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An Economic Evaluation of the Footrot Eradication Program in the New England Region of New South Wales

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An assessment is presented of the costs and benefits of a scheme in the New England region of New South Wales for the control of footrot in sheep. An *ex post* evaluation is presented of the operation of the scheme since its inception in 1960 to the present, and also an *ex ante* appraisal is made of the proposed continuation of the scheme in the future. Data were collected from the implementing agencies and from samples of sheep farmers in the target area and in another area where the disease is endemic. Some coefficients not otherwise available were estimated by a panel of experts by use of a Delphi procedure. Net benefits from the scheme were estimated directly as producers' surpluses less administrative costs, assuming no effects on output prices. Relatively large positive net present values and benefit-cost ratios were obtained for both the past and future operation of the scheme. The findings are shown to be robust under sensitivity analysis. It is argued that any reduction in the price of wool caused by the supply shift would not offset the advantages to producers in the region of the scheme. Producers in other regions, however, would suffer losses from a price fall, although the net benefit to Australia as a whole is likely to be positive.

Introduction

Footrot is a mixed infection of the epidermal structures of the feet of sheep due to a synergistic association between *Fusiformis necrophorus* and *Bacteriodes nodosus* (Egerton and Graham 1969; Egerton and Roberts 1969 *a, b*). The disease causes lameness and evident associated pain. Infected sheep fall off in condition, and body weights and wool cuts are both reduced. Badly affected sheep may die. Lesions may become fly struck and fertility is said to be reduced.

The development of footrot depends upon both infective and environmental factors. *B. nodosus* is the only essential component not normally present in healthy sheep and so footrot does not occur on a previously clean farm without the introduction of this bacterium. Moreover, even if introduced, *B. nodosus* will cause footrot only if environmental conditions are suitable in terms of ground moisture and temperature (Graham and Egerton 1968). It appears that wet conditions soften the feet of sheep and lower their resistance to infection. Warm temperatures are required for the disease to spread.

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Footrot is endemic throughout large areas of the temperate, high rainfall areas of Australia. Despite efforts to control it, outbreaks commonly occur in central and southern New South Wales, Victoria and Tasmania, and the higher rainfall zones of South Australia and Western Australia. It does not persist in western Queensland or western New South Wales.

Footrot was once widespread in the New England region of New South Wales. The earliest report of the disease in the area was in 1890 with further reports over the next few years (Beveridge 1941). It seems that footrot was virtually absent in the area from about 1902 until the early 1950s. The re-appearance of the disease is linked with the introduction of improved pastures which provide an environment suitable for persistence and spread of the disease (Clark 1971).

By the late 1950s it was becoming evident to government veterinary staff that footrot was potentially a major production inhibitor in the region. After much agitation by sheep farmers an eradication scheme was introduced. Legislation provided that the relevant authorities be notified of all introductions of sheep to the declared Protected Area and that all outbreaks of the disease be reported. Powers to enforce treatment of the disease and restrictions on movement of infected stock were provided. Government footrot inspectors were appointed to enforce the scheme.

The treatment of footrot involves paring of the feet and regular footbathing of infected sheep. Some infected animals may be sold for slaughter. The required regular inspections and treatments are expensive. These costs must be added to the production losses that occur until the disease is eliminated.

Preventive measures on non-infected farms involve avoiding introduction of *B. nodosus*. The organism does not survive for long other than in the feet of sheep. Consequently, prevention is attained by avoiding the introduction of infected stock. Unfortunately, footrot exists in both benign and virulent forms and, especially in the benign form, may be difficult to detect. The establishment of a Footrot Protected Area means that sheep farmers can be more confident that any stock they purchase within the area are free of the disease.[1]

This paper is a summary of a research project designed to assess the costs and benefits of footrot control in the New England area. Information has been assembled on the costs to sheep owners of control and eradication methods. The costs of the disease to the whole sheep industry in the region have been assessed. Account has also been taken of the administrative costs of the New England Protected Area scheme to try to answer two questions:

(1) Since its inception in 1960, has the footrot eradication program in the New England region of New South Wales yielded a positive net benefit to society?

(2) Do the predicted benefits to society from continuing the footrot eradication program outweigh the predicted costs?

[1] Vaccination to control footrot has been a possibility for some time, however, the treatment cost per sheep has been high—too high to induce widespread use of the vaccine. Recent developments in the techniques of producing the vaccine point to substantially lower treatment costs (about 30 cents per sheep). In that case the future benefits from the scheme under investigation in this paper will be overstated. Alternatively, information from this research can be used to assess the benefits from the development of a cheap and effective vaccine for footrot.

The answer to the second question is directly relevant to the issue of whether the eradication program should be continued. The answer to the first question has some bearing on whether eradication programs should be established in other (similar) areas.

Research methods

Rational economic decisions about disease control policies require valuation of the costs and benefits of each policy (James and Ellis 1979). Such evaluations require estimates of internal costs and benefits accruing to farmers whose stock are affected by disease as well as of external costs and benefits accruing to other people. Social cost-benefit techniques allow the incorporation of both internal and external costs and benefits. The principles and procedures of social cost-benefit analysis are widely discussed in the literature (e.g., Dasgupta and Pearce 1974; Little and Mirrlees 1974) and are not elaborated here.

Estimation of the benefits of disease control is usually more difficult than estimation of the costs (James and Ellis 1979). The economic effects of the disease both with and without the control measure being considered are required.[2] In the case of footrot, little quantitative experimental data could be found relating to the effects of the disease on production of sheep, reflected in lower wool cuts, reduced fertility, higher mortality etc. It was necessary, therefore, to conduct a survey of sheep farms, representing situations both with and without footrot, in order to estimate the economic impact of the disease. Some of the information needed to carry out the analysis of the control policy, by its nature, could not be observed directly and had to be estimated subjectively. It was recognised at the outset that some of the required data could not be obtained with a high degree of reliability, given the research resources available. This was taken into account both in the way the analysis was carried out and in the interpretation of the results.

Introduction of the footrot eradication program in New England may be presumed to have had an impact on costs and production of sheep farms in the region, this impact being reflected in shifts in the regional and hence national supply curves for wool and sheepmeats. The evaluation of the scheme requires an estimate of the present value of the economic surplus arising from the supply shifts, net of any administrative costs.

A model for estimating the economic surplus arising from a technological innovation leading to a supply shift has been elaborated by Lindner and Jarrett (1978). Edwards and Freebairn (1982) have shown how the model can be extended to the case where the supply shift occurs in only part of an industry that is producing a tradeable commodity. They point out that, in such circumstances, the economic surplus should be calculated accounting for the loss suffered by those producers not able to benefit from the innovation, this loss arising from the fall in the price of the product following the shift in regional and hence aggregate supply. They also point out that, when evaluating an innovation from the national viewpoint, the economic surplus should be calculated net of that portion of the consumer surplus that accrues to people overseas.

[2] Strictly, it is only necessary to know the changes in costs and benefits that result from introducing the control measure.

While appropriate for the present task, application of the model described by Edwards and Freebairn is not easy in the present study. The products of the New England sheep industry are diverse, and include lambs and grown sheep of various kinds, both stores and fats, stud stock, and wool of various types and grades. Moreover, the impact of the eradication scheme on the supply curves for these various products is complex and not revealed by the data that could be collected. In other words, information is not available about the shape of the various supply curves nor about the magnitudes and natures of the shifts in those curves.[3] Thus, despite its undoubted relevance, it was not considered worthwhile to perform the economic evaluation of the eradication program using the model of Edwards and Freebairn. Instead, the main factors involved in such an evaluation are discussed and some inferences are drawn from the results obtained by Edwards and Freebairn.

As noted, introduction of the footrot eradication program in the New England area may be presumed to have had an impact on national wool and sheepmeat production. This impact can be viewed as a shift in the supply function from *SS* to *SS'* of Figure 1. This shift may be presumed to have occurred because of the reduction in the level of footrot and, hence, in production losses and costs. For a commodity that is not traded internationally, the change in net social benefit to the nation arising from the shift is measured by the area *abdf* in Figure 1.

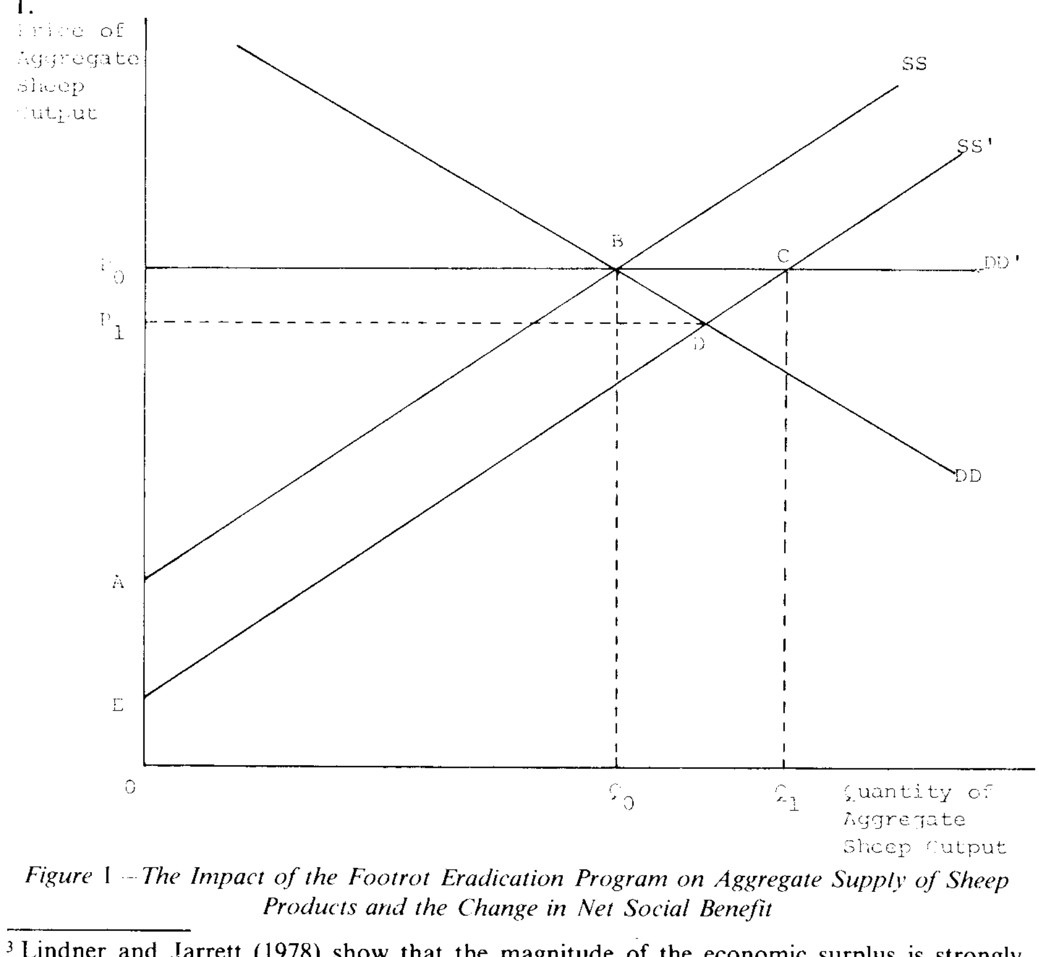

Figure 1 – The Impact of the Footrot Eradication Program on Aggregate Supply of Sheep Products and the Change in Net Social Benefit

[3] Lindner and Jarrett (1978) show that the magnitude of the economic surplus is strongly affected by the nature of the supply shift—whether divergent, parallel or convergent.

The impact of supply on sheep outputs at the national level from the eradication program will have been relatively small. There are about 140 million sheep in Australia, approximately 5 million of which are in the Protected Area. Of these 5 million, appreciable reductions in production costs and increases in output from the introduction of the eradication program will come from only about 100 000 to 300 000 affected sheep.[4] Moreover, the disease does not drastically reduce output of all sheep affected, especially if treatment is timely.

Because of the small proportionate shift anticipated in the aggregate supply curve, the simplifying assumption is made that no reductions in prices of sheep outputs have occurred in consequence of the introduction of the eradication program. In other words, the demand curve is treated as horizontal over the relevant range of outputs, i.e., *DD'* rather than *DD* in Figure 1.

The assumption of an effectively horizontal demand curve means that the net social benefit will be measured wholly as producers' surplus, i.e., by the area *abcf* in Figure 1. Moreover, in the (assumed) absence of any effect on prices, the corrections to economic surplus for losses by producers in other regions and for consumer surplus going to foreigners are not relevant.

The economic surplus can be estimated by direct application of the net social benefit model of Figure 1. This involves estimating the area *abcf* from the supply functions for sheep outputs and the nature of the supply shifts arising from the introduction of the eradication program. This method seems unnecessarily complicated and difficult in this case. A simpler, more practical approach is for economic surplus to be budgeted directly as changes in costs and outputs. In this case, area *abcf*, in Figure 1 is approximated by the reduction in costs of producing the existing output, area *abef*, and the net return from increased production, area *bce*.

The budgeting approach requires measurement of the differences in costs and benefits between the with and without eradication program situations, over the time periods considered. The main quantifiable costs from having an eradication program are:

(a) costs to the owners of infected sheep within the Protected Area in the forms of:

(i) extra inspection and treatment costs for infected sheep;

(ii) extra direct costs from restraints on the movement and marketing of sheep;

(iii) extra indirect costs and losses through necessary changes in stock management;

(b) public costs incurred by the government agencies responsible for enforcing the regulations relating to the Protected Area.

The main quantifiable benefits from the eradication program are:

(a) avoidance of direct production losses through reductions in sheep output caused by the disease;

(b) savings in precautionary costs occasioned by the reduced risk of infection of sheep in the Protected Area.

[4] Some smaller savings in production costs will occur for all sheep because of the reduced need for precautionary measures on uninfected farms.

In addition, sheep producers may benefit from an increased demand for footrot-free stock from the Protected Area. Unfortunately, it proved impossible to estimate the magnitude of any such benefits and they have been excluded from the analysis. Similarly, both sheep farmers and others interested in animal welfare may gain satisfaction from the reduction in suffering of infected sheep, but this item is also judged to be unquantifiable in dollar terms. On the other hand, some farmers, especially those whose sheep become infected, may be irked by the loss of freedom embodied in the powers of the enforcement agency in the Protected Area. This item too has been excluded from the formal analysis.

The quantifiable costs and benefits listed above can be represented in the following general budgeting model:

$$(1) \quad NPV = \Sigma_t A_t [(PLN_t - PL_t) + (PCN_t - PC_t) + (CTN_t - CT_t) + (MMN_t - MM_t) + (ICN_t - IC_t) - (SCN_t - SC_t)],$$

where

NPV = net present value, measuring change in net social benefit;

A_t = social discount (compounding) factor for year t;

PLN_t = production losses in year t with no scheme;

PL_t = production losses in year t with the scheme;

PCN_t = precautionary costs in year t with no scheme;

PC_t = precautionary costs in year t with the scheme;

CTN_t = direct control and treatment costs in year t with no scheme;

CT_t = direct control and treatment costs in year t with the scheme;

MMN_t = costs of restraint on movement and marketing of sheep in year t with no scheme;

MM_t = costs of restraint on movement and marketing of sheep in year t with the scheme;

ICN_t = other indirect costs to management in year t with no scheme;

IC_t = other indirect costs to management in year t with the scheme;

SCN_t = public costs in year t with no scheme;

SC_t = public costs in year t with the scheme.

All costs and benefits were adjusted for inflation and expressed in constant (1979–80) prices. Costs and benefits were also compounded or discounted, as appropriate, at a social rate, to express them in present value terms (t = 0 for 1979–80). In the absence of a generally accepted rate of interest for social decision making, a range of real values was used, i.e., 0, 5, 10 and 15 per cent. Since all costs and benefits were expressed in constant 1979–80 values, these are real discount rates.

The model of equation (1) was estimated twice, once for the period since the inception of the scheme in 1959–60 until 1978–79, to assess historical performance. The second estimation was based on forecasts for 1979–80 to 2000–01 to predict the future value of the scheme. The planning horizon was set at the year 2000–01 to reflect the likelihood that new control measures for the disease, or other changed circumstances, will have made the present scheme obsolete by that date.

Data collection

Three separate sample surveys using personal interviews were undertaken to elicit from sheep farmers data relating to the costs and benefits of footrot eradication or control. From the records kept by the N.S.W. Department of Agriculture in Armidale of footrot-infected farms within the Protected Area, a stratified random sample of thirty farms was drawn. These farmers were interviewed to obtain information about the production losses observed in infected sheep, the direct costs of treatment and control, the costs of restraint on movement and marketing of sheep during the time each farm was in quarantine, and other indirect costs.

A second survey was designed to obtain information from New England sheep farmers about the costs of preventing footrot on farms that had not been quarantined. Again, a stratified random sample of 30 respondents was selected and these farmers were also interviewed.

A third survey was undertaken of sheep farmers on the Central Tablelands of New South Wales. The aim was to obtain some insights into the situation that might prevail in regard to footrot in the New England area without the eradication program. No such scheme exists on the Central Tablelands, which was selected as a study area for this reason and because of its general similarity to New England. Twenty-two farmers were selected by non-random sampling. Sheep on most of these farms had been infected with footrot over the past five to ten years. Results of the surveys are reported in full in Carmody (1981).

In making use of average costs from the three surveys to estimate the model of equation (1), main reliance was placed on the data from the two New England surveys. These results were judged to be more relevant than the Central Tablelands data for two reasons. First, the samples were larger and more appropriately selected than the sample for the Central Tablelands survey. Second, despite the broad similarity of conditions in the two regions, there are important differences in environment. Where results from two or more of the surveys were inconsistent, choice between alternative estimates was based on prior expectations of likely differences, drawn from the literature on the disease and its consequences. The advice of people experienced in the eradication program was also taken in making these essentially subjective judgments.

Information on the public costs of the eradication scheme was obtained from the Department of Agriculture and the Pasture Protection Boards involved in its implementation. These data are also detailed in Carmody (1981).

As noted earlier, not all the information required for the analysis could be estimated from farm surveys. In particular, estimates were required of the number of farms in the Protected Area that would have been infected in the absence of an eradication scheme. In addition, forecasts were required of the numbers of farms infected in the future with and without the continuation of the scheme.

Data that could not be estimated from the surveys were obtained using the Delphi approach. This technique can be used to elicit responses from a group of experts. It exploits some of the advantages of groups, such as pooling of information, while avoiding most of the disadvantages (Pill 1971; Martino 1972). Delphi procedures involve anonymity to reduce dysfunction from direct interpersonal interaction, controlled feedback, designed to share knowledge and insights, and reassessment in the light of shared information and knowledge of the views of others.

A panel of six experts was selected to include people from a variety of backgrounds who were all judged to be knowledgable about footrot and about the operation of the eradication program. Because time and other resources were short, and a reasonable consensus was reached quickly, the Delphi procedure was limited to two rounds. In round 1, the panellists were provided with basic background information and were asked to make estimates of three well-defined, representative situations, giving their reasons. In round 2 the panellists were provided with a summary of the results of round 1 and were asked to review their original estimates. Further details of the procedures used, the results obtained and the extrapolations made from those results are given in Carmody (1981).

Results of analyses

A summary of the results obtained is presented in Table 1. Net present values are shown for both the historical and projected operation of the scheme. Results for both the "most likely" and the "worst possible" scenarios are given for each of the four interest rates used.

Table 1: *Net Present Values and Benefit-Cost Ratios of the Eradication Program for the* ex post *and* ex ante *Evaluations with Various Assumptions*

Item	Discount rate	Net present value[a]	B-C ratio[a]
	per cent	$ m	
Ex post *analysis from 1959–60 to 1978–79:*			
Most likely scenario	0	27.6	21.3
	5	41.3	17.9
	10	64.6	14.9
	15	104.7	12.4
Worst possible scenario	0	11.6	5.3
	5	17.9	4.8
	10	28.5	4.3
	15	46.9	3.9
Ex ante analysis from 1979–80 to 2000–01:			
Most likely scenario	0	46.4	24.3
	5	25.5	18.6
	10	15.5	14.4
	15	10.2	11.5
Worst possible scenario	0	19.7	8.0
	5	11.2	6.3
	10	7.1	5.2
	15	4.9	4.4

[a] Figures are rounded to the nearest decimal place. 1979–80 is year 0.

In addition to the net present values, the results are expressed as benefit-cost ratios to give an indication of the relative profitability of resources allocated to the eradication program for comparison with alternative uses of those resources. No internal rates of return are given because net benefits are positive in every year in all cases, implying infinite internal rates of return.

The contributions to net present values made by the various components of costs and benefits are shown in Table 2.

Table 2—Relative Contributions to Net Present Value of the Components of Equation 1, \$ million[a]

	Ex post analysis		*Ex ante* analysis	
	Most likely scenario	Worst possible scenario	Most likely scenario	Worst possible scenario
$\Sigma_t\ (PLN_t - PL_t)$ ..	4.0	1.6	7.1	3.1
$\Sigma_t\ (PCN_t - PC_t)$ ..	11.3	11.3	15.5	15.5
$\Sigma_t\ (SCN_t - SC_t)$ ..	− 0.8	− 0.8	− 1.3	− 1.3
$\Sigma_t\ (CTN_t - CT_t)$ ..	4.0	0.4	7.0	1.1
$\Sigma_t\ (MMN_t - MM_t)$ ..	0.1	− 1.6	1.9	− 1.0
$\Sigma_t\ (ICN_t - IC_t)$ ..	9.1	0.8	16.2	2.3

[a] Figures rounded to nearest decimal place. Results are for zero discount rate.

The results presented in Table 1 indicate that the footrot eradication scheme in the New England region of New South Wales has been worthwhile. The historical appraisal for the most likely scenario shows net present values of between \$27.6 m and \$104.7 m, depending on the interest rate. The associated benefit-cost ratios range from 12.4:1 to 21.3:1, indicating that the conclusion about the profitability of the scheme is robust. This is confirmed by the sensitivity analysis; the net present values remain positive despite an arbitrary halving of assumed values for three key coefficients to represent a "worst possible" scenario.[5] Similarly, the benefit-cost ratios for the worst possible scenario vary between 3.9:1 and 5.3:1.

From Table 2, it can be seen that the main positive contributions to net present value for the most likely scenario are from reductions in precautionary costs and indirect costs to management, while the negative contribution is from public costs. The reduction in precautionary costs remain the main positive component under the worst possible scenario.

[5] The "without program" values of direct control/treatment costs per sheep, indirect costs to management per farm, and expected number of farms infected were simultaneously reduced to half their values for the most likely scenario.

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For the future, Table 1 shows a similarly favourable prospect for the scheme. The net present values for the most likely scenario are again positive, ranging from $10.2 m to $46.4 m, while the benefit-cost ratios range from 11.5:1 to 24.3:1. Again under the worst possible scenario, net present values remain positive while the benefit-cost ratios vary from 4.4:1 to 8.0:1.

The conclusions about the contributions of various costs and benefits to the net present value drawn for the historical analysis also apply to the projected cases.

Distribution of the economic surplus

The preceding estimates are of the economic surpluses assumed to accrue to the producers within the region covered by the program. If the costs of the program are met by producers within the region and the effects on prices received by producers are indeed negligible, then it can be argued that the above analysis is sufficient for those decision makers in the region to determine whether to continue the program or not. To them, any effects that accrue outside the region (see below) will not be relevant. In the case of the New England program, only part of the costs are met by producers within the region with the balance being provided by taxpayers generally, via the State Department of Agriculture. In this case, consideration must be given to effects that might arise beyond the region.

Edwards and Freebairn (1982) have developed a model and computed some estimates of these effects for a problem similar to that analysed here, namely the net benefits deriving from control of serrated tussock in some regions of New South Wales (Vere, Sinden and Campbell 1980). The thrust of the Edwards and Freebairn analysis is that a program in a region which changes regional supply (or demand), will have "feedback" effects both inside and outside the region (in the rest of Australia and the rest of the world) on both producers and consumers of that commodity. In the case where a program involves public expenditures, decisions about these expenditures should be made considering the benefits and costs in the rest of the country as well as in the region. There is no strong case for accounting for effects accruing outside the country.

To estimate empirically the effects on producers and consumers in the region and the rest of Australia requires comprehensive information about supply and demand functions in the different producing and consuming regions for all the sheep products affected. Such information is not available. Even if we assume that wool is the only product affected (as Vere, Sinden and Campbell also assumed), and if we adopt the model of Edwards and Freebairn which is based on assumed linear supply and demand functions with a parallel supply shift, we would still need five price elasticity estimates, viz: point elasticities of supply for the region, the rest of Australia and the rest of the world, and point elasticities of Australian and world demand for wool. (Regional demand for wool is not included because it is effectively zero.) There are no well-defined and agreed on estimates of these elasticities. Thus, we could either compute estimates of the size and distribution of the economic surplus for a range of elasticity values (as Edwards and Freebairn have done), or draw some general conclusions from the theory and the empirical estimates of Edwards and Freebairn. We have chosen the latter option.

The increase in supply of the region because of the program can be presumed to have effects outside the region, chiefly through lower market prices for wool. In reviewing these effects, the first point to make is that regional supply of wool is about three per cent of Australian production. Thus, even a large increase in supply due to the program (say 25 per cent) would increase Australian supply by less than one per cent. Second, these small increases in supply will have an effect on wool prices, but, because Australian demand for wool represents a very small proportion of total production (less than five per cent), the benefits that accrue to Australian consumers will be negligible. In fact, most of the consumers who benefit are located outside Australia, as shown in Edwards and Freebairn (1982, Table 1). Thus, most attention needs to be given to effects on producers.

In relation to effects on producers, it can be deduced that the benefits accruing to sheep farmers in the region are not likely to be materially eroded by the small price effects involved. Most of their gain comes from the supply shift effect, i.e., lower per unit costs. Consequently, we can confidently conclude that the footrot eradication program is worthwhile from the point of view of this regional group of producers. But the situation for producers in the rest of Australia is much less certain because even quite small shifts in aggregate supply can lead to large losses, especially if demand is relatively inelastic. Any price reduction affects large quantities of wool and is not offset, for these producers, by cost savings. The distribution of the reduction in total revenue among producers depends on the elasticities of supply in the region, the rest of Australia and the rest of the world. The worst situation for producers in the rest of Australia would be if the elasticity of supply for their production were substantially lower than in the region and the rest of the world, while their best situation would be the reverse. Although no reliable estimates of the elasticities are available, it can be argued that, because of the array of production alternatives, the elasticity of supply of wool in the New England area is likely to be higher than in most other parts of Australia. This would suggest appreciable losses to producers in other regions.

Edwards and Freebairn confined their calculations of the distribution of economic surplus from serrated tussock control on the Central and Southern Tablelands of New South Wales to cases where world, Australian and regional supply elasticities are assumed equal. They noted that losses to producers in the rest of Australia are then necessarily less than gains to regional producers. Hall (1981) has suggested that supply elasticities are low, of the order of 0.3, suggesting, perhaps, that scope for large differences in elasticity between regions is also low. Overall, therefore, while we cannot be confident that there will be net gains to Australia as a whole from the footrot eradication scheme, we judge that the gains to producers in the New England are likely to exceed losses to other Australian sheep farmers.

Conclusions

The decision whether or not to continue the eradication program must be made by policy makers whilst considering an array of possible social investments. The results of the projected analysis indicate that sheep producers in New England will almost certainly benefit, and Australian society as a whole will probably benefit, if the program is continued.

The historical analysis also indicates that the scheme has been economically justified, but the implications of this finding for proposals to establish similar schemes in other areas are not clear cut. There are some special features in favour of the New England scheme that would not apply elsewhere. First, the program of eradication was commenced early, before substantial pasture improvement had taken place, so that the incidence of footrot at the start of the scheme was lower than it would have been later. Second, the New England region is surrounded on three sides by areas where footrot is generally not present. These areas form natural barriers to the entry of the disease into the Protected Area, so contributing to the success of the program. It may be concluded that region-specific studies would be needed to assess the economics of eradication programs outside the New England Protected Area.

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