SPATIAL EQUILIBRIUM ANALYSIS, SOCIAL WELFARE AND RURAL POLICY: THE CASE OF THE WOOL MARKETING INNOVATIONS AND REFORMS

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Radical wool marketing changes are mooted by the Australian Wool Corporation. While these intentions include wide ranging increases in market power for this supreme marketing authority, the overall proposals in their entirety, are argued as necessary to operationalize newly available wool selling and handling innovations. Supporting empirical evidence on the gains from adopting these innovations relies on spatial equilibrium models not fully in accord with the economic theory on which they are based. This paper sets out the shortcomings of these back-up studies. Based on a reconsideration of the theoretical premises, counter policy measures are advanced for consideration.

1.0 INTRODUCTION

A thread that runs in common through the accumulated series of reports charged with examining the structure and efficiency of Australia's wool marketing, is the implication that transport and handling innovations if adopted either alone or allied with acquisition of the clip, will result in cost savings that will accrue to woolgrowers directly and in total.[1] A typical statement reads as follows:

In many areas—particularly in the pastoral and wheat/sheep zones—the scope for further productivity gains or diversity is extremely limited. Because productivity is limited and with no immediate expectations of a substantial price recovery, the industry is looking to improvements in marketing methods to cut costs and increase net income . . . Wool transport is a major area of potential cost savings to woolgrowers [1, p. 142].

In a policy context further importance attaches to questions of wool handling and transport innovations. The existence of these cost savings is often advanced as the major reason behind proceeding with a radical reorganization of the wool marketing system as a whole.[2] The Bureau of Transport Economics notes this conjunction:

For example to a large extent the argument in support of a radical change in wool marketing rests on the lower cost of transport, handling and storage options which are said to become available [11, p. 3].

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[1] The current Australian Wool Corporation Report [3] is the eighth since 1952, with three in the series spawned since 1970.

[2] These proposals are currently before the Australian Government. *See* Baxter's comments concerning the latest report [4] [5].

The major empirical support for these arguments was derived from operations research studies commissioned by the then Australian Wool Board. With the aid of linear programming techniques (cast in the mould of spatial equilibrium formulations) these studies modelled the optimal (cost-minimizing) number, location, and size of wool selling centres that would be necessary to operationalize the technological advances now available in the handling, transport, and preparation of Australian wool for export. Much of this work was reported in this journal [17] [18] [19].[3]

Our aim is to illustrate that in the first place these commissioned operations research back-up studies err in crediting the full amount of such potential cost savings to domestic woolgrowers. The practical implications of this oversight are examined in the case of the wool industry proposals, and the theoretical reasoning concerned is detailed for the benefit of this and related studies in other industries. Industry observers reviewing the 1974 Wool Marketing Report have commented on the proposed assignment of nearly complete market power to the emerging Australian Wool Corporation (A.W.C.) [4] [5]. A clear intention is seen of creating a monopolistic situation for the benefit of wool producers. In this instance, if maximum income gains to wool-growers is agreed on as the "real" objective of implementing an overall marketing reorganization, further deficiencies of the Australian Wool Board's commissioned research becomes apparent. The models employed do not allow such monopolistic objectives to be pursued. A discussion concerning the type of models that could perform this task under the monopolistic assumptions forms part of this paper.

It is the contention of this article that the imperfections associated with the commissioned research are brought about by neglect of the underlying economic theory on which the industry models are raised. For this reason the paper proceeds by re-examining the relevant theoretical underpinnings. Then the relationship between the appropriate theoretical treatment and the practical problem is forged. Finally counter-proposals, of interest to policy-makers, suggested by a re-consideration of the problem in the light of the relevant theory, are advanced.

2.0 THEORY REVISITED

2.1 SOCIAL WELFARE AND SPATIAL EQUILIBRIUM ANALYSIS

Revisiting the economic theory concerned, involves in the first place, gaining insights into that branch of analysis that deals with spatial price equilibrium (or the problem of "communication of markets" as it was known in the early literature). A complete review of this area would lead us to re-examine papers written by many of the great

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[3] Related studies published directly by the Australian Wool Board and not appearing as journal articles include [1] [2]. A precursor of this work was the article by Dent [14].

pioneers of modern economics.[4] However in this instance it is only necessary to begin in the 1950's with Samuelson's *Spatial Price Equilibrium and Linear Programming*, as this contribution forms the applied welfare economics basis of the operations research models used by the wool industry researchers.

Samuelson [32] demonstrated firstly, that maximization of the gains from trade between regions or countries can be examined geometrically in the two-region case, and illustrated that such a process involves maximization of an objective function which he terms "net social payoff". Orr [28] building on Samuelson's work, but invoking in addition elements of the theory of derived demand, provides proof of the equivalence of Samuelson's "net social payoff" and the area delineating the "consumers' surplus" formed under the derived demand for transport curve.[5] This connection between Samuelson's "net social payoff" gains from trade and the applied welfare economics usage of this idea as an "economic surplus", accruing to both final consumers and to producers as factor rents, is given in the quotation from Orr below. The figures referred to are reproduced hereunder.

In his article Professor Samuelson does not refer to the curve D_t of figure 2 as the transport demand function, but refers to it (the curve NN in his figure 2 p. 299) as the "net" curve. He defines the area between this curve and the transport rate line as the net social payoff which is a maximum when the equilibrium conditions are satisfied. Thus he is able to state the problem of spatial price equilibrium, which includes inside it the problem of minimizing transport costs, as a maximization problem although no entrepreneurs, singly or in concert, set out to maximize the net social payoff. The net social payoff can be partitioned into the net social payoff in each region by use of the excess supply functions. (It is equal to the sum of the areas $P'_2 P_2F$ and P'_1p_1G in figure 1. These areas in turn are equal, respectively, to the areas $A'B'C'$ and ABC of figure 1.) It can be further partitioned by use of the original supply and demand functions into changes in producers' and consumers' surplus in each region. When traffic moves from region 1 to region 2 there is a loss of consumers' surplus in region 1 but a gain in producers' surplus. The net gain is measured by the area ABC of figure 1. Similarly, $A'B'C'$ measures the net gain of consumers and producers in region 2. *Thus the effects of rate changes, which alter the net total value of the service (or net social payoff) can be traced to the four groups of economic decision-makers on whom the rates are incident* [28, p. 69] (emphasis supplied).

The reader can readily verify that should the lower transport cost of t'_{12} (figure 2) become applicable between region 1 and region 2 the net social payoff would increase and lead to further producers' gains in region 1 and gains of consumers' surplus in region 2. Alternatively, these extra combined gains are measured by the area $t_{12} XYt'_{12}$ under the derived demand for transport curve D_t of figure 2. To present a simple example to capture the essence of our problem, consider that the mooted wool industry transport and handling innovations are

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[4] Cournot, Barone, Viner, Pigou and Taussig amongst others have probed this area.

[5] Perhaps a better term than "consumers' surplus", when speaking of the area under the derived demand curve for the transport service factor, would be to term this area the "net total value of the service". A recent World Bank study [35] covers much of the theoretical ground involved in Orr's proof and comes to the same conclusions. With respect to international trade this IBRD study makes the further point (emphasized in our paper) that some of the beneficial effects of domestic transport improvements are captured by consumers in the importing countries.

responsible for the fall in transfer charges of t_{12} to t'_{12} (figure 2). Modelling the situation before and after the innovations (as the operations researchers of the wool industry did) would reveal cost savings contingent on their optimal wool flows that would be equal to the value of the gain in economic surplus, i.e. $t_{12} \, XYt'_{12}$ of figure 2. However, by our previous explanation these net cost savings are divided between overseas consumers and domestic producers according to our exposition of this split-up depicted in figure 1.

DIAGRAM 1: SPATIAL PRICE EQUILIBRIUM AND WELFARE GAINS (AFTER ORR)

FIGURE 1:

Product Market
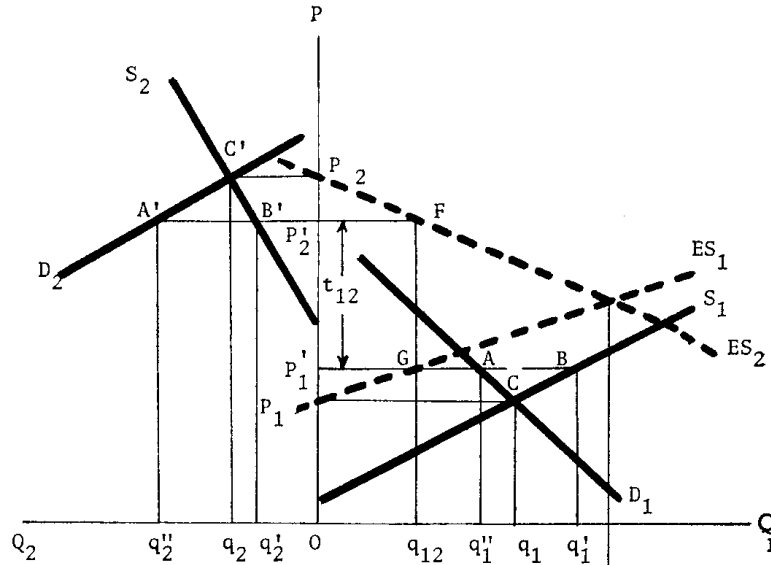
FIGURE 2:

Factor Market (Transport Services)
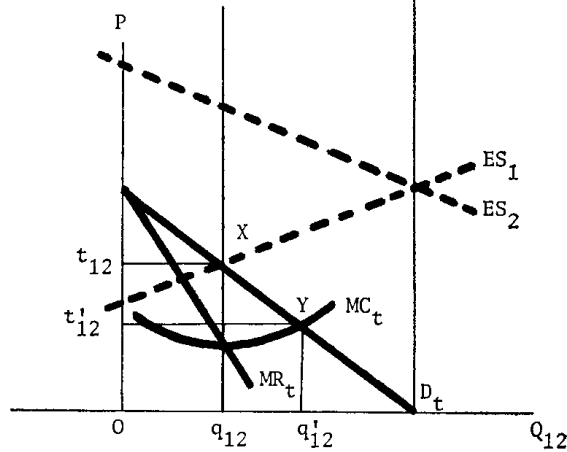
NOTE: The *ES* functions show the difference between the quantity supplied and the quantity demanded in each region at each price level. The curve ES_2 in figure 1 is the excess supply curve of region 2 if read with respect to the left hand quantity axis; it is the excess-demand curve if read with respect to the right-hand quantity axis. This is true since excess demand is the negative of excess supply and a change in the axis of reference has the effect of changing the sign of the quantities read from the curve.

Note that the maximization of the gains from trade implies adoption of a social welfare function akin to that underlying formal benefit cost analysis, i.e. a maximization of the sum of consumers' and producers' surplus (net social payoff) unweighted by any consideration of "whomsoever such gains accrue to". Put baldly, models that are structured on this theoretical base (as the operations research models used by the wool industry researchers were) do not have as their objective the maximization of income gains to producers. If Orr's figure 1 is seen as representing the export market for Australian wool (with region 1 as Australia and region 2 the rest of the world) then that part of the gains from trade shown by the area $A'B'C'$ accrues to overseas consumers as a surplus. To add fuel to the flames, that component of the total gain termed an increase in producers' surplus experienced in the domestic market (i.e. area ABC in figure 1 region 1) does not accrue to domestic wool-producers alone. Berry underlines the confusion inherent in such an accreditation:

It was perhaps unfortunate that the term "producers' surplus" instead of "factor surplus" was introduced by Marshall, since it led to some confusion, in particular to the erroneous idea that the area measure refers to a gain going only to entrepreneurs. Clearly the relevant phenomenon (whether correctly measured by the area suggested by Marshall or not) is an economic rent going to all factors of production [6, p. 81].

From an examination of the models employed and the theory underlying them, the evidence produced illustrates there is no basis to assume a one to one correspondence between the cost savings available from innovations and increases in wool growers' incomes. In fact our analysis underlines that such an assumption of direct correspondence is fallacious.

2.2 LINEAR PROGRAMMING AND COMPETITION

Samuelson's important further contribution in the same paper [32] was to show how, in the n-region case, the shipment pattern yielding the maximum gains from trade can be found in an operational sense by means of linear programming. His article conveys how the general problem of solving for the equilibrium prices and the pattern and volume of trade between regions that maximizes net social payoff, also yields a solution that minimizes transport costs, given the total shipments from or to each region. In other words, the formulation of a linear programming transportation cost minimization problem is embedded within the Enke-Samuelson problem of determining a spatial price equilibrium between competitive regional markets, and the consequent maximization of net social payoff.

The wool industry support studies [1], [2], [17], [18] and [19] drew on models that used the insights derived from Samuelson's pioneering paper, to cast their problem of solving for efficient cost-minimizing wool flows through handling sites, into a linear programming transhipment model

variation of the classic "transportation model".[6] Thus as we have commented before, the gains from transport and handling innovations show up in our linear programming solutions as cost savings; these should be interpreted as an estimate of potential economic surplus gains that would be partitioned, as Orr has shown, between consumers and producers. Adoption of these linear programming frameworks implies a further important theoretical assumption, often unfortunately misunderstood, that the underlying market structure being examined with the aid of these models conforms closely to a competitive structure. Hsiao [24] , von Boventer [7] and Stevens [33] have all illustrated that there is no need for a Commissar or Central Control Board to organize the entrepreneurs involved to maximize this economic surplus. The decentralized decision-makers under competitive conditions, acting on their own behalf and in accordance with the linear programming formulation, will maximize net social payoff by performing an overall transportation and processing cost minimization.

The authors believe that neglect of a consideration of this important theoretical underpinning has led astray the studies of the Australian Wool Board, besides others.[7] The stance of the A.W.C., the now supreme marketing authority, is seen to be that of one approaching a monopolistic orientation. Accordingly, our view of the wool industry's objectives as gleaned from industry statements and reviews of the latest wool marketing proposals by expert industry commentators [4] and [5], is that the "real" objective function in the minds of industry leaders is one in keeping with the monopolistic bent of the A.W.C., i.e. a maximization of woolgrower income gains from these transport innovations and by other marketing methods. Both Campbell [12] and Brownlee [8] reviewing the Australian and U.S. rural scenes respectively, have indicated that in a majority of cases primary producers gain most by monopoly powers, even though they often cloak the assumption of such powers in rhetoric concerning implementing efficiency in marketing. Campbell sees it this way:

Studies which have been undertaken (for example by the United States National Commission on Food Marketing) suggest that such gains in returns as are achieved by the exercise of market power are procured from consumers in the form of higher prices. Despite grandiose statements of intent, it is rare that producers achieve any significant gains from a reduction of marketing margins or increased efficiency [12, p. 181].

If our insights are correct and the true objectives of the latest wool marketing proposals are monopolistic in intent, it follows that the Wool Board's commissioned operations research studies do not conform with these objectives. The models employed here utilized the "wrong"

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[6] The models utilized were direct descendants of Logan and King's pioneering work in this field [27]. Logan and King expounded how generalization of the linear programming transportation model to include first stage processing, and associated raw product assembly and product distribution costs, does not alter Samuelson's theoretical treatment.

[7] A further example of misuse of a competitive formulation in a spatial equilibrium study where a non-competitive framework was necessary, is provided in the honey industry study of Holyrod [23].

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objective function (maximization of economic surplus) and are based on conformity to decentralized competitive decision-making, not centralized monopolistic decision-making.[8]

As might be expected there are spatial models that conform to monopolistic specifications. Orr develops the theoretical considerations inherent and expresses these in a framework using explicit marginal cost and marginal revenue functions to maximize profits or "shippers surplus" from trade between regions. Plessner [29] furnishes an example of how Orr's theoretical propositions may be made operational by means of quadratic programming. A monopolistic orientation leads into the question of supply control (e.g. production quotas) and price discrimination between markets and consumers. Guise and Aggrey-Mensah [22] provide a spatial price equilibrium model concerning banana marketing in Australia that considers all the monopolistic characteristics outlined above, and in their case, indicates gains of 20 to 25 per cent in producers' revenue. Such models as those of Guise *et al*, deliver as further output the supply regions where curtailment of production would most increase industry producers' revenue taken as a whole.

An examination of potential income gains to wool producers in such a monopolistic case remains to be performed. A useful insight to the probable outcome can be gleaned from a consideration of the price elasticity of demand for Australian wool. Econometricians report it to be elastic.[9] Thus the implication is that in the case of wool, gains in producers' revenue will not be forthcoming as a result of monopolistic restrictions on output, unless such restrictions result in proportionally larger production and marketing cost reductions.

3.0 THEORY AND PRACTICE

To tie the theory and the specific wool industry problem together at this stage it may be useful to employ a further diagrammatic example. Diagram 2 attempts in a simple fashion to provide an illustration of the first point we made, that it is fallacious to accredit all innovationary transport and processing cost savings to domestic woolgrowers. Further

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[8] Weinschenck *et al*, in their wide ranging review of spatial models recognize this dichotomy:

"Therefore it is useful to distinguish two types of spatial equilibrium models:

(a) models in which the optimal (cost minimizing) structure of production and distribution is determined from the viewpoint of a central planning board; and

(b) models which are based on decentralized decision-making and simulate the market mechanism. In these models it is assumed that single firms make their decisions, without knowledge of optimal location, on the basis of the given economic data at the time [36, p. 40]."

If acquisition of the wool clip at farm gate was implemented the correspondence of the A.W.C. proposals and model type (a) is immediately recognizable.

[9] Footnote 13 of the appendix provides some sources of the price elasticity of demand for Australian wool.

use will be made of this framework to provide the basis for a numerical example illustrating the incidence of gains from adoption of these efficient wool marketing techniques.

Consider figure 3 (a) represents the market for export wool at quayside in Australia.[10] The demand curve D_j represents the woollen goods manufacturers' demand and is a compound demand curve for the raw wool besides its transportation from farm to quayside, along with its first-stage handling, testing, and processing for export. To correspond with this curve the compound supply curve S_j represents the reactions of the different agencies concerned in providing the commodity and its associated services. Figure 3 (b) provides an illustration of the underlying factor market for domestic transport, handling, testing, and first stage processing for export of raw wool. These compound factor demands and supply curves are denoted D_i and S_i respectively. A further assumption here is that of the existence of fixed proportions between the product and factor markets. For the purposes of this exercise the supply of factors to the industry concerned is considered as being perfectly elastic.

The result of the handling and transport innovations modelled in the Wool Board's operations research studies is to shift the factor supply curve S_i downwards to its new position S'_i. This curve now intersects the derived factor demand curve D_i at I. By our previous discussion the area P_3HIP_4 of figure 3 (b) constitutes the economic surplus gain (equivalent to the industry "cost savings") that can be had from innovation. Nonetheless as we have noted, the results of this change in the factor market must by the theory of derived demand make its effects known in the product market of figure 3 (a). Here supply curve S_j shifts downwards (the same vertical difference as S_i shifted to S'_i) to its new position S'_j. The outcome of these simple dynamics is to describe how the partitioning of the economic surplus gain is performed by market forces. $PFEGP_2$ in figure 3 (a) represents an equivalent area to the P_3HIP_4 gain shown in figure 3 (b). As is detailed fully in the appendix, the economic surplus gain in the product market $(PFEGP_2)$ is divided into that part accruing largely to overseas consumers $PFEP_1$ and that accruing to domestic factor owners as rents (the "producers' surplus" P_1EGP_2). The appendix mentioned offers proof that the ratio of the increase in consumers' surplus to the increase in producers' surplus, is given by the ratio of the price elasticity of supply of Australian export wool to the absolute value of the price elasticity of demand for Australian wool exports. That is,

$$\frac{E_s}{|E_D|} = \frac{\Delta CS}{\Delta PS}$$

Having established that innovatory savings accrue to both consumer and producer groups, and further, detailed the proportional relationship that governs this distribution, it is now possible to consider the practical aspects that emerge for the wool industry. Table A1 in the appendix

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[10] As approximately 97 per cent of the Australian wool clip does in fact get exported the market depicted will reflect the major gains and losses to be considered.
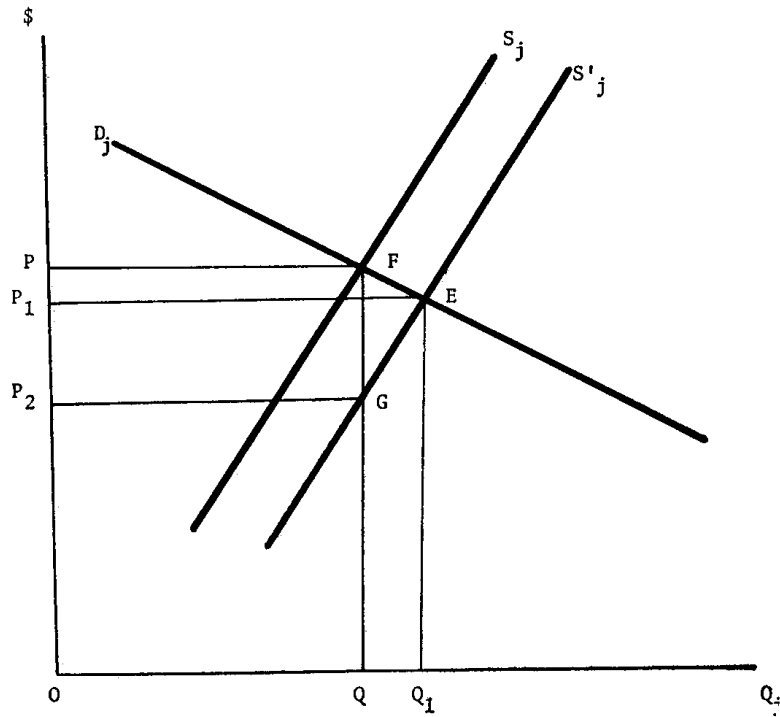
DIAGRAM 2

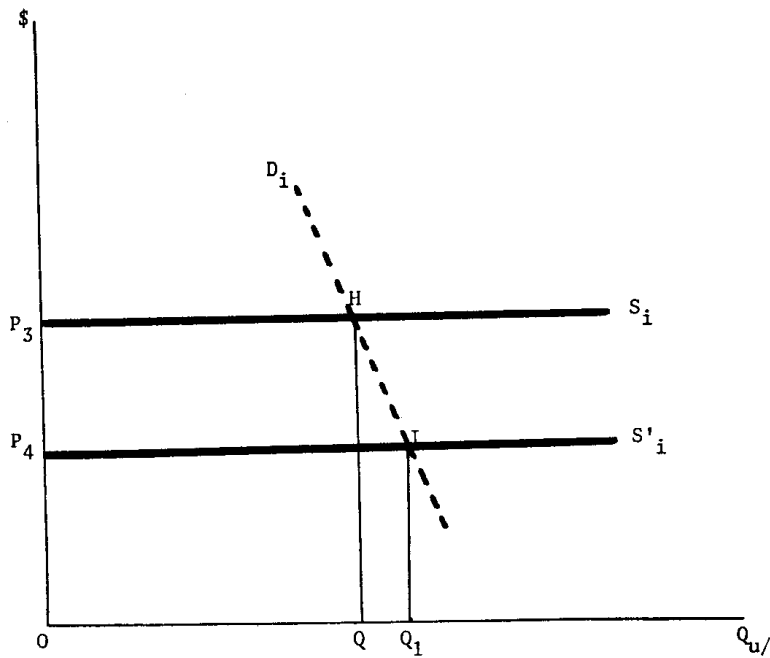FIGURE 3 (a). *Product Market: Australian Wool Exports Quayside*

FIGURE 3 (b). *Factor Market: Transport Services and Associated Factors*

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provides the full range of outcomes expected when consideration is given to the range of elasticity values deemed applicable. In the short run, these reveal a leakage of economic surplus ("cost savings") to mainly overseas consumers of a maximum of 9 per cent. In the long-run this same leakage ranges up to a maximum of 27 per cent. As the long-run elasticities however, are considered to involve too great an adjustment period in their estimation (greater than 50 years) perhaps the appropriate planning horizon is that of the intermediate-run period. Here the leakage of gain to consumers ranges between 5 and 10 per cent, a rather minor loss.

Such an outcome proves rather fortunate for the validity of the empirical estimates from the Wool Board studies. Both implicitly and explicitly all "cost savings" determined by the operations research models have been regarded as gains passing to woolgrowers. In fact the cost savings accrue as rents to owners of all factors used in the production of Australian wool, and as increases in consumers' surplus to those who purchase this wool. Had similar models and interpretations been applied to situations where the elasticities were less favourable, the resulting empirical findings would have been invalid for planning purposes.

An important further theoretical assumption that underlies the estimates given above, is that the same level of competition prevails throughout the markets concerned as prevailed in the past before the innovatory activity. In other words, no monopolistic middleman (say with a process patent for these improvements) is able to capture for himself these gains from innovation. Of course, if the A.W.C. was monopolistically oriented, it would be possible for this entity itself to capture some of the gains and dissipate them on objectives of its own; possibly objectives that were not in full accord with those of woolgrowers. Such a possibility is always present in large organizations not subject to market competition, and the losses of social welfare possible are discussed in the growing literature of "X-inefficiency" [26].

A related shortcoming of the Wool Board studies is that they stop short of considering the very important ocean transport leg to our overseas customers. The importance of this growing level of charges is given by Sturgess:

The most suspect links in the marketing chain are those of exchange and ocean transport and wharfage. Those searching for excess capacity, unnecessary services, and sluggish competition though not necessarily high profits, could well begin here. Freight rates, in particular, have moved up relentlessly on many commodities, a serious matter for an agriculture so heavily dependent on distant markets . . . Wool freights, for example, were 40 per cent higher on average in 1963–4 to 1965–6 than in 1953–4 to 1955–6 period, a period in which wool prices declined 12½ per cent [34, p. 79].

Here of course the "middleman", shipping conferences, are organized on a monopolistic basis. It is possible for these people to price their services for shipping wool on "what the market will bear". With innovatory activity promising further returns to woolgrowers and with these producers basically price-takers in the international wool trade, the incidence of increased freight charges would fall mainly on domestic wool producers. It is not fanciful to envisage an erosion of the "cost

savings" on the reorganized domestic transport and marketing leg (i.e. erosion of the rents accruing to domestic factor owners). These can be siphoned off by the conference shipowners leaving the volume of trade much as before. In the practical industry setting policies to deal with this eventuality on the ocean shipping leg are as important as the domestic marketing efficiency measures so widely acclaimed.

Returning for the present to the numerical estimates of leakage of "cost savings" to overseas consumers, and the mirror image of these estimates, retention of the greater part of this surplus as rents to factor owners, what is to be made of these in a policy context? Recall that the operations research models that derived these gains implied an underlying competitive structure, even though that implication seems not to have been fully understood. These gains in economic surplus ("savings") would have been available from a fully informed competitive market given time for adjustment and the absence of other imperfections. Without whatever extra gains a fully monopolistic A.W.C. could bring about (e.g. by production quotas and market or consumer discrimination) these gains represent the maximum that the wool industry could obtain with the new transport and handling technology adopted domestically. A leakage of perhaps ten per cent of these gains would seem to be an acceptable outcome from the standpoint of the wool-producer. Such a "loss" would still occur even if a superbly organized A.W.C. acquired the clip at farm gate and simulated the competitive market exactly, while processing and marketing the clip itself.[11]

4.0 CONCLUSIONS

With respect to the application of spatial equilibrium analysis to the problems of wool marketing, we have shown that research workers to date have not applied their models and reported their findings in full accord with the underlying economic theory involved. However, as we outlined, particular market forces and circumstances concerning the wool industry, in particular the specific value of the strategic elasticities, rescue the empirical outcomes and render them fair approximations of what should have been sought with these models.

These wool market circumstances alluded to throw further light on practical organizational consequences of interest to the wool industry. If the price elasticity of demand for Australian wool exports is as elastic within the relevant ranges as the estimates provided by econometricians suggest, then producer income gains from full monopoly may be rather meagre. Total revenue would fall as output was restricted and income gains would only be set in train by associated production and marketing costs falling faster as output contracts. In any event, such a monopolistic estimate incorporating the latest handling and transport innovations remains to be modelled.

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[11] The authors believe that to expect such perfectly efficient behaviour from a market colossus as the A.W.C. would be in this case is to hope for a "Nirvana" outcome. Efficiency losses arising from "X-inefficiency" would be highly likely. Perhaps such losses would exceed the leakage of surplus to consumers. Demsetz [13] details the pitfalls underlying this approach.

If a full scale monopolistic A.W.C. is ruled out, or on investigation offers little additional gain, it does not follow that the next best role for it to play is that of "Transport Commissar". In this role the A.W.C. in search of efficiency gains would direct (by acquisition at farm gate?) each and every shipment through first stage processing to market at quayside. In our view, the A.W.C. would in the first instance, contribute more by providing the appropriate information concerning optimal technology and size and siting of handling centres to private industry. Then, perhaps by providing some incentives and coercion (the carrot and stick approach) the A.W.C. could restructure the industry into a semblance of the efficient pattern. Incentives could take the form of the A.W.C. constructing the optimally sized and sited facilities, equipped with the new technology, and leasing these back to private woolbroking and handling operators. Auctioning of the rights to operate each facility may be an appropriate rationing mechanism. If for any reason, firms were reluctant to operate at an appropriate locality, then the A.W.C. could step into the breach as a processor itself.

Our view of the present marketing ferment is one that judges the development of the new handling, transport, and marketing technology as analogous to the innovatory shocks experienced in other rural industries in earlier decades. The ranks of dairy processing plants, to take one example, were greatly thinned in the 1930's following the general adoption of motor truck transportation and refrigeration. With some friction and trauma the structure of these industries adapted without the need to take over the industry completely. Similarly, the A.W.C. could act to facilitate the necessary change in structure and location arising out of the present shocks, i.e. minimize the friction and trauma by the incentives and other methods noted above. Having lent weight to the restructuring problem, the A.W.C.'s role in the handling and processing field would revert to that of a provider of information, and perhaps research and development.

It remains to remind the reader that notwithstanding all that has gone before, in an overwhelmingly export-oriented industry dependent on ocean transport, a proposed marketing reorganization that stops short of considering this leg may prove unrewarding to domestic producers. Conference cartels of shipowners organized in monopolistic fashion stand to capture the innovatory gains by pricing their services at "what the market will bear". Australian shippers have not had great success in controlling freight charges. Policy in respect of containing ocean freight charges is a necessary concomitant to the proposed domestic marketing changes.

APPENDIX: PRICE ELASTICITIES AND THE DISTRIBUTION OF CHANGES IN ECONOMIC SURPLUS

The purpose of this appendix is twofold. First, it will be demonstrated that the gains in economic surplus resulting from a shift in the supply or demand curve is distributed among consumers and producers in the ratio of the price elasticities of the supply and demand functions. Second, quantitative estimates of the distribution of gains in economic surplus arising from improvements in the efficiency of marketing the Australian wool clip will be presented.

Consider figure 3 (a) in the text. The initial price and quantity determined by the intersection of demand (D_j) and supply (S_j) curves are OP and OQ respectively. Now suppose there is a shift downwards of the supply curve to S'_j. The gain to consumers, is the area $PFEP_1$, while the area P_1EGP_2 represents gain to producers.

The gain in consumers' surplus (ΔCS) is:

$$\Delta CS = (P - P_1) OQ + \tfrac{1}{2}[(P - P_1) \Delta Q] = (P - P_1) (OQ + \tfrac{1}{2}\Delta Q) \quad \ldots \ (1)$$

The gain in producers' surplus (ΔPS) equals:

$$\Delta PS = (P_1 - P_2) OQ + \tfrac{1}{2}[(P_1 - P_2) \Delta Q] = (P_1 - P_2) (OQ + \tfrac{1}{2}\Delta Q) \quad \ldots \ (2)$$

The ratio of the change in consumers' surplus to the change in producers' surplus is given by:

$$\frac{\Delta CS}{\Delta PS} = \frac{(P - P_1) (OQ + \tfrac{1}{2}\Delta Q)}{(P_1 - P_2) (OQ + \tfrac{1}{2}\Delta Q)}$$

$$\frac{\Delta CS}{\Delta PS} = \frac{P - P_1}{P_1 - P_2} \quad \ldots \ (3)$$

For shifts upward of the supply curve (say from S'_j to S_j) our argument holds, but with the result that the changes in consumers' and producers' surpluses are losses rather than gains.

The price elasticity of the demand curve at point E is:

$$| E_D | = \frac{\Delta Q}{Q} * \frac{P}{\Delta P} = \frac{\Delta Q}{OQ_1} * \frac{OP}{P - P_1} \quad \ldots \ (4)$$

From which we obtain:

$$\frac{\Delta Q}{OQ} = | E_D | * \frac{P - P_1}{OP_1} \quad \ldots \ (5)$$

The price elasticity of the supply curve at point E is:

$$E_S = \frac{\Delta Q}{Q} * \frac{P}{\Delta P} = \frac{\Delta Q}{OQ_1} * \frac{OP_1}{P_1 - P_2} \quad \ldots \ (6)$$

by substituting (5) into (6) we obtain:

$$E_S = | E_D | * \frac{P - P_1}{OP_1} * \frac{OP_1}{P_1 - P_2} \quad \ldots \ (7)$$

Thus:

$$\frac{E_s}{| E_D |} = \frac{P - P_1}{P_1 - P_2} \quad \ldots \ (8)$$

and from (3):

$$\frac{E_s}{| E_D |} = \frac{\Delta CS}{\Delta PS} \quad \ldots \ (9)$$

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Thus the ratio of the change in consumers' surplus to the change in producers' surplus is equal to the ratio of the price elasticity of supply to the absolute value of the price elasticity of demand. The relationship holds for shifts of the demand curve as well.[12]

We now turn to our second purpose, the quantitative estimation of the distribution of gains in economic surplus resulting from an improvement in the efficiency of wool marketing. We have selected from various quantitative studies a range of price elasticities of demand and supply for Australian wool corresponding to the likely values in the short, intermediate and long run.[13] Table A1 shows, for the chosen range of elasticities, the percentage of the total gain in economic surplus accruing to consumers.[14] Most of the gains in economic surplus accrue to producers. Even in the consumers most favourable case (the long run) their gain ranges from only 20·0 to 27·3 per cent of the total increase. In the least favourable situation (the short run) from 2·5 to 9·1 per cent of the total gain passes to consumers. This outcome is to be expected since in every possible combination of elasticities, $| E_D | > E_S$, ensuring that the change in consumers' surplus is less than the change in producers' surplus.

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[12] Note that the elasticities to be employed in the calculations of this ratio are those prevailing at the intersection of the supply and demand curves corresponding to point E in figure 3 (a).

[13] Estimates of the price elasticities of supply of Australian wool in the short run include 0·03 to 0·08 [9], 0·05 [21] and 0·07 [31]. Those for the intermediate run are 0·07 to 0·26 [9], 0·25 [21], 0·335 [31], and 0·369 [20]. Long run estimates by the B.A.E. range from 1·00 to 1·13 [9], while Powell and Gruen estimate a range from 1·2 to 2·2 [30]. Short run price elasticities of demand estimated by Edwards range from −0·45 to −2·12 [16] which compare with −0·77 to −1·17 estimated by the B.A.E. [10]. Edwards also calculated estimates of the long run world elasticity of demand for Australian wool to range downwards from −3·8. These compare with the range assumed by Jenkins of −1·0 and −1·5 [25] and that of Duloy and Parish of −0·25 to −3·00 [15].

[14] The percentage increase in producers' surplus is, of course, the difference between the percentage increase in consumers' surplus and 100.

TABLE A1

Percentage Gain in Economic Surplus Accruing to Consumers as a Result of an Improvement in the Efficiency of Marketing Australian Wool

Price elasticities of demand for Australian wool	Price elasticities of supply of Australian wool					
	Short run	Intermediate run			Long run	
	0·05	0·15	0·25	0·35	1·00	1·25
Short run 0·5	9·1	..	..	..	..	..
2·0	2·5	..	..	..	..	..
Intermediate run 3·0	..	4·8	7·7	10·5	..	..
Long run 4·0	..	..	..	..	20·0	27·3

1. The percentage change in economic surplus accruing to consumers is:

$$\frac{\Delta CS \times 100}{\Delta CS + \Delta PS} = \frac{E_s \times 100}{|E_D| + E_s}.$$

2. *See* footnote 13 for the sources of supply and demand elasticity estimates.

3. The values for the price elasticities of demand are absolute values.

4. Blank cells have no relevance.

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