agriculture. (Incidentally, chemical-free farmers incur substantial costs in finding out about, and in using such means as crop rotations, choice of crop varieties and timing of planting for the purpose of controlling pests; these costs are not subsidised.) Tariffs, which raise prices, apply to pesticides in Australia. They were decreased from 30 to 15 per cent (nominal rate) in 1987 (Department of Primary Industry 1987). Although tariffs are not instituted to reflect the external costs of using an input (and are not first-best for that purpose), that objective can be achieved if the increase in price reflects the external cost. In Sweden, taxes are levied on the use of pesticides to make farmers take account of external costs of their use (Eitjes and De Haan 1987). It is not clear how the size of the tax is determined.

An additional advantage of taxing the use of chemicals in agriculture should be mentioned. When taxes are introduced which internalise external diseconomies, revenue is raised without the deadweight costs that characterise taxes used primarily to raise revenue (for example, Findlay and Jones 1982). In fact, by generating government revenue, a tax that corrects an external diseconomy allows reductions in other distortion-creating taxes; this improves the prospect of a net efficiency gain from a tax on use of chemicals in agriculture.

Information

Producers. Information policy has two components. These relate to the discovery of knowledge (research) and to the dissemination of knowledge (extension).

In terms of the public interest or market failure justification for government intervention, a role can be seen for government in

extension activities for chemical-free farming. Efficiency may be increased by policies that reduce the substantial gap between the knowledge that exists on chemical-free farming and the knowledge possessed by practitioners and potential practitioners of this form of agriculture. The possibility of achieving national benefits in excess of the costs from extension programmes that improve know-how on chemical-free farming is enhanced by the external benefits that exist in both production and consumption from a shift towards this type of agriculture. Establishing the precise form of extension programme that would be most effective would require careful consideration. The case for a government role in improving information on chemical-free farming would be weakened, but not necessarily removed, with internalisation of external diseconomies of chemical use in agriculture and of externalities in the pricing of health services.

The traditional case for public sector involvement in research rests mainly on the public good nature of findings and on other external economies arising from research. These considerations apply to research oriented to chemical-free farming, as well as to that directed towards conventional agriculture and other areas. There appears, however, to be a basis in technical considerations for expecting chemical-free agriculture to be under-researched relative to conventional agriculture. This is the seemingly greater relative importance of physical input-demanding practices in conventional farming as opposed to knowledge-demanding practices in chemical-free agriculture which was noted earlier.

While patents and other forms of property rights provide profit incentives for research directed to producing new inputs (private goods), this is typically not so for research leading to knowledge of practices (public goods). It might therefore be expected that, in the absence of intervention to prevent it, knowledge-intensive chemical-free agriculture would be under-researched relative to input-intensive conventional agriculture. Lindner and Jarrett (1978) make the related point that with a free market approach biological and organisational research will likely be neglected relative to chemical and mechanical research.

At present, most Australian research is oriented to conventional farming, while little research is useful to chemical-free farmers. An increase in research into chemical-free agriculture could be expected if externalities in the use of chemicals were removed, thereby enhancing the relative profitability of chemical-free agriculture. Similarly, an increase in the demand for 'healthy' food upon removal of the subsidy for health services would be expected to induce extra research into chemical-free farming. If the externalities arising from use of chemicals in agriculture and from underpricing of health services are not removed, the economic case for intervention in research is strengthened. Such intervention might be directed to reducing externalities in conventional agriculture (for example, by the development of less-harmful pesticides) as well as research into chemical-free farming. Perhaps research into the transition process from conventional to chemical-free farming merits high priority.

While a full discussion of research issues cannot be given here, it is suggested that research directed to chemical-free agriculture is underfunded relative to research for conventional agriculture. Key reasons

are the minimal allocation of resources to chemical-free farming, together with the existence of uncorrected diseconomies in conventional agriculture and in health services, and the greater difficulty of exerting property rights over research useful to chemical-free agriculture.

Consumers. The health benefits from the consumption of food produced on chemical-free farms are likely to arise not only from reduced chemical residues, but also from improved nutritional quality (see, for example, Hodges 1981; Balfour 1975). Reducing the use of chemicals in agriculture, for example by taxing chemicals, can be expected to improve health in both ways. However, there may be an economic case for action to promote directly the consumption of healthy food (not confined to food from chemical-free farms) and balanced diets. One case is provided by consumers' deficient information on the private benefits from eating good quality food and a balanced diet. The first-best policy for doing this is not a subsidy on 'healthy' food, which encourages extra consumption by people already eating a good diet as well as those eating poorly, but provision of information. This policy would be neutral between domestic and imported food. If the externality due to pricing of health services is not removed (its removal being a first-best policy) the prospect for increasing economic efficiency with an information programme, or a subsidy on healthy food, is enhanced. No attempt is made here to assess the adequacy of existing consumer information programmes.

Marketing

Marketing arrangements for agricultural products can restrict the opportunities available to chemical-free farmers. Would-be consumers of the chemical-free product are also disadvantaged by being denied the product of their choice. In Australia, some products (such as wheat, eggs and milk) must be marketed via marketing boards. These marketing boards mostly do not differentiate between produce from chemical-free and conventional agriculture. As chemical-free farmers grow a product which can often command a higher price in the market than the conventional product, they are penalised. Permission can be obtained to sell some produce, such as wheat, privately only after the producer has first sold it to, and bought it back from, the marketing board. Disadvantages exist for the chemical-free farmer in such a situation. For example, when buying back the wheat the producer-buyer does not receive the same services (such as credit and storage) rendered to other buyers. This is because transactions between the marketing board and producer-buyer are purely administrative; services are paid for, but still need to be provided by the farmer. From 1984 the charges amounted to $16 per tonne (Australian Wheat Board 1987).

Growers of chemical-free wheat are penalised by the pooling mechanism for revenues and marketing costs, criticised recently by the Industries Assistance Commission (1987). While chemical-free wheat can by-pass the Bulk Handling Authority (BHA) system via Australian Wheat Board-approved grower to buyer sales, this typically involves a charge of $5 per tonne for (unused) BHA facilities. The practice of charging for facilities not used was described by the IAC (1987, p. 121)

as without justification. The practice is difficult to reconcile with a positive attitude to innovation, an attitude normally viewed as conducive to gains in efficiency, and one supported officially by the Australian Government (Hawke and Kerin 1986). Apart from the $5 for unused BHA facilities, levies are charged for wheat research and for the Australian Wheat Board headquarters ($0.45 and $0.10 per tonne respectively in 1987–88).

Government regulations requiring the application of pesticides before interstate import hinder the marketing of chemical-free produce. For example, fruit from Queensland and Northern New South Wales cannot be imported into other states without a certificate stating that it has been dipped or fumigated against the fruit fly. (Victoria is the only state where, at a cost, a 100 per cent physical sampling by the Department of Agriculture is allowed to substitute for chemical treatment.) Such goods might no longer be bought for the premium price they would otherwise command.

The importance of the marketing system for the development of chemical-free farming was noted in the second section. Because buyers cannot differentiate between chemical-free and conventional produce, control of standards is needed in the production and distribution stages. As social benefits fron consumption of healthy food exceed private benefits, there is a *prima facie* case for government to take responsibility for implementing these standards; the demonstration of an actual case for standards requires detailed analysis of the costs and benefits.

Establishment costs

Conversion from conventional to chemical-free farming can cause several problems (see also Blobaum 1983; Lampkin 1986). First, it is likely that yields will drop in the initial years after conversion. This can be due to several factors including unfamiliarity with the new management techniques, and time needed for the establishment of biological activities in the soil. Concurrently with a drop in yields, there might be added expenses. Although the picture is not clear, extra equipment may be needed at the time of conversion to the new management system (such as different tillage equipment, fencing). Most quality control schemes for produce from chemical-free agriculture (in Australia and overseas) include a clause for exclusion of producers for two or more years after conversion. This means that higher prices are not likely to be obtained in those years.

Research into the transition phase would allow better-informed decisions on adoption of chemical-free farming. However, there appears to be no reason for thinking that the private costs of establishing chemical-free farming exceed the social costs. Hence, while the adjustment costs retard the establishment of chemical-free farming, they do not appear to provide a first-best case for government intervention.

Conclusion

The benefits from a movement towards chemical-free farming include several categories of externalities, while the costs of such a move are mainly privately borne. The survey results indicate that

private financial net benefits from chemical-free livestock/cereal farming in a steady-state situation in parts of south-eastern Australia could be similar to those from conventional farming. The results of subsequent studies will be of interest. There are costs of transferring to chemical-free farming which reduce the likelihood that people farming conventionally will change over. Research could reduce those costs. Several policies for achieving an efficiency-increasing movement of resources to chemical-free farming were considered. The most clearcut policy recommendations are the non-subsidisation of synthetic fertilisers, and the introduction of a tax on the use of this input and on pesticides to reflect the external costs they cause. These actions would promote efficiency-increasing cut-backs in the use of chemicals by farmers remaining in conventional agriculture, as well as removing efficiency-reducing barriers to adopting chemical-free farming. The prospect of a net increase in efficiency from this policy is increased because it would allow reductions in other revenue-raising taxes which generate social costs. There is reason to think that economic efficiency would be increased by the allocation of extra resources to research and extension activities helpful to chemical-free farming. There is a *prima facie* economic case for government to take responsibility for implementing quality standards for chemical-free produce; however, closer examination of the costs and benefits of action in this area is needed. Subsidising establishment costs of chemical-free farming appears to be least desirable.

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