A Farm-Level Approach to Examining Supply Shifts and Research Benefits

Kevin A. Parton[1] and Melissa J. O'Brien[2]

[1]Department of Agricultural Economics and Business Management
University of New England, Armidale.

[2]National Australia Bank, Tamworth.

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1. Introduction

Agricultural economists have debated at length the type of industry supply shift that occurs when an innovation is being taken up (Lindner and Jarrett 1978, Rose 1980, Lynam and Jones 1985). This issue is particularly significant to the assessment of benefits that flow from agricultural research because the producer surplus changes are sensitive to the type of supply shift involved. Lindner and Jarrett (1978) argued that the characteristics of the new technology determine whether the shift of the supply curve is convergent, parallel or divergent. For example, a biological innovation that is diffused evenly is likely to result in a divergent shift of the supply curve because the percentage increase in yield is similar for both marginal and inframarginal producers. Based on this type of argument, a specific sort of supply curve shift typically is assumed when a particular agricultural research activity or innovation is being evaluated.

A stimulus for the research work reported in the current paper was the study of Collins and Poulter (1990), who assumed that a parallel shift of the industry supply curve was associated with the "Wormkill" program to combat sheep helminths. By investigating the progressive adoption of this innovation on six case study farms, a method was developed to examine the accuracy of the parallel shift assumption.

The next section of the paper considers the relevant themes in the literature relating to supply curve shifts. This is followed sequentially by sections describing our method, fieldwork and results. Finally, given the preliminary nature of the work some interim conclusions are drawn and suggestions are made for extending the analysis.

2. Selections from the Literature

The economic surplus approach to research evaluation was applied by Schultz (1953) when he calculated the value of inputs saved in US agriculture through more efficient production and compared them with the cost of research inputs. To calculate the value of inputs saved he estimated how many resources would have been required to produce 1950 output using the technology of 1910. The method seems to involve a parallel shift in a perfectly elastic supply function with a perfectly inelastic demand curve.

Griliches (1958), when analysing returns to hybrid corn research, assumed that the supply curve was shifted downwards or to the right by the new technology. He analysed the polar cases of perfectly elastic or perfectly inelastic supply curves. The standard economic surplus approach was developed by Peterson (1967) when applying rightward shifting positively sloped supply curves to the estimation of the benefits of poultry research. Next, Ayer and Schuh (1972) showed, in the case of Brazilian coffee research, that the model can be developed to include lag effects.

Lindner and Jarrett (1978) showed that there was an empirical problem for the economic surplus approach to estimating research benefits by pointing out that the type of supply shift matters. The level of research benefits is influenced by both the size of the shift and how the shift operates along the length of the supply curve. In other words, innovations may affect marginal and inframarginal producers differently, and this must be accounted for in estimating research benefits.

For example, rice research in south east Asia over the last two decades has produced largely convergent supply curve shifts because it favours inframarginal firms on better land that have lower marginal and average costs. Conversely, a divergent shift is likely to result from development of herbicides because it is likely to lead to a proportional reduction in unit costs (as long as the innovation is adopted equally by high and low cost producers). That is, marginal, higher cost producers obtain a larger absolute reduction in costs.

In an attempt to present a general model of supply curve shifts, Lynam and Jones (1985) proposed equation 1, in which any type of supply curve shift (convergent, parallel or divergent) can be accommodated by appropriate changes to the K values.

(1) $Q = K_1 c(K_2P - K_3m)^d$.

The above research is important in showing that the estimated surplus benefits of research are dependent on the type of supply curve shift, and that the type of shift reflects firm-level effects of innovations. Hence, proper evaluation of research benefits requires knowledge of the impact on costs and output at the firm level.

In the context of the Wormkill program, Collins and Poulter (1990) estimated the welfare gains under the assumption of a parallel rightward shift of a linear supply function. While there appear to be some errors in the paper, unrelated to the supply shift, it is the accuracy of the assumption of a parallel supply curve shift for the Wormkill innovation which is examined in the remainder of this paper.

3. Method

The method adopted was to study in detail six wool-producing farms in the New England region during 1991 and to record their approach to combatting sheep parasite problems since 1984/85. Based on this information a linear programming (LP) matrix was developed for each farm to represent the technological situation on the farm year-by-year as different components of the Wormkill strategy were adopted.

The type of supply shift on each individual farm was estimated by use of the LP models. By parametrically varying the price of wool a supply function was mapped out for each farm which incorporated the actual technology in use. Then to assess the impact of the Wormkill innovation, the actual 1991 technology was replaced in the LP model with the technology employed by non-adopters in 1991. A second supply function was then estimated by parametric programming for the non-adoption situation. By comparing the two generated curves, the type of supply curve shift was observed.

4. Results

4.1 The Farms

The locations of the six case-study farms are shown in Figure 1. The properties were chosen according to the following criteria:

(a) be located within the New England region;
(b) produce Merino wool; and
(c) monitor egg counts and carry out drench efficiency trials.

One of the six properties (Farm 2) has only just fulfilled the criteria and was used for comparison with the others, which have met the criteria since 1984/85. This method of selecting farms ensured that observations were obtained on the method of applying the Wormkill innovation. Furthermore by reviewing farm activities over the period since 1984/85, the changing nature of the innovation was observed.

Interviews with the farmers were conducted during August, 1991 and additional information was collected by telephone after the interviews. Information was obtained on characterisics of the farms (see Table 1) including property size, stock numbers and types, soils, pasture types and costs of production. This was combined with information from farm records and further budget data from Turvey (1988) to establish the base farm LP models.

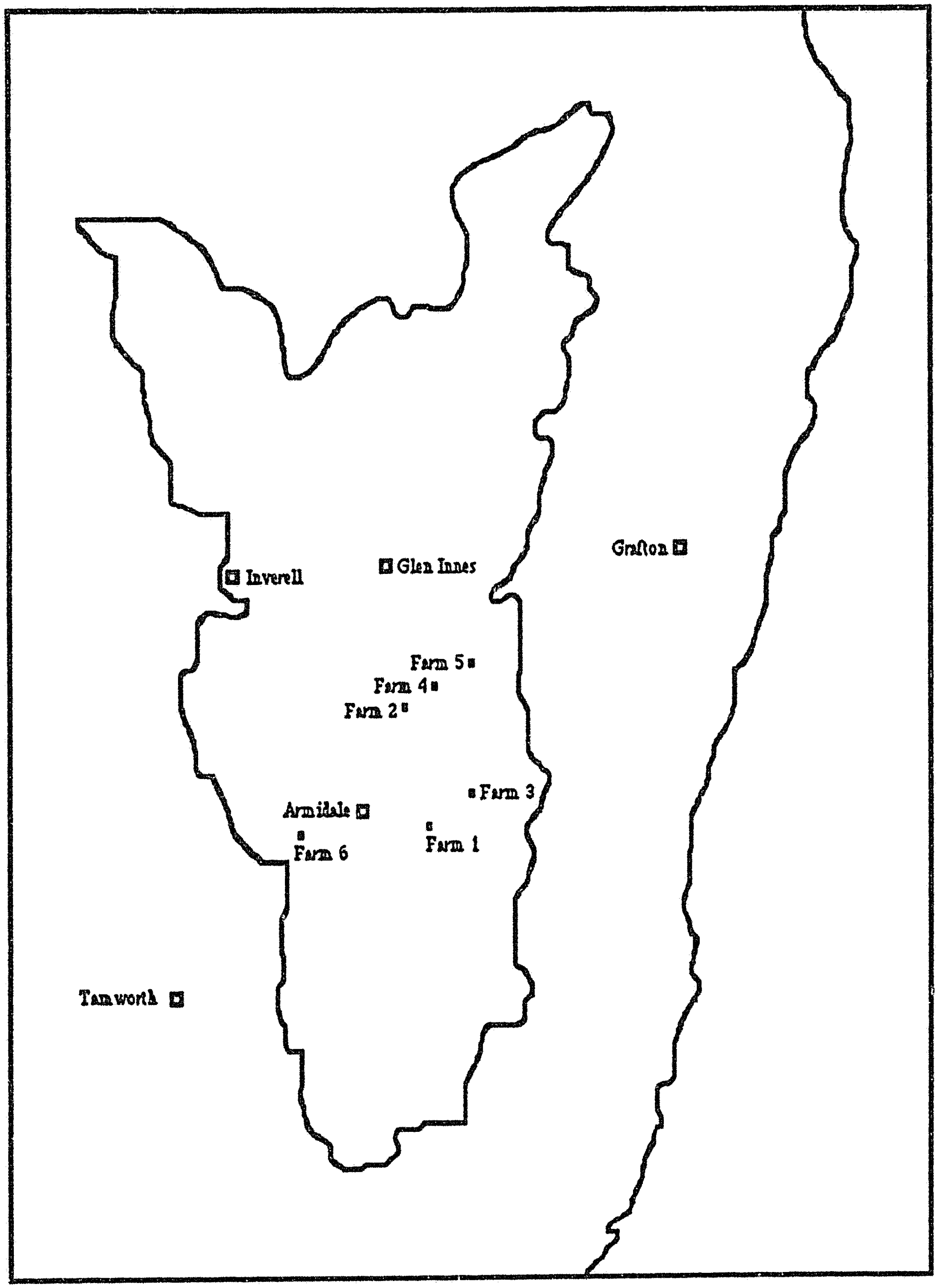

Figure 1 Locations of the case-study farms in the New England region.

Table 1

Structure of the Six Case-Study Farms

	Farm 1	Farm 2	Farm 3	Farm 4	Farm 5	Farm 6
Area (ha)	1000	144	2100	1095	486	1918
Sheep no. (ewes)	1850	620	1180	21[illegible]	1850	3500
Cattle no.	0	0	1190	110	155	270
Sheep enterprise	Merino breeding	Merino breeding	Merino breeding	Merino breeding, Merino wethers	Merino breeding	Merino breeding

4.2 The Innovation

Infonnation on the use of Wormkill by each farm was obtained both from Elders and during the farmer interviews. Elders had completed drench efficiency tests and had monitored egg counts for each farm, and this information was used to support that obtained from the farmer.

In the event it turned out to be a difficult task to define the various aspects of the innovation. To understand this multifacited innovation requires a consideration of its development and evolution since it was introduced.

4.2.1 The anthelmintic component

Before the introduction of Wormkill, producers relied on the tactical application of anthelmintics when the condition of sheep or seasonal conditions demanded it. For the control of barber's pole worm (Haemonchus contortus) in New England, Gordon (1948; 1953; 1958) proposed a strategic program with treatments in August, November and February. Watts, Dash and Lisle (1978) performed field studies on this and other strategies and found some difficulty achieving effective control of barber's pole worm. This seemed to be because sheep were becoming re-infected in spring with larvae which had over-wintered on pasture.

Hence the position for producers in the early 1980s was one in which strategic application of anthelmintics was not generally possible and many producers were forced (or at least considered they were forced) to apply drench with rapid regularity; in some cases monthly. This led to a situation in which the reliability of anthelmintic–based control became questionable because of the emergence of worm species resistant to the most widely-used broadspectrum drenches (Prichard, Hall, Kelly, Martin and Donald 1980). Martin, Anderson, Jarret, Brown and Ford (1982) showed in an experimental situation that frequent anthelmintic treatment causes rapid selection for resistance; and, in a survey conducted in the Northern Tablelands by Webb, McCully, Clarke, Greentree and Honey (1979), Thibenzole was less than 90 per cent effective on 45 per cent of farms. An urgent research objective was to find a method of reducing the number of treatments of newly-introduced broadspectrum anthelmintics and still retain control over barber's pole worm. Wormkill, introduced in July 1984, enabled this to be achieved. It was based on a sustained-action narrowspectrum chemical called Closantel (trade name Seponver), directed against barber's pole worm, combined with a reduced frequency of broadspectrum anthelmintic to control other worm species, importantly black scour worm (Trichostrongylus colubriformis). Following the regime shown in Table 2,

Table 2

The 'Wormkill' Program

	Adults and Hoggets			Lambs		
	Seponver		Broadspectrum drench	Seponver		Broadspectrum drench
1st August	*	plus	*			
1st November	*	plus	*	*	plus	*
1st February	*			*	plus	*
1st April						*

Source: Newman and Parton (1985).

the method was to reduce contamination of pasture by means of drenching in August and November, and then to combat summer contamination with treatments in February and April (Dash, Newman and Hall 1985).

4.2.2 Other components of Wormkill

In addition to the drenching regime shown in Table 2, nine other components of Wormkill were identified on the case-study farms. Complete adoption of the innovation would require inclusion of all these components in the set of farming activities. In order of importance, including the use of anthelmintics, these were: (a) preparation of first weaning paddock, (b) maintaining adequate nutrition, (c) monitoring egg counts, (d) early weaning, (e) monitoring drench efficiency, (f) preparation of second weaning paddock, (g) reducing stocking rate, (h) monitoring growth rates, (i) changing flock structure and (j) reducing grazing intensity.

The emphasis given to each of these components does (and should) differ from farm to farm given the varying characteristics of the farm such as class of stock, size of the property and type of pasture. All farms, except farm 2 have gone some way towards introducing all aspects of the Wormkill innovation.

4.3 The Model

To model the six case study farms, a conventional LP analysis was complete. As shown in Table 1, the farms are principally Merino woolgrowing properties with some cattle. Table 3 shows the structure of the LP matrices.

Special attention was given to the components of the Wormkill program. The ten components were grouped into the four categories: grazing management (items a, f, g, i and j from the list in section 4.2.2.); nutrition (items b and h); early weaning (item d); and efficient drenching (items c and e). Then, for each farm, activities were established in the LP matrix representing the progress made by the farmer along these four dimensions.

The base model represented actual decision making in 1990/91. The Wormkill activities included in the model were those that it had adopted during that season. The model was solved by parameterizing the wool price and observing the quantity of wool produced. Hence, individual-farm supply curves for wool were mapped out

Table 3

Structure of the Linear Programming Matrices

	Standard farm activities	Selling activities	Risk activities	Wormkill activities
Stock Land Labour Feed Wool transfer Risk constraints				
Objective function				

The parameterization was then repeated in a revised model in which the Wormkill activities were replaced by activities representing a tactical drenching regime, which it is judged would be the alternative technology to Wormkill. This involved a labour input for drenching nearly 2.5 times that used with Wormkill, suffered reduced wool yields and numbers of lambs produced, but reduced drenching costs by over 50 per cent. The objective was to represent the situation of non-adopter in 1990/91 as adequately as possible.

The result was a second firm-level supply curve for each farm, to the left of the first. Comparison between the two curves provides an indication of the form of the supply curve shift at the farm level.

4.4 Aggregation to the Industry Level

Many representative farm LP models either include a formal method of aggregation to arrive at an industry-level result or are themselves representative of a regional aggregate. The approach taken in this project is to regard the case study farms merely as case studies. Hence, no definite statement about industry-level supply shifts can be made based on the results of these six studies. Nevertheless, they can be regarded as the first step in a process that will allow informal integration of results from a larger number of individual-farm analyses to an industry-level picture of supply shifts.

5. Results

The results of the parametric LP analysis for each farm are shown in Figures 2 to 7. In addition, the supply curves of Figure 8 are the horizontal summation of the individual farm supply curves. Clearly the Wormkill innovation is shown to shift the wool supply curves noticeably to the right. On the issue of the type of supply shift involved, the results are inconclusive. As early sample evidence, they do not point to any particular type of shift. There is no evidence to reject the assumption of Collins and Poulter (1990) that Wormkill resulted in a parallel shift.

6. Concluding Remarks

A series of LP models was constructed to represent decision making related to the Wormkill innovation on six individual case study farms in the New England region. By solving these models employing a parameterization of the wool price, six wool supply curves were established to represent the current situation in which the innovation is available. Following adjustment of the LP matrix and re-solving, a second set of individual-farm supply curves were obtained, representing the situation without the innovation. Comparison between these two sets of supply curves provided inconclusive evidence about the nature of the supply curve shift.

A final issue worthy of consideration is the limitation presented by the linearity of the activities in the programming model. Non-linear features of production on real farms are not captured in such a framework, which consequently offers only an approximation to the actual situation. Whether the approximation has a significant influence on conclusions about the nature of farm-level supply shifts is currently under investigation.

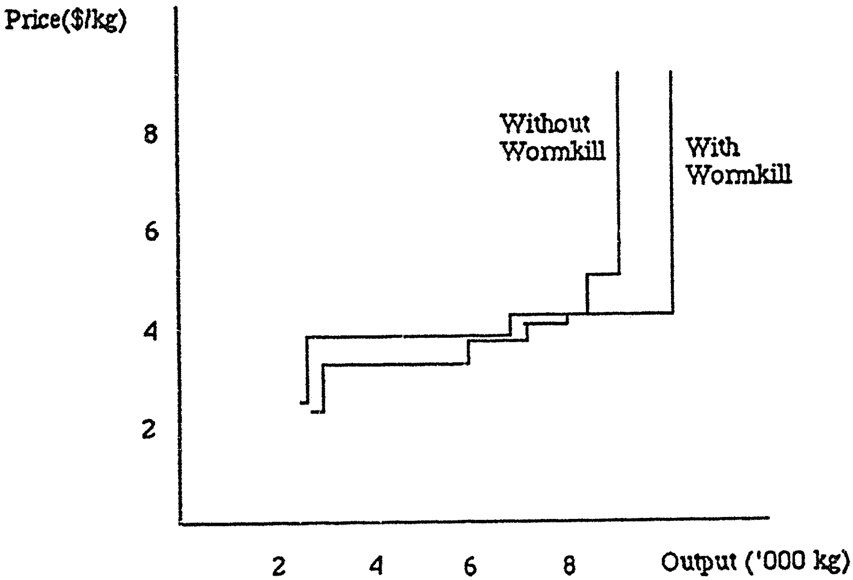

Figure 2: Supply shift on farm 1

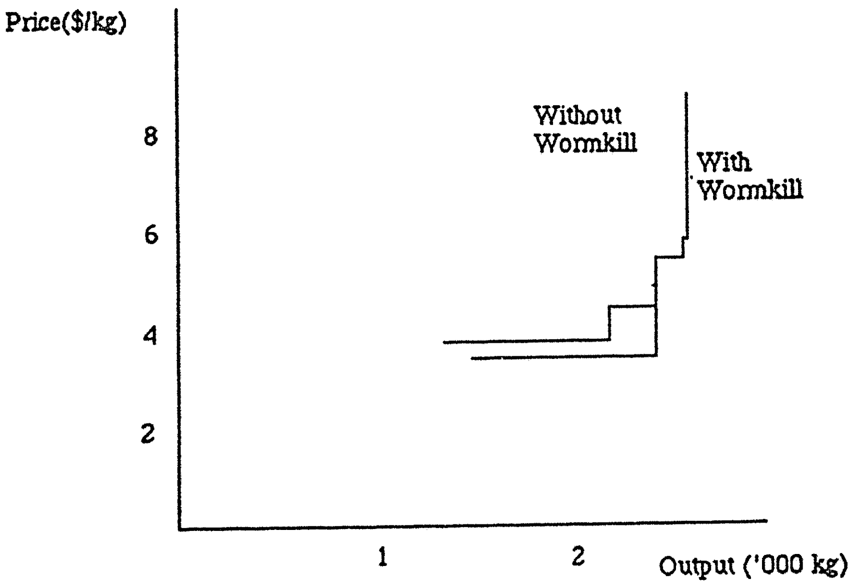

Figure 3: Supply shift on farm 2

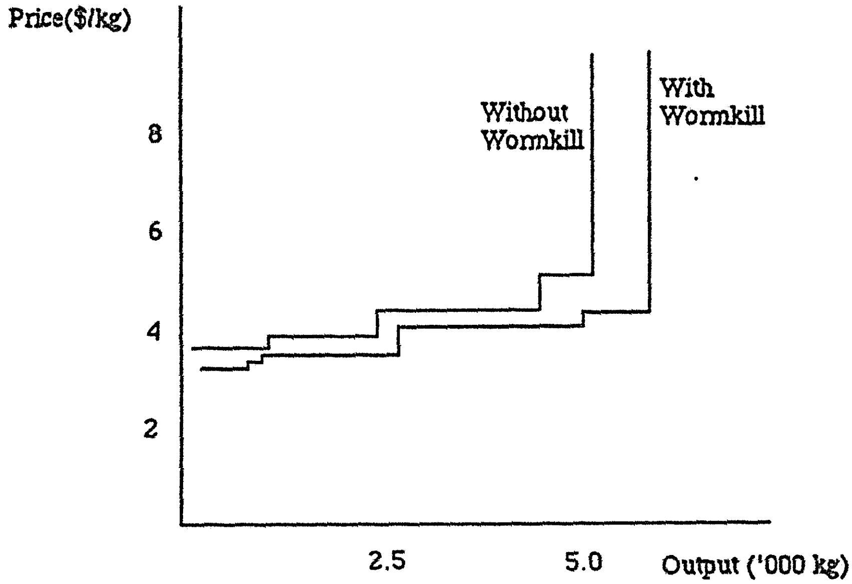

Figure 4: Supply shift on farm 3

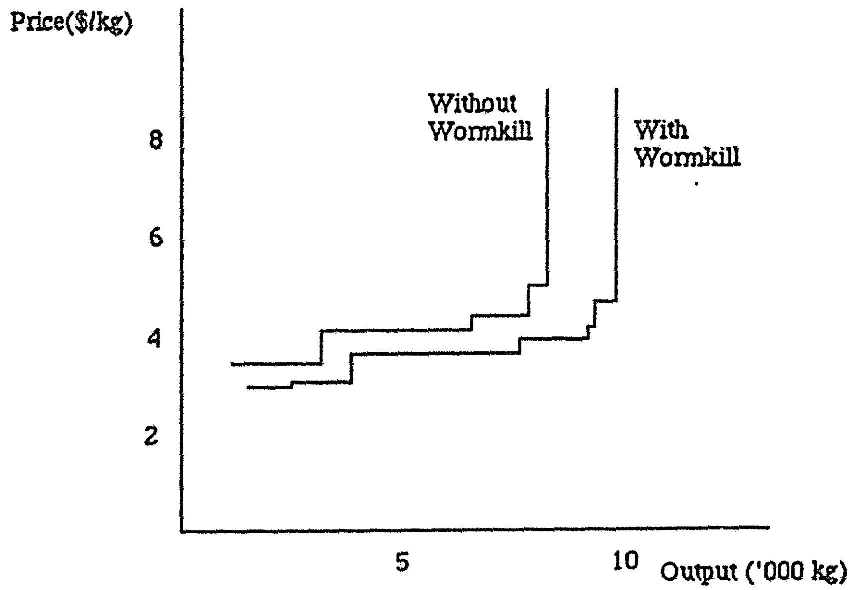

Figure 5: Supply shift on farm 4

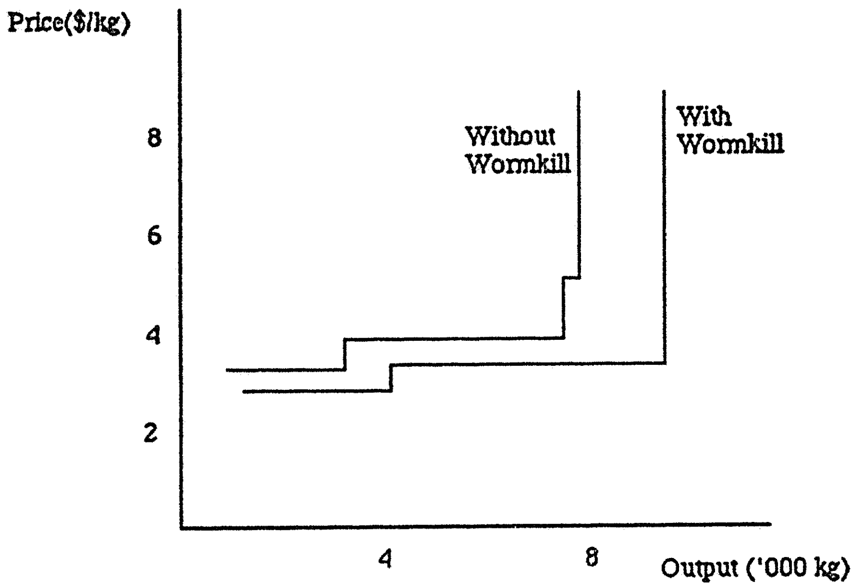

Figure 6: Supply shift on farm 5

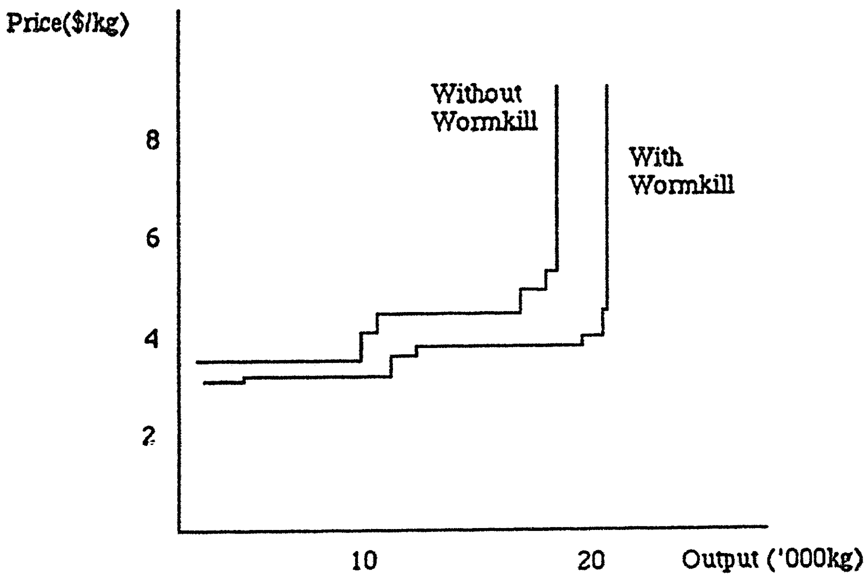

Figure 7: Supply shift on farm 6

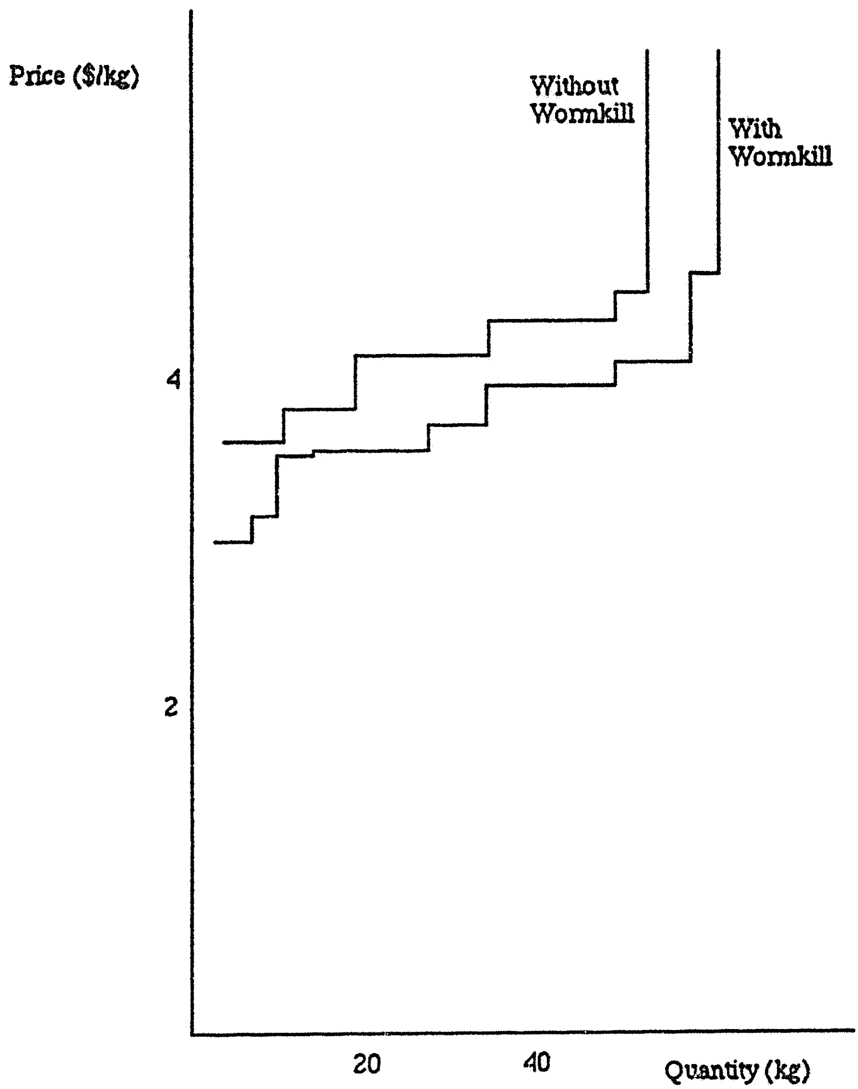

Figure 8: Supply shift for six farms

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COVER SHEET

TITLE: Analysis of Rangeland Degradation Using Stochastic Dynamic Programming

AUTHORS: George Passmore
Queensland Department of Primary Industries
GPO Box 46
Brisbane QLD 4001
Telephone: (07) 2393244
Facsimile: (07) 2214049

Colin Brown
Department of Agriculture
University of Queensland
QLD 4072
Telephone: 07 3652148
Facsimile: 07 3651177

ABSTRACT:

Arid rangeland degradation, and efforts to control that degradation, have become topical issues. However, the inherent characteristics of the rangeland and the intertemporal nature of the problem complicate the analysis of degradation issues in the search for more appropriate rangeland policies. Stochastic dynamic programming is examined as one means of allowing for those complexities. Using the case of the Queensland mulga rangelands, optimal stocking rates are shown to rise with lower property sizes, higher discount rates, higher wool prices and declining risk aversion. Importantly, the analysis reveals that a strategy of high stocking rates with the potential for rangeland degradation is an optimal response to the economic and social factors that confront graziers and is not an intertemporal information problem alone.

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