Articles and Notes

An Economic Framework for Evaluating New Wheat Varieties

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Estimation of the benefits of research using changes in producer and consumer surplus following a research-induced shift in the supply curve provides a useful framework for the analysis of new wheat varieties. However, the framework assumes an homogeneous product, which is not the case for wheat where there are changes in quality as a result of research. This aspect is particularly important where there is a trade-off between quality and yield, as in the case of a higher-yielding, but lower-quality wheat variety. The aim of this paper is to incorporate these quality aspects into an analysis based on a partial equilibrium framework by separating the wheat market into segments based on wheat quality. A change in the type of wheat produced can then be represented as a shift from one segment to another. The analysis involves identifying those who will produce the new variety, and defining supply curves for those producers and other producers separately. Empirical testing of the model with hypothetical varieties indicates that the results obtained are consistent with prior expectation.

1. Introduction

The current arrangements for the release of new wheat varieties in Australia are highly institutionalised, with the release of a new variety dependent upon the approval of a number of committees. In such an environment, an evaluation framework is particularly important when a trade-off exists between yield and quality. For example, dilemmas have occurred in the past over whether to release a variety which is superior in yield but inferior in quality to the variety it replaces. For example, Godyn and Johnston (1984) found that the decision not to release one promising breeding line could have cost Australian producers substantially. This dilemma has also occurred in other countries. Carter, Loyns and Ahmadi-Esfahani (1986) examined the effect of restricting Canadian producers to high-quality wheats and concluded that Canada would be significantly better off by producing higher-yielding, medium-quality wheats.

At present, there is no adequate means of evaluating the likely gains from a variety prior to its release, particularly when quality differences are important. This paper is an attempt to provide a basis for the incorporation of quality aspects into wheat variety evaluation. The theoretical basis for a partial equilibrium analysis of the gains from research through shifts in the supply curve was reviewed by Norton and Davis (1981). A variety of methods of analysis have been employed (for example, see Griliches 1958, Akino and Hayami 1975, Lindner and Jarrett 1978). Essentially, the analyses estimate the change in producer and

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consumer surplus resulting from a research-induced shift in the supply curve. Edwards and Freebairn (1981, 1984) extended this framework to consider the traded nature of the commodity, to account for the impact on the rest of the world and on the world market itself. The analysis in this paper extends these earlier models by segmenting the wheat market into sub-markets for wheats of different quality. The extended framework permits an *ex ante* evaluation in which both quality and productivity improvements can be examined in a benefit-cost framework.

2. Segmented Market for Australian Wheat

The Edwards and Freebairn model can be useful in analysing the effect of innovations in a market where the commodity is homogeneous. However, such a model has only a limited use for analysing Australia's wheat markets, since wheat is an "heterogeneous product composed of many types of wheat suited to particular end users" (Jeffery 1984, p. 4). Thus, for example, the replacement by producers of a wheat suited to bread-making with one suited for feed cannot be represented by a shift in the demand curve (Unnevehr 1986), but rather is a shift to a different market. To accommodate this shift between markets, the model is extended to allow for the different segments of the aggregate wheat market.

The basic Edwards and Freebairn model is extended by considering the aggregate wheat market as consisting of separate segments for each type of wheat. For convenience, two segments (high quality and low quality) are considered. There is no aggregate world market for "wheat", since the types of wheat are considered essentially different commodities with different end-uses. Rather, two separate markets for different types of wheat are assumed. As in Edwards and Freebairn, the model is an annual static model.

Following Edwards and Freebairn (1982), it is important to distinguish between the producers affected ("Region") and the "rest of Australia" (ROA) which does not adopt the new variety. In the following, the term Region is used to denote those producers who will adopt the new variety in the given year. As defined, Region does not imply a geographical area, but rather a group of producers.

The two-segment model is illustrated in Figure 1. In each segment, there are separate markets for the Region and ROA, leading to an aggregate Australian supply, as well as for the "rest of World" (ROW) and "World" markets.

Using linear approximations to represent supply functions implies that supply curves derived from aggregating two component markets (*e.g.* Australia and World in Figure 1) have a kink, unless the price intercept is identical for each region (Edwards and Freebairn 1981, pp. 50-52). As a result, producer and consumer surpluses in these markets equal the sum of the surpluses in the component markets.

In this model, a change in quality resulting from a variety change can be represented as a shift in supply between markets. The effect of the replacement by producers of a low-quality variety with a high-quality variety is shown in Figure 1. In the low-quality segment (top panel), the Region's supply curve shifts upwards. This shifts the Australian and World supply curves upwards (assuming that the variety is not adopted in ROW) and induces a price rise for low-quality wheat. In the high-quality segment (bottom panel), the Region's supply curve (and hence the Australian and World supply curves) shifts downwards, as more producers enter the high-quality segment, inducing a price fall. The net result is that

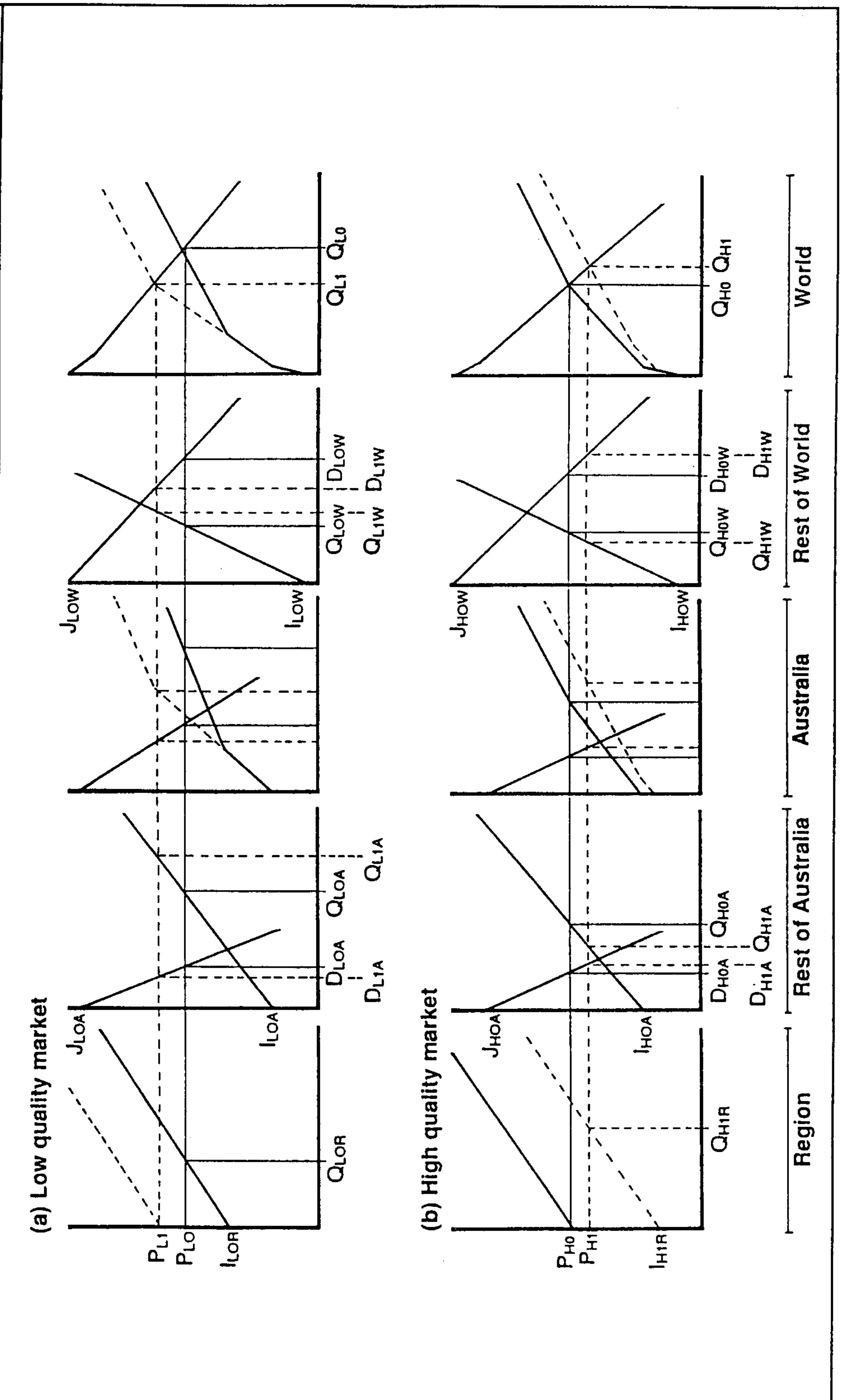

Figure 1: Two -segment Model for Australian Wheat

the difference in price between the two wheat types decreases. Since the Region is defined to include those who shift production, the demand curve for wheat in the Region is the infinitely elastic price line.

The extent of the shifts in the supply curves is determined by the definition of the Region. Since the Region is defined to include all and only those who adopt the new variety, the shift in supply is just sufficient for the Region to no longer produce that quality of wheat. Thus the supply curve shifts until its intercept is equal to the new equilibrium price. In the higher-quality segment, since no change in inputs or yield is assumed at this stage, the costs and therefore the same intercept as in the lower-quality segment will apply. Before the new variety, there was a "shadow" supply curve in the Region for high-quality wheat, with an intercept equal to or above the initial equilibrium price in that segment, since no high-quality wheat was produced. With the new variety, the shadow supply curve shifts downwards until the intercept equals that in the low-quality segment initially.

The effects on producer and consumer surplus are as follows: In the low-quality segment, consumer surplus in both Australia and ROW is reduced through the increase in price, while producer surplus is lower in Australia and higher in ROW. In the high-quality segment, consumer surplus in Australia and ROW increases, while producer surplus falls in ROW and is likely to increase in Australia. The net social benefit for Australia depends on the relative effect of the gains and losses to each group. The algebraic specifications for estimating these changes are shown in Appendix A.

An implicit assumption of the model is that there is no substitution in demand between the wheats of different qualities. There is an examination of the validity of this assumption, and its implications for the results, in section 4.3 below.

Empirical testing of the model requires a precise definition of supply and demand curves. The nature of the research-induced shifts in these curves can also be important. Lindner and Jarrett (1978) noted that the shift may be divergent for most biological innovations, as also argued by Griliches (1958) for hybrid corn. For simplicity, and following the approach of Edwards and Freebairn, parallel shifts are assumed in this paper. If the true shift is divergent, the results of this analysis may overstate the producer benefits.

3. Defining Supply and Demand Curves

A linear supply curve can be defined uniquely by the current equilibrium price and quantity in the market and the point elasticity at that equilibrium. This places great importance on the accuracy of the estimates of price, quantity and point elasticity. Problems with estimating elasticities include: (a) linear supply and demand curves imply different elasticities at each point on the curve, unless they pass through the origin (implying an elasticity of one); (b) elasticities derived from time series or other studies generally relate to mean outputs and mean prices over the sample period of the data; and (c) elasticities are only valid if prices, costs and levels of output of alternative enterprises correspond to those in the original studies. Further, it is difficult to obtain supply and demand elasticities for the different types of wheat for the segmented market.

In view of these difficulties, a different method of defining supply and demand curves was considered necessary. The equilibrium price and quantity define one point on the curve. One other point on the curve, namely the intercept on the price axis, can be identified with some degree of accuracy, in a regional application of this model. Sensitivity analysis can be used to test for the effect of errors in these estimates (see section 4.2).

3.1 Wheat supply curve

The supply curve consists of a "direct" marginal cost component (which also includes marketing as well as production costs) and a component of the marginal economic rent to land from the best alternative enterprise (Rose 1980). It is difficult to determine these components at a national level. Rose (1980, p. 837) considered:

> it is unlikely that any sensible measure of [the intercept], for a rent-free cost curve, could be made, and the critical shift [in the intercept] could therefore not be estimated. However, as suggested by Lindner and Jarrett (1978), it is possible to obtain some empirical estimate of the rent-free or rent-inclusive intercept on the vertical axis of the supply curve, provided supply curves are disaggregated to a regional basis.

In the following section, an estimate is made of the intercept of the supply curve for wheat in southern New South Wales. Even though these intercepts are crude approximations, any changes in welfare measured by gains or losses in producer surplus can be tested for sensitivity to the intercept chosen. Since the range of possible intercepts can be relatively well defined, the model will prevent the occurrence of anomalies and counter-intuitive results which can be obtained from determining the intercept from the equilibrium point and elasticity alone.

3.2 Estimating supply intercept

From regional gross margin budgets, an estimate of the minimum "direct" marginal costs (including marketing costs) per tonne can readily be estimated (see Appendix B). There are several ways of estimating the opportunity cost of wheat production; the analysis below follows the method suggested by Rose (1980). Because the supply of a commodity is a function of other commodity prices, opportunity costs reflect the marginal rent to land from alternative enterprises. These opportunity costs can also be estimated from regional gross margin budgets. From this information, the supply intercept (that is, the price at which the first tonne of wheat will be produced) can be estimated.

It is not possible to be certain of the relationship between "direct" marginal cost and opportunity cost. If the most efficient wheat producer (in terms of lowest marginal costs) is also very efficient at alternatives, such as barley, then the opportunity costs are likely to be relatively high for the low marginal cost producer. If, however, there is no correlation between "direct" marginal costs and opportunity costs (as may be the case with wool), then the low "direct" marginal cost producer may have average or low opportunity costs.

For the ROA sector, similar estimates can also be made of the "direct" marginal cost and opportunity cost components of the supply price intercept.

For the ROW sector, no information is available on the likely price intercept. Because wheat could be grown in subsistence areas with no marketing costs and low "direct" marginal and opportunity costs, the intercept was assumed to be zero. Thus, the ROW supply curve is specified to pass through the origin. This gives the ROW (and hence

World) supply curve a steeper slope than if there was a positive price intercept, and hence the price effect of a given quantity shift is greater. The welfare outcome of a variety which only shifts the Australian supply curve is generally unaffected by the intercept assumed for ROW.

3.3 Linearity or non-linearity

There is no *a priori* reason to assume a straight line joining the intercept and the equilibrium point. Indeed, there are some observations which suggest that supply curves are non-linear. For example, large areas of farmland have similar factor endowments, and could be expected to have similar "direct" marginal and opportunity costs. Thus, the supply curve could be expected to be relatively flat, with a large number of farms having similar cost structures. However, elasticity estimates imply a more steeply-sloping supply curve near the equilibrium point. A supply curve that was initially relatively flat at low levels of output but which became more steeply-sloping at higher production levels (as wheat was produced with different factor endowments) would be consistent with these observations. The possibility of a non-linear supply curve is not considered in this paper; for simplicity, linearity is assumed. This may introduce some specification bias, but it is assumed that the introduction of non-linearity is not necessary for the arguments and analysis developed here.

3.4 Wheat demand curve

While the current equilibrium point is one point on the demand curve that is readily observable, it is difficult to conceive of the price intercept for the demand curve. There appears to be no empirical basis for determining the price intercept of the demand curve, and no estimates are available of the price that consumers would be willing to pay for the first tonne of wheat on the market. Demand elasticities indicate that the Australian domestic demand curve for wheat is inelastic. The demand curve for this analysis was determined from the elasticity and the equilibrium point (as in Edwards and Freebairn). Subsequent analysis showed that the results obtained with shifts in supply curves are insensitive to the definition of demand curve, although the distribution of benefits can be affected.

4. New Wheat Variety

For the purposes of the empirical analysis, the world wheat market was assumed to be composed of four segments, comprising the following wheat types: Prime Hard (PH), Australian Standard White (ASW), General Purpose (GP) and Feed wheats.

Before using the model for analysing the effects of the release of a new variety, the initial equilibrium price and quantity and the supply price intercept for each segment need to be estimated. The assumptions made for each of the four market segments at their initial equilibrium situations before the release of a new variety are shown in Table 1. The supply intercept for ASW in southern New South Wales (NSW) was estimated to be $117 per tonne (see Appendix B), as follows:

Opportunity cost	$28 per tonne
Variable costs	$23 per tonne
Marketing costs	$66 per tonne.

Table 1: Assumptions for Initial Equilibrium

		PH[a]	ASW[a]	GP[a]	Feed
Price ($A/t)		176.00	166.00	163.25	121.00
Quantities supplied:					
- Region	(mt)	0.0	1.0	0.0	0.0
- ROA[a]	(mt)	4.3	6.5	3.0	0.7
- Australia	(mt)	4.3	7.5	3.0	0.7
- ROW[a]	(mt)	54.7	111.5	116.0	85.3
- World	(mt)	59.0	119.0	119.0	86.0
Quantities demanded:					
- Region	(mt)	0.0	0.0	0.0	0.0
- ROA	(mt)	0.7	0.7	0.0	0.7
- Australia	(mt)	0.7	0.7	0.0	0.7
- ROW	(mt)	58.3	118.3	119.0	85.3
- World	(mt)	59.0	119.0	119.0	86.0
Elasticity of demand:					
- Region		infinite	infinite	infinite	infinite
- ROA		-0.4	-0.4	-0.4	-1.7
- ROW		-0.4	-0.4	-0.4	-1.7
Price intercept of supply curve:					
- Region	($A/t)	176.00	114.00	163.25	121.00
- ROA	($A/t)	117.00	117.00	117.00	117.00
- ROW	($A/t)	0.00	0.00	0.00	0.00
Implied elasticity of supply at equilibrium:					
- Region		b	3.4	b	b
- ROA		3.0	3.4	3.5	30.3
- Australia		3.8	3.4	4.6	33.8
- ROW		1.0	1.0	1.0	1.0
- World		1.2	1.2	1.1	1.3

a: PH: Prime Hard; ASW: Australian Standard White; GP: General Purpose; ROA: Rest of Australia; ROW: Rest of World
b: no initial supply curve in Region

Sources:

Prices: 1984-85 prices (Australian dollars) for PH, ASW, GP and Feed wheat categories (Brennan and Benson 1986).

Quantities: World totals obtained from International Wheat Council, *World Wheat Statistics 1984*, for 1981-82. Estimated break-down for Australia based on data from Australian Wheat Board, *Annual Report*. Estimated break-down for ROW based on US and Canada data for PH, IWC data for feed, and arbitrary split for ASW and GP.

Demand elasticities: I. Shaw, Australian Bureau of Agricultural and Resource Economics (personal communication).

In the empirical analysis, the supply curve of the Region was assumed to have an intercept of \$117 per tonne. Since the Region was initially assumed to be able to grow only ASW wheats, the intercepts for the other quality segments in the Region were at or above the initial prices in those segments. ROA was also assumed, for convenience, to have an intercept of \$117 per tonne for all segments, while ROW was assumed to have an intercept of zero.

From these data, supply and demand curves are estimated. The implied elasticities of these curves at equilibrium are also shown in Table 1. These elasticities tend to be higher than those found in other studies, because of the flatter nature of the supply curves thus derived.

4.1 Empirical analyses

Four cases of possible new wheat varieties were analysed. They were chosen to represent the cases that could occur when new wheat varieties are being assessed. In each case, the new varieties were assumed to be adopted only in Australia. While it is evident that technology transfer, in the form of Australian varieties being adopted in other producing countries, could have an impact on the net welfare effects (Edwards and Freebairn 1984), varieties developed in Australia have generally not been widely grown overseas. Thus, it would be unlikely that an Australian variety would have sufficient impact on the ROW supply curve to alter the results obtained in this analysis.

The cases analysed were as follows: (1) increase in yield with no quality change, (2) increase in quality with no yield change, (3) small fall in quality with 5 per cent yield increase, and (4) large fall in quality with 20 per cent yield increase.

With a new variety of different quality, producers were assumed to be able to supply the different quality wheat. The supply curves shifted in both segments. As described in section 2, the ASW intercept shifts upwards until it is equal to the new price, since Region is defined to include all and only those who shift out of producing ASW. Without yield change (*i.e.* only quality is changed), the intercept in the other segment falls to the same level as it was initially for ASW.

Case 1: Increase in yield with no quality change

The first case examined is where a higher-yielding variety is adopted in the ASW segment in the Region, and nowhere else, so that the supply curve for that segment shifts downwards. A 10 per cent increase in yield in ASW in the Region is assumed.

For Case 1, the shift is 9.1 per cent of its initial equilibrium price (\$15.10 per tonne). The ASW price falls by \$0.28 per tonne (Table 2). The resultant welfare effects are a gain to the Region's producers of \$17.1 million, and overall gains of \$17.4 million in all sectors. Small gains occur in consumer surplus in ROA and ROW (and hence Australia and World), while producers in other regions lose, because of the fall in price. In ROA and ROW, the net effect is relatively small.

Case 2: Increase in quality with no yield change

The second case examined is where there is a higher-quality variety released, so that some producers in the ASW segment in Australia are able to produce PH wheat, and hence move

Table 2: Gains to Producers and Consumers: Cases 1 and 2 ($Am)

	Case 1	Case 2		
	ASW[a]	ASW[a]	PH[a]	Total
Gain to Region				
Producers	17.1	-24.5	32.9	8.4
Consumers	0.0	0.0	0.0	0.0
Total	17.1	-24.5	32.9	8.4
Gain to Rest of Australia				
Producers	-1.8	6.0	-9.4	-3.4
Consumers	0.2	-0.6	1.6	0.9
Total	-1.6	5.4	-7.9	-2.5
Gain to Australia				
Producers	15.3	-18.5	23.4	5.0
Consumers	0.2	-0.6	1.6	0.9
Total	15.5	-19.1	25.0	5.9
Gain to Rest of World				
Producers	-30.9	103.5	-121.6	-19.1
Consumers	32.8	-108.3	130.8	22.5
Total	1.9	-5.8	9.2	3.3
Gain to World				
Producers	-15.6	84.0	-98.2	-14.2
Consumers	33.0	-108.9	132.3	23.4
Total	17.4	-25.0	34.2	9.2
Fall in equilibrium price ($A/t)	0.28	-0.92	2.24	

a: See Table 1 for definition of abbreviations.
Note: Totals may not add exactly due to rounding errors.

into another (higher-quality) segment. The Region's ASW supply curve shifts upwards, and the shadow PH supply curve in the Region (which was not formerly producing PH wheat) shifts downwards until the intercept is $117 per tonne as in the ASW segment initially. The supply curves for Australia and World also shift in the ASW segment because of these shifts.

If one million tonnes of ASW production in the Region is replaced, the ASW price increases by $0.92, and the price in the PH segment falls by $2.24. The resultant welfare effects (Table 2) are a $24.5m loss for the Region's producers in the ASW segment and a gain of $32.9m in the PH segment. The net result is an overall gain of $8.4m for Australian producers, and $9.2m gain over all sectors. There is a small net loss for ROA and a small net gain for ROW.

Case 3: Small fall in quality with 5 per cent yield increase

The third case examined is where a higher-yielding, lower-quality (GP) milling wheat replaces a higher-quality (ASW) milling wheat variety. The ASW supply curve in the Region shifts upwards, as in Case 2, and the Region's shadow GP supply curve shifts downwards. The downward shift has two components: (a) the quality shift (equivalent to Case 2), where the new intercept in GP is the same as the initial ASW intercept, and (b) where the GP intercept is lowered because of the increase in yield (as in Case 1). With a 5 per cent yield increase, the GP intercept falls to $117 per tonne with the quality shift, and then falls by a further $7.77 (4.8 per cent of the equilibrium price $163.25) to $109.23 per tonne because of the yield increase. The Australian and World supply curves also shift because of these shifts.

If one million tonnes of ASW production in the Region is replaced, the ASW price increases by $0.92, as in Case 2, while in the GP segment the price falls by $1.01 per tonne. The resultant welfare effects (Table 3) are a $24.5m loss for the Region's producers in the ASW segment (as in Case 2) and a gain of $28.7m in the GP segment. The net result is a gain of $4.2m for the Region's producers, and a similar overall gain over all sectors, as gains in ROA are offset by losses in ROW. In short, the 5 per cent yield gain is more than sufficient to offset the lower price received for GP wheat.

Case 4: Large fall in quality with 20 per cent yield increase

The fourth case examined is where a high-yielding Feed quality wheat variety is released to replace a higher-quality (ASW) milling wheat. This is shown as a shift from the ASW segment to the Feed segment. The ASW supply curve in the Region shifts upwards (as in Case 2), while the Region's Feed wheat supply curve shifts downwards. As in Case 3, the Feed wheat supply curve intercept in the Region falls to $117 per tonne with the change in quality, and a further $20.17 (16.7 per cent of $121.00, the initial Feed price) with the change in yield.

The ASW price increases by $0.92 per tonne, while the price in the Feed segment falls by $0.23 per tonne. The resultant welfare effects (see Table 3) are a loss of $24.5m for the Region's producers in ASW (as in Cases 2 and 3) and a gain of $5.8m in the Region's Feed segment. There is a net loss to Region's producers of $18.7m, since the gains in the Feed segment are markedly lower than the loss in the ASW segment. Overall, the net loss is $19.1m to all sectors. In short, the 20 per cent yield gain is not sufficient to offset the lower price received for Feed wheat. The net loss of welfare in the ROW offset the gains in ROA.

4.2 Sensitivity analysis

A sensitivity analysis was carried out to test the model for changes in the supply and demand intercepts (Table 4). Only the results for the gains to the Region's producers are reported, since they are the dominant influence on the net overall gains. The initial equilibrium is given in each market segment (within the confines of data availability). In addition to assumptions about linearity, the assumption about the level of the intercept is also critical to the results. Accordingly, tests were made of supply intercepts 20 per cent above and below the base levels in each market. While the gains and losses in each segment were found to vary with the different intercepts (Table 4), the net effect of shifts between segments was similar at all levels of supply intercept.

The model was further tested for changes in demand elasticities. Tests were made of elasticities above and below the base levels. The results for shifts in supply were insensitive to the demand elasticities (Table 4), although the distribution of benefits between producers and consumers in ROW was affected.

Table 3: Gains to Producers and Consumers: Cases 3 and 4 ($Am)

	Case 3			Case 4		
	ASW[a]	GP[a]	Total	ASW[a]	Feed	Total
Gain to Region						
Producers	-24.5	28.7	4.2	-24.5	5.8	-18.7
Consumers	0.0	0.0	0.0	0.0	0.0	0.0
Total	-24.5	28.7	4.2	-24.5	5.8	-18.7
Gain to Rest of Australia						
Producers	6.0	-3.0	3.0	6.0	-0.2	5.9
Consumers	-0.6	0.0	-0.6	-0.6	0.2	-0.5
Total	5.4	-3.0	2.4	5.4	0.0	5.4
Gain to Australia						
Producers	-18.5	25.7	7.2	-18.5	5.7	-12.8
Consumers	-0.6	0.0	-0.6	-0.6	0.2	-0.5
Total	-19.1	25.7	6.5	-19.1	5.8	-13.3
Gain to Rest of World						
Producers	102.5	-117.2	-14.8	102.5	-19.9	82.5
Consumers	-108.3	120.8	12.5	-108.3	20.0	-88.3
Total	-5.8	3.6	-2.3	-5.8	0.1	-5.8
Gain to World						
Producers	84.0	-91.6	-7.6	84.0	-14.2	69.7
Consumers	-108.9	120.8	11.9	-108.9	20.1	-88.8
Total	-25.0	29.2	4.3	-25.0	5.9	-19.1
Fall in equilibrium price ($A/t)	-0.92	1.01		-0.92	0.23	

a: See Table 1 for definition of abbreviations.
Note: Totals may not add exactly due to rounding errors.

The results indicate that the size of the total welfare gains are influenced to a relatively minor extent by substantial changes in the supply price intercept, but that they are influenced very little by changes in the demand elasticities.

4.3 Demand substitutability

The analysis presented in this paper depends on the assumption that there is no substitutability in demand between the different wheat types. Thus, in Case 2 for example, the ASW price increases while the PH price decreases. Where there is substitutability between

Table 4: Sensitivity to Supply Intercepts and Demand Elasticities (Gains to producers in Region, $Am)

	Case 1			Case 2		
Demand elasticity	-0.2	-0.4	-0.5	-0.2	-0.4	-0.5
ASW[a] Supply intercept:						
$93.60	16.4	16.4	16.4	7.8	8.2	8.3
$117.00	17.0	17.1	17.1	8.0	8.4	8.5
$140.40	18.7	18.8	18.8	8.5	8.9	9.0
	Case 3			**Case 4[b]**		
Demand elasticity	-0.2	-0.4	-0.5	-0.2	-0.4	-0.5
ASW[a] Supply intercept:						
$93.60	4.0	4.1	4.2	-20.9	-20.8	-20.7
$117.00	4.0	4.2	4.2	-18.7	-18.7	-18.6
$140.4	4.1	4.3	4.4	-12.8	-12.8	-12.8

a: ASW: Australian Standard White.

b: Demand elasticities shown relate to ASW. Equivalent demand elasticities for Feed wheat taken as -0.7, -1.7 and -3.0 respectively (Source: I. Shaw, Australian Bureau of Agricultural and Resource Economics, personal communication).

wheats, the buyers of ASW could shift from ASW to either PH or GP, as both are now more price-competitive with ASW. This substitution would shift both demand curves. Thus there would be second round effects of shifts in demand in response to the changes in price that result from the initial shifts in supply. Thus, the effect of substitutability would be seen through shifts in the demand curve to at least partly restore the initial price differentials.

In principle, it is desirable to include these effects in the model. However, there is no ready method of examining the impact of such substitution in demand. The nature of the demand shift and the extent of it in each segment cannot be determined from known parameters. The magnitude of gains or losses in each segment are reduced if substitution is allowed, since the price change is lower than if there is no substitution in demand. However, it is not possible to determine the net effect across segments using the model, because the magnitude of the gains in one segment relative to the losses in the other are not known.

Of course, this partial analysis does not address the distributive effects of substitutability. An examination of these distributive effects would require a detailed specification of the nature of the substitutability and the nature of the subsequent shifts in demand. While such an examination may reveal the need for improved specification of this model in analysing major supply shifts, it is less likely to be important where the impact of a single wheat variety is being analysed. The shift in supply resulting from a single variety released in Australia would be unlikely to shift the world supply curve to such an extent that the price effects led to measurable flow-on effects in the other segments of the market for different quality wheats.

5. Conclusions

Practical methods of applying the Edwards and Freebairn model to *ex ante* evaluation of wheat varieties prior to their release were examined, with particular reference to the manner of assessing questions of different quality wheats. This analysis is a step towards developing a means of evaluating new wheat varieties and providing a ranking of alternative varieties on the basis of their quality and yield characteristics, and of incorporating quality-yield trade-offs into the analysis.

The methods of analysis described in this paper departed from the Edwards and Freebairn model in two respects. First, in the method of defining supply curves, and second, in allowing for different market segments to account for different wheat qualities. Estimates were made of the intercept of the supply curve on a regional basis. Estimates of the price intercept and equilibrium levels provide a better definition of the supply curve, and therefore of the changes in producer surplus where the supply curve shifts, than a method of defining supply curves from the point elasticities at the equilibrium level.

The results of empirical testing of hypothetical varieties indicate that Australian society, and producers in particular, can make gains in welfare through the release of higher-yielding varieties. Smaller gains are available from varieties which have higher quality at the same yield.

Further, the empirical analysis indicated that there is a potential for net gains to Australian producers (and to Australian society as a whole) from the production of wheat varieties which are higher yielding but have lower quality, provided the wheat meets quality standards for the GP category. These varieties are not currently approved for release by the regulating authorities in the wheat-growing States. In the empirical analysis, varieties of feed quality with yield increases of 20 per cent led to an overall loss of welfare. The results were not found to be sensitive to assumptions about demand elasticities or supply intercepts.

The implications of these findings for policies on the release of new wheat varieties are that any evaluation system which does not permit the benefits from higher yields to be offset against the losses from lower quality wheat may lead to lower levels of overall welfare in Australia, and to lower levels of producer welfare in particular, than could have been obtained. These results point to the need to examine variety evaluation and release procedures to ensure that appropriate economic evaluation is carried out before varieties with the potential to increase overall welfare are rejected.

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Appendix A

Calculating Welfare Effects of Shift from Low- to High-Quality Wheat Variety

A.1 Producer Surplus

Region

(a) Initial situation

In the low-quality segment, initial supply price intercept = I_{L0R}, initial equilibrium price = P_{L0}, and initial quantity produced = Q_{L0R}. Thus, initial producer surplus = $0.5(P_{L0} - I_{L0R})Q_{L0R}$.

In the high-quality segment, initial supply price intercept at or above price, so no production and producer surplus zero.

(b) After the new variety

In the low-quality segment, supply intercept equal to new equilibrium price, so production and producer surplus zero.

In the high-quality segment, supply price intercept = I_{H1R}, price = P_{H1} and quantity = Q_{H1R}, so producer surplus = $0.5(P_{H1}-I_{H1R})Q_{H1R}$.

(c) Gains in producer surplus

Gains in producer surplus = Gain in high-quality segment + Gain in low-quality segment = $0.5(P_{H1}-I_{H1R})Q_{H1R} - 0.5(P_{L0} - I_{L0R})Q_{L0R}$.

Rest of Australia

(a) Initial situation

In the low-quality segment, initial supply price intercept = I_{L0A}, initial equilibrium price = P_{L0}, and initial quantity produced = Q_{L0A}. Thus, initial producer surplus = $0.5(P_{L0} - I_{L0A})Q_{L0A}$.

In the high-quality segment, initial supply price intercept = I_{H0A}, initial equilibrium price = P_{H0}, and initial quantity produced = Q_{H0A}. Thus, initial producer surplus = $0.5(P_{H0} - I_{H0A})Q_{H0A}$.

(b) After the new variety

In the low-quality segment, supply price intercept = I_{L1A}, price = P_{L1} and quantity = Q_{L1A}, so producer surplus = $0.5\,(P_{L1}-I_{L1A})Q_{L1A}$.

In the high-quality segment, supply price intercept = I_{H1A}, price = P_{H1} and quantity = Q_{H1A}, so producer surplus = $0.5(P_{H1}-I_{H1A})Q_{H1A}$.

(c) Gains in producer surplus

Gains in producer surplus = Gain in low-quality segment + Gain in high-quality segment
$= 0.5(P_{L1}-I_{L1A})Q_{L1A} - 0.5(P_{L0}-I_{L0A})Q_{L0A}$
$+ 0.5(P_{H1}-I_{H1A})Q_{H1A} - 0.5(P_{H0}-I_{H0A})Q_{H0A}$.

Australia

Gains in producer surplus = Gains in Region + Gains in Rest of Australia.

Rest of World

Calculated in same manner as Rest of Australia.

World

Gains in producer surplus = Gains in Australia + Gains in Rest of World.

A.2 Consumer Surplus

Region

Infinitely elastic demand curve in Region, so no consumer surplus.

Rest of Australia

(a) Initial situation

In the low-quality segment, initial demand price intercept = J_{L0A}, initial equilibrium price = P_{L0}, and initial quantity demanded = D_{L0A}. Thus, initial consumer surplus = $0.5(J_{L0A} - P_{L0})D_{L0A}$.

In the high-quality segment, initial demand price intercept = J_{H0A}, initial equilibrium price = P_{H0}, and initial quantity demanded = D_{H0A}. Thus, initial consumer surplus = $0.5(J_{H0A} - P_{H0})D_{H0A}$.

(b) After the new variety

In the low-quality segment, demand price intercept = J_{L1A}, price = P_{L1} and quantity demanded = D_{L1A}, so consumer surplus = $0.5(J_{L1A}-P_{L1})D_{L1A}$.

In the high-quality segment, demand price intercept = J_{H1A}, price = P_{H1} and quantity demanded = D_{H1A}, so consumer surplus = $0.5(J_{H1A}-P_{H1})D_{H1A}$.

(c) Gains in consumer surplus

Gains in consumer surplus = Gain in low-quality segment + Gain in high-quality segment
= $0.5(J_{L1A}-P_{L1})D_{L1A} - 0.5(J_{L0A}-P_{L0})D_{L0A}$
+ $0.5(J_{H1A}-P_{H1})D_{H1A} - 0.5(J_{H0A}-P_{H0})D_{H0A}$.

Australia

Gains in consumer surplus = Gains in Region + Gains in Rest of Australia.

Rest of World

Calculated in same manner as Rest of Australia.

World

Gains in consumer surplus = Gains in Australia + Gains in Rest of World.

Appendix B

Estimation of Supply Price Intercepts in Southern New South Wales

B.1 "Direct" Marginal Costs

The "direct" marginal production costs can be equated with the variable costs of a farmer, as the variable costs generally relate to the additional cost of producing one extra unit of wheat. The variable costs per tonne of wheat may vary considerably within a region with changes in inputs and in yields per hectare. For example, even with the same variable costs per hectare of $69 (Godyn and Reilly 1986), at yields of 3 tonnes per hectare the variable cost is $23 per tonne, and at 1 tonne per hectare it is $69 per tonne.

When market prices are used, marketing costs form part of marginal costs. The average marketing costs (cartage, freight, handling, storage, and Australian Wheat Board charges) in southern NSW were in the order of $66 per tonne in 1984-85 (Brennan and Benson 1986). This varies between regions, but is likely to be relatively constant throughout a geographically small, relatively homogeneous region.

B.2 Opportunity Cost

A second component of the supply curve is opportunity cost or economic rent on land. Rose (1980) stated that whenever there are two competing users for land, the supply curve must include a marginal rent to land in addition to non-land costs. Beck *et al.* (1986, pp. 5-6) pointed out that "The rent component of price will be greatest when competitive enterprises are important".

There are several ways of estimating the opportunity cost of wheat production. This analysis follows the method suggested by Rose (1980) that, because the supply of a commodity is a function of other commodity prices, opportunity costs reflect the marginal rent to land from alternative enterprises. For most of southern NSW, the major alternative to wheat would be barley or wool. Gross margins at average yields for the south-west slopes (Godyn and Reilly 1986) were wheat $138 per hectare, barley $64 per hectare and $14 per wether for wool (which translated to $140 per hectare at an average stocking rate of 10 wethers per hectare). On the basis of these figures, the opportunity costs of producing wheat were $64 per hectare (barley) and $140 per hectare (wool). At average wheat yields of 2.3 tonnes per hectare, these translated to opportunity costs per tonne of wheat of $28 per tonne (barley) and $61 per tonne (wool). On the basis of these figures, wool has a higher opportunity cost. However there are other costs involved in adjusting from wheat to wool, while adjustment costs from wheat to barley are close to zero. In the empirical analysis, barley was taken as the alternative to wheat, implying opportunity costs of $28 per tonne.

It is possible that the returns from the next most profitable enterprise are highly correlated with the returns from wheat (this would be expected in the case of barley, for example). In that case, the land rent component would be correlated with the "direct" marginal costs of wheat. Where the next most profitable alternative was wool, its net returns are unlikely to be highly correlated with the "direct" marginal costs for wheat, so that the land rent component would be independent of the level of marginal costs for wheat production.

B.3 Estimating the Supply Intercept

From the above, the intercept (that is, the price at which the first tonne of wheat will be notionally produced) can be estimated. Given marketing costs, the intercept will be at least $66 per tonne. The marginal costs of the "first" tonne are likely to be at least $23 per tonne, based on variable costs of $69 per hectare and maximum yields of 3.0 tonnes per hectare. As outlined above, it is not possible to be certain of the relationship between "direct" marginal cost and opportunity cost. If the most efficient wheat producer (in terms of lowest "direct" marginal costs) is also very efficient at alternatives, such as barley, then the opportunity costs are likely to be relatively high for the low marginal cost producer. If, however, there is negative or no correlation between marginal costs and opportunity costs (as may be the case with wool), then the low marginal cost producer may have average or low opportunity costs. In any case, the total of "direct" marginal and opportunity costs can be expected to be greater than the minimum "direct" marginal cost. Thus, the minimum total costs will be $23 per tonne, and the estimated minimum intercept will be $89 per tonne when marketing costs are included.