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Who gains from Australian generic wine promotion and R&D?*

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The present paper estimates the distributions of aggregate returns from different types of research and promotion investments by the Australian grape and wine industry among grapegrowers, winemakers, domestic and foreign consumers, and the tax office. The results show that most of the gains from cost-reducing R&D in grape and wine production go to producers and that producers get a far larger share of the benefit from export promotion than that from domestic promotion. Foreign consumers of Australian wine also enjoy a significant share of the benefits from Australian R&D. Sensitivity analysis shows that the key results hold for a wide range of parameter values.

1. Introduction

During the latter half of the 20th century, the wine industry in many parts of the world has gradually become more professional in its approach to investing both in research and development (R&D) and in promotion. This has been particularly pronounced in the New World as the industry has corporatized and large firms have emerged,¹ and as export-orientated output has expanded.² Brand-level promotion can be, and is, undertaken by

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¹ The shares of national wine production held by the top five firms in 2000 are as follows: Australia 68%, New Zealand 80%, USA 73%, Argentina 50% and Chile 47%. In contrast, they are much lower in the Old World, where small cooperatives still dominate: 13% in France (excluding Champagne), 10% in Spain and 5% in Italy (Anderson *et al.* 2003).

² Between 1988 and 1999, wine production grew at 5.3% per year in Australia, 2.8% in the USA, 2.4% in Chile and Uruguay and 2.0% in New Zealand; the share of global wine production that is exported rose from 15 to 25% (Anderson and Norman 2001, tables 11 and 32).

large and medium firms, but because most firms are small, even in the USA and Australia, many cannot afford mass media promotion campaigns. They therefore depend on generic promotion of their nation and region of origin. With respect to R&D, even large firms, let alone small ones, cannot, on their own, justify undertaking much large-scale research. In addition, the public good nature of both research and generic promotion is such that there is underinvestment unless these activities are funded collectively. Hence, grapegrowers and winemakers in countries such as Australia agree to pay a production-based annual levy to fund both these activities. The Australian Government supplements those funds, matching them in the case of R&D on a dollar-for-dollar basis up to 0.5% of the value of production.

Specifically, R&D via Australia's Grape and Wine Research and Development Corporation (GWRDC) is currently funded by a levy of \$5 per tonne of grapes (\$2 per tonne from grapegrowers on grapes received by wineries and \$3 per tonne from wineries on the weight of grapes crushed for wine), which is matched by a similar grant from the Federal Government. There has been a significant increase in real dollar terms in the grape and wine R&D expenditure since the early 1980s as a result of industry expansion and past increases in the levy rate. The annual R&D expenditure for 2001–2002 reached \$13 million in nominal terms (GWRDC 2001). However, the producer proportion of that represents only approximately 0.3% of the value of production, well below the 0.5% limit to which matching government funding applies. Proposals are currently being considered by producers to raise the industry R&D levy and, possibly, to move to an *ad valorem* levy system. This would ensure the funding level moves with the product price as quality rises over time and/or as supply growth depresses some prices. The support for such a rise has been boosted by a recent benefit–cost study suggesting that the current portfolio of GWRDC research projects is expected to yield a 9 : 1 benefit/cost ratio and that a sample of past projects yielded ratios ranging from 7 : 1 to 76 : 1 (McLeod 2002).

Generic national promotion abroad is funded by a Federal Government grant plus a compulsory wine export levy based on the freight on board value of wine exported (0.2% of an exporter's first \$10 million of sales, 0.1% for the next \$40 million and 0.05% for sales beyond \$50 million per year). The manager of those funds and provider of promotion is the Australian Wine and Brandy Corporation (AWBC; AWBC 2001). Generic regional promotion is funded by voluntary membership of regional associations.

How should these funds be allocated and who benefits from the investment of the funds? Grape growers, winemakers and the government, on behalf of taxpayers and domestic consumers, are all interested in maximising the pay-offs from their investments. Issues of interest to various parties include

the returns from research versus promotion, from R&D for grapes versus for wine, from cost-reducing R&D versus quality-enhancing R&D and from domestic promotion versus export promotion. Both the aggregate returns from these broad types of investments and the distributions of total returns among groups, such as premium and non-premium grape growers, premium and non-premium winemakers, domestic retailers, taxpayers and domestic and overseas consumers, are of interest. For example, to what extent do premium producers benefit relative to producers of lower-quality wine? How do these outcomes change as the industry becomes more export orientated?

The distributional issue also relates to the question of who should pay for what types of investments: not only as between government and producers, but also as between grape growers and wineries. Just as the benefits from a new technology in one sector of an industry are distributed across all related producer and consumer groups, the costs of the R&D nominally paid by a producer group are also shared by various parties along the chain. For example, are the grape growers paying a larger share of the costs than their shares of R&D benefits? While the non-premium grape and wine producers pay a significant amount of the tonnage-based R&D levy, most of the funded R&D projects are targeted at premium grapes and wine. Are the non-premium producers paying more than their fair share? In addition, the impacts on the government treasury via both the Wine Equalisation Tax (WET) and the Goods and Services Tax (GST) from alternative investment choices are also relevant.

This Australian case study is particularly timely because of the planned increase in levy rate (proposed for 2003–2004) and a recently launched new marketing drive (WFA and AWBC 2001). As recent modelling results demonstrate (Anderson 2003; Anderson *et al.* 2003), the latter is going to be essential when the industry is in a vulnerable position due to the recent boom in plantings, which is translating into ever-greater supplies of premium wines on the international market.

The present paper aims to address these questions. The published literature on the economic evaluation of research and promotion expenditures is growing rapidly (Alston *et al.* 1995, 2002; Byerlee and Anderson 2002). One of the approaches has been the use of a partial equilibrium, comparative static framework to measure the effects on economic welfare within an industry (Freebairn *et al.* 1982; Wohlgenant 1993; Alston *et al.* 1999; Zhao *et al.* 2000b). This approach is adopted in the present paper because of its convenience in modelling disaggregated industry sectors and its moderate data requirements.³ We use a multisectoral partial equilibrium model of the

³ An alternative approach is to use an economy wide, general equilibrium model (see, for example, Anderson and Nielsen 2002); however, this model is inappropriate for an industry as small as the wine industry with few close substitutes in production or consumption.

markets for two types of Australian grapes and wine (premium and non-premium) to study the distributions of returns from different types of research and promotion investments. The distinction between premium and non-premium is crucial, because one-third of the market is non-premium and, yet, virtually all the R&D and marketing efforts are focused on just premium products in an attempt to raise quality as consumers continue to move upmarket.

Previous studies have shown that welfare distribution hinges crucially on input substitution possibilities in the post-farm sectors. Freebairn *et al.* (1982) conclude that if farm inputs and processing inputs are used in strictly fixed proportions in the processing sector, the distribution of returns among industry groups is the same, regardless of where along the chain funds are invested in R&D or promotion. However, Alston and Scobie (1983) show that when input substitution is possible, each sector receives a larger share of total benefits from investment in its own sector. In this case, farmers receive a larger share of returns from farm research than from post-farm research and promotion. Furthermore, Alston and Scobie (1983) show that farmers can even lose welfare from post-farm research if the input substitution elasticity is bigger in size than the demand elasticity for the retail product. Using a model involving two post-farm sectors, namely processing and marketing/distribution, Holloway (1989) showed further that the benefits to farmers also depend on the post-farm stage to which the research is directed. He derived analytical conditions in terms of market elasticities that are necessary and sufficient for the farmers to gain from various types of post-farm research. With this in mind, another objective of the present paper is to investigate the implication of the uncertainty in the values of many market elasticities for the returns to growers from alternative investments, including the possibility of growers losing welfare from wine research, in a vertically, as well as horizontally, disaggregated industry.

The model is presented first and the data and market parameters are described next. Results are then presented, followed by a section on sensitivity analysis of the results to changes in key elasticities. Discussion of the implications and related issues is provided in the final section of the present paper.

2. The model

The structure of the model of the Australian grape and wine industry is provided in figure 1, where each rectangle represents a production function and each arrowed straight line represents the market for a product, with the arrowed end being the demand and the non-arrowed end being the supply of the product. Each oval represents a supply or demand schedule where an exogenous shift may occur.

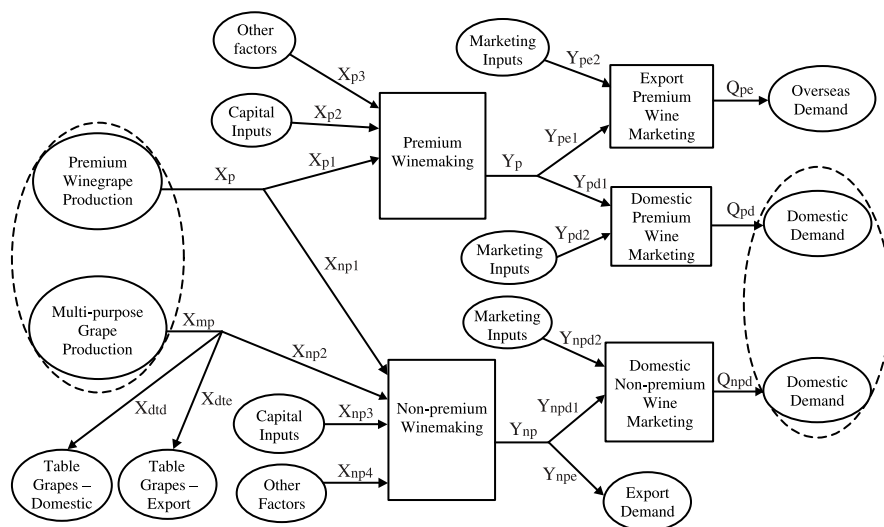


Figure 1 Structure of the model.

Vertically, the industry is separated into the sectors of grape production, winemaking, wine marketing and final consumption. This enables us to study impacts of R&D and promotion investments on individual parts of the chain. Horizontally, the industry is disaggregated into premium and non-premium wine sectors. Grapes are divided into premium and multi-purpose (non-premium). Grapes for uses other than winemaking account for only one-tenth of total usage. Sultana accounts for two-thirds of multi-purpose grapes and approximately 5% of grape inputs into wine production. No reported variety is used exclusively for non-wine purposes so, for simplicity, we classify non-premium and multipurpose grapes as the same input (ABS 2001).

We assume that all sectors are profit maximisers and the technologies are characterised by constant returns to scale.⁴ A set of demand and supply equations with general functional form is used to describe the relationships among various industry links in the chain (equations 1–37). The impacts of alternative R&D and promotion investments are modelled as 15 exogenous variables that shift the relevant supply or demand curves, and the changes in prices and quantities resulting from new technologies or promotion are

⁴ For an industry such as this, which has more than 1400 wineries and thousands more grape-growers of varying sizes, Diewert (1981) has shown that under very weak regularity conditions it is reasonable to assume that the industry's aggregate production function can be approximated by constant returns to scale.

then solved to obtain the welfare implications for various industry groups. Variable notation is also shown in figure 1.

2.1 Input supply to the premium and non-premium wine sectors

$$X_p = X_p(w_p, w_{mp}, T_{Xp}, T_{Xmp}) \quad (1)$$

$$X_p = X_{p1} + X_{np1} \quad (2)$$

$$X_{p2} = X_{p2}(w_{p2}, T_{Xp2}) \quad (3)$$

$$X_{p3} = X_{p3}(w_{p3}, T_{Xp3}) \quad (4)$$

Equation 1 is the supply function for premium wine grapes, relating total quantity supplied X_p to own price w_p and the price of multipurpose grapes w_{mp} . In other words, it is assumed that the premium grape growers can shift some of the production to multipurpose grapes, through grafting for example, in response to changes in the relative prices of the two types of grapes. T_{Xp} and T_{Xmp} are the supply shifters representing the impacts of new technologies that reduce the costs of producing premium and non-premium grapes, respectively. The identity given in equation 2 shows that the premium grapes can be used for producing either premium wine (X_{p1}) or non-premium wine (X_{np1}). Equations 3 and 4 are supply functions for two other aggregated inputs to premium wine production. X_{p2} represents fixed capital, human capital and other inputs that are specific to premium wine making. Supplies of these inputs are relatively inelastic because they require specific skills that take time to supply. X_{p3} represents mobile factors, such as labour, chemical and other factor inputs, that are non-specific to premium wine making. Supply of these inputs is much more elastic. T_{Xp2} and T_{Xp3} are supply shifters for X_{p2} and X_{p3} , respectively. T_{Xp2} can be used to represent technical changes in the premium wine making sector.

$$X_{mp} = X_{mp}(w_{mp}, w_p, T_{Xp}, T_{Xmp}) \quad (5)$$

$$X_{mp} = X_{np2} + X_{dtd} + X_{dte} \quad (6)$$

$$X_{np3} = X_{np3}(w_{np3}, T_{Xnp3}) \quad (7)$$

$$X_{np4} = X_{np4}(w_{np4}, T_{Xnp4}) \quad (8)$$

Equation 5 is the supply of multipurpose grapes relating the quantity supplied to own price and the price of premium grapes, with T_{Xp} and T_{Xmp} as

the supply shifters. Prices for multipurpose grapes used for non-premium winemaking and for fruit are assumed to be the same w_{mp} . Equation 6 shows that multipurpose grapes can be used either for non-premium wine production or as dried and table grapes for domestic (X_{dtd}) or export (X_{dte}) markets. Equations 7 and 8 are supply functions for capital inputs (X_{np3}) and mobile inputs (X_{np4}), respectively, into non-premium wine production, with T_{Xnp3} and T_{Xnp4} as supply shifters.

2.2 Demand for table grapes

$$X_{dtd} = X_{dtd}(w_{mp}, N_{Xdtd}) \quad (9)$$

$$X_{dte} = X_{dte}(w_{mp}, N_{Xdte}) \quad (10)$$

Equations 9 and 10 are demand schedules for dried and table grapes for domestic (X_{dtd}) and export (X_{dte}) markets, respectively. N_{Xdtd} and N_{Xdte} are the respective demand shifters.

2.3 Output-constrained input demand of the premium wine sector

$$X_{p1} = Y_p^* c'_{Yp,1}(w_p, w_{p2}, w_{p3}) \quad (11)$$

$$X_{p2} = Y_p^* c'_{Yp,2}(w_p, w_{p2}, w_{p3}) \quad (12)$$

$$X_{p3} = Y_p^* c'_{Yp,3}(w_p, w_{p2}, w_{p3}) \quad (13)$$

The above three equations 1, 12 and 13 are the output-constrained input demand for X_{p1} , X_{p2} and X_{p3} , derived using Shephard's Lemma (Chambers 1991, p. 262). $c'_{Yp,i}(w_p, w_{p2}, w_{p3})$ ($i = 1, 2, 3$) are partial derivatives of the unit cost functions $c_{Yp}(w_p, w_{p2}, w_{p3})$ ($i = 1, 2, 3$).

2.4 Output-constrained input demand of the non-premium wine sector

$$X_{np1} = Y_{np}^* c'_{Ynp,1}(w_p, w_{mp}, w_{np3}, w_{np4}) \quad (14)$$

$$X_{np2} = Y_{np}^* c'_{Ynp,2}(w_p, w_{mp}, w_{np3}, w_{np4}) \quad (15)$$

$$X_{np3} = Y_{np}^* c'_{Ynp,3}(w_p, w_{mp}, w_{np3}, w_{np4}) \quad (16)$$

$$X_{np4} = Y_{np}^* c'_{Ynp,4}(w_p, w_{mp}, w_{np3}, w_{np4}) \quad (17)$$

Equations 14–17 are the output-constrained input demand for non-premium wine production, also derived using Shephard's Lemma. $c'_{Y_{np,i}}(w_p, w_{mp}, w_{np3}, w_{np4})$ ($i = 1, \dots, 4$) are partial derivatives of the unit cost functions $c_{Y_{np}}(w_p, w_{mp}, w_{np3}, w_{np4})$ ($i = 1, \dots, 4$).

2.5 Market-clearing condition/supply of premium and non-premium wholesale wine

$$V_p = c_{Y_p}(w_p, w_{p2}, w_{p3}) \quad (18)$$

$$V_{np} = c_{Y_{np}}(w_p, w_{mp}, w_{np3}, w_{np4}) \quad (19)$$

The aforementioned market-clearing conditions specify that unit prices for outputs equal the unit costs of production at the margin.

2.6 Destination of wine at the cellar door

$$Y_p = Y_{pd1} + Y_{pe1} \quad (20)$$

$$Y_{np} = Y_{npd1} + Y_{npe} \quad (21)$$

Equations 20 and 21 show that both premium and non-premium producer wines are destined for either domestic and export markets.

2.7 Supply of wine marketing inputs

$$Y_{pd2} = Y_{pd2}(v_{pd2}, T_{Y_{pd2}}) \quad (22)$$

$$Y_{pe2} = Y_{pe2}(v_{pe2}, T_{Y_{pe2}}) \quad (23)$$

$$Y_{npd2} = Y_{npd2}(v_{npd2}, T_{Y_{npd2}}) \quad (24)$$

Equations 22–24 show that the supplies of marketing inputs (Y_{pd2} , Y_{pe2} and Y_{npd2}) relate to own prices (v_{pd2} , v_{pe2} and v_{npd2}) and other supply shifters ($T_{Y_{pd2}}$, $T_{Y_{pe2}}$ and $T_{Y_{npd2}}$), such as R&D, in marketing sectors. These include any technical changes that reduce marketing margins, such as new technologies with lower packaging costs, internet selling or labour market reforms in the retailing sector.

2.8 Output-constrained input demand of the wine marketing sectors

$$Y_{pd1} = Q_{pd}^* c'_{Qpd,1}(v_p, v_{pd2}) \quad (25)$$

$$Y_{pd2} = Q_{pd}^* c'_{Qpd,2}(v_p, v_{pd2}) \quad (26)$$

$$Y_{pe1} = Q_{pe}^* c'_{Qpe,1}(v_p, v_{pe2}) \quad (27)$$

$$Y_{pe2} = Q_{pe}^* c'_{Qpe,2}(v_p, v_{pe2}) \quad (28)$$

$$Y_{npd1} = Q_{npd}^* c'_{Qnpd,1}(v_{np}, v_{npd2}) \quad (29)$$

$$Y_{npd2} = Q_{npd}^* c'_{Qnpd,2}(v_{np}, v_{npd2}) \quad (30)$$

These are the output-constrained input demand for the three marketing sectors based on Shephard's Lemma.

2.9 Market-clearing condition for the marketing sectors

$$p_{pd} = c(v_p, v_{pd2}) \quad (31)$$

$$p_{pe} = c(v_p, v_{pe2}) \quad (32)$$

$$p_{npd} = c(v_{np}, v_{npd2}) \quad (33)$$

These specify that the unit output price for each of the three marketing sectors is equal to the unit cost.

2.10 Final demand for wine

$$Y_{npe} = Y_{npe}(v_{np}, N_{Y_{npe}}) \quad (34)$$

$$Q_{pd} = Q_{pd}(p_{pd}, p_{npd}, N_{Qpd}, N_{Qnpd}) \quad (35)$$

$$Q_{pe} = Q_{pe}(p_{pe}, N_{Qpe}) \quad (36)$$

$$Q_{npd} = Q_{npd}(p_{pd}, p_{npd}, N_{Qpd}, N_{Qnpd}) \quad (37)$$

These are the demand functions for the four final wine products/markets. The N functions are demand shifters representing impacts of promotion or increases in product quality in individual markets. As can be seen from equations 35 and 37, the premium and non-premium wines are assumed to

be substitutes in the domestic market.⁵ Note that there is no marketing sector specified for exported non-premium wine, because this is a very insignificant segment of total production, accounting for less than 8% of the volume and 1% of the value of total sales. Similarly, given the relatively small volume of non-premium exports, the two wine types are not treated as substitutes in the export market.

The structural model described defines equilibrium in all markets. When a new technology or promotion disturbs the system, a displacement from the base equilibrium results. By totally differentiating the system of equations at the initial equilibrium, the displacement model that linearly relates changes of endogenous variables to changes in exogenous shifters can be derived with market elasticities as parameters. The displacement model is detailed in the Appendix. Definitions of all market parameters are given in tables 1,2. Integrability conditions, such as symmetry and homogeneity conditions, have been imposed implicitly.

3. The data

The inputs required for solving the model in equations 1'–37' in the Appendix are in three parts: (i) base equilibrium prices and quantities for all sectors and markets; (ii) market parameters that describe producer and consumer responsiveness to any price changes; and (iii) the values of exogenous variables that quantify the effects of R&D and promotion.

The database used for the base equilibrium for 2005 is adapted from the model of global wine markets outlined in Anderson *et al.* (2003) and Wittwer *et al.* (2003), which describe the sectoral disaggregation of the Australian wine industry as projected to 2005. We used a base of 2005 to capture the effect of recent expansion of the industry. Because it takes up to 7 years before newly planted vines are fully bearing in terms of quality and yield, the projection of production to 2005 is likely to be reasonably robust. The disaggregation between premium and non-premium wines is based on containers, with premium wines referring to those in bottles of 2.0 L or less and non-premium otherwise.

The input cost structures for industry sectors are adapted and reconstructed from the database in Wittwer *et al.* (2003). Inputs other than grapes to the two winemaking sectors are grouped into two aggregated inputs: capital inputs and mobile factors. The inputs to wine marketing sectors are grouped into wholesale wine inputs and other marketing

⁵ Cross-price effects from other substitutes, such as beer and spirits, are ignored because their cross-price elasticities are very small according to the literature review reported in Wittwer and Anderson (2002).

Table 1 Base equilibrium values projected for 2005 (in AU\$ million)

Grapes	
Premium grapes	
Total value	$TV_{Xp} = 1350$
Destinations	$\rho_{Xp1} = 0.96, \rho_{Xnp1} = 0.04$
Multi-purpose grapes	
Total value	$TV_{Xmp} = 450$
Destinations	$\rho_{Xdtd} = 0.26, \rho_{Xdte} = 0.42, \rho_{Xnp2} = 0.32$
Wine production	
Premium wine	
Total value	$TV_{Yp} = 4784$
Cost shares	$\kappa_{p1} = 0.27, \kappa_{p2} = 0.43, \kappa_{p3} = 0.30$
Non-premium wine	
Total value	$TV_{Ynp} = 652$
Cost shares	$\kappa_{np1} = 0.09, \kappa_{np2} = 0.24, \kappa_{np3} = 0.43, \kappa_{np4} = 0.24$
Marketing sectors and final wines	
Premium wine	
Domestic	
Before WET	$TV_{Ypd1} = 1436$
After GST	$TV_{Qpd}^* = 3452$
Cost shares for marketing	$\lambda_{pd1} = 0.59, \lambda_{pd2} = 0.41$
Export	
Producer value	$TV_{Ype1} = 3348$
f.o.b. value	$TV_{Qpe} = 3680$
Cost shares for marketing	$\lambda_{pe1} = 0.91, \lambda_{pe2} = 0.09$
Non-premium wine	
Domestic	
Before WET	$TV_{Ynpd1} = 560$
After GST	$TV_{Qnpd}^* = 1304$
Cost shares for marketing	$\lambda_{npd1} = 0.61, \lambda_{npd2} = 0.39$
Export	
Producer value	$TV_{Ynpe} = 46$

Source: derived from the database used in Wittwer *et al.* 2003.

WET, Wine Equalisation Tax; GST, Goods and Services Tax; f.o.b., freight on board.

inputs. The cost structures for marketing sectors are based, in part, on the margin information in Wittwer *et al.* (2003), as are the splits among domestic and export destinations for both premium and non-premium wines. The base values and the resulting cost shares are summarised in table 1.

The market elasticity values used are given in table 2. These are chosen according to limited empirical studies and subjective judgement.⁶ On the supply side, we choose a low and a high set, reflecting our uncertainty about these critical parameters. We have used 0.4 and 0.5 (premium and

⁶ See James and Alston (2002) for further discussion of the choice of elasticities for a quality disaggregated equilibrium displacement model of the Australian wine industry.

Table 2 Assumed market elasticities

Grape supply	
Low	$\varepsilon_{(Xp,wp)} = 0.4, \varepsilon_{(Xmp,wp)} = 0.5,$ $\varepsilon_{(Xmp,wp)} = -0.2$ ($\varepsilon_{(\Xi\pi,\omega\mu\pi)} = -0.07$)
Higher	$\varepsilon_{(Xp,wp)} = 0.8, \varepsilon_{(Xmp,wp)} = 1.0,$ $\varepsilon_{(Xmp,wp)} = -0.6$ ($\varepsilon_{(Xp,wp)} = -0.22$)
Other winemaking input supply	
Low	
Premium	$\varepsilon_{(Xp2,wp2)} = 0.4, \varepsilon_{(Xp3,wp3)} = 5$
Non-premium	$\varepsilon_{(Xnp3,wnp3)} = 0.5, \varepsilon_{(Xp3,wp3)} = 5$
Higher	
Premium	$\varepsilon_{(Xp2,wp2)} = 0.8, \varepsilon_{(Xp3,wp3)} = 5$
Non-premium	$\varepsilon_{(Xnp3,wnp3)} = 1.0, \varepsilon_{(Xp3,wp3)} = 5$
Table grape demand	$\eta_{(Xdtd,wdtd)} = -0.6, \eta_{(Xdte,wdte)} = -5$
Input substitution for winemaking	
Premium	$\sigma_{(Xpi,Xpj)} = 0.1$ ($i, j = 1, 2$ and $3; i < j$)
Non-premium	$\sigma_{(Xnp1,Xnp2)} = 0.15$, rest $\sigma_{(Xnpi,Xnpj)} = 0.1$ ($i, j = 1, 2, 3$ and $4; i < j$)
Wine marketing input supply	
Premium	$\varepsilon_{(Ypd2,vpd2)} = 2, \varepsilon_{(Ype2,vpe2)} = 2$
Non-premium	$\varepsilon_{(Ynpd2,vnpd2)} = 2$
Input substitution for marketing	
Premium	$\sigma_{(Ypd1,Ypd2)} = 0.1, \sigma_{(Ype1,Ype2)} = 0.1$
Non-premium	$\sigma_{(Ynpd1,Ynpd2)} = 0.1$
Final wine demand	
Premium	$\eta_{(Qpd,ppd)} = -0.8, \eta_{(Qpe,ppe)} = -5.0$
Non-premium	$\eta_{(Qnpd,pnpd)} = -0.9, \eta_{(Ynpe,vnpe)} = -7.0$
Cross-price in domestic market	$\eta_{(Qnpd,ppd)} = 0.3$ ($\eta_{(Qpd,pnpd)} = 0.11$)

non-premium, respectively) for the low set of own-price supply elasticities and 0.8 and 1.0 for the high set of supply elasticities. Cross-price supply elasticities are assumed to range from a low of -0.2 to a high of -0.6 for multipurpose grapes with respect to premium grape price. The values for the other pair of the cross-price supply elasticities (-0.07 and -0.22) are determined using the symmetry condition. On the demand side, we have assumed much higher own-price elasticities for export markets (-5 for premium and -7 for non-premium) relative to the domestic market (-0.8 and -0.9). The analytical relationship provided in Dixon and Rimmer (2002, pp. 222–5) is used as a guide in choosing the export demand elasticities. We have also included a cross-price elasticity of final demand between premium and non-premium wine for the domestic market, and imposed the standard symmetry condition.

As explained in the model section, for the winemaking sectors, we have chosen inelastic supply elasticities for the fixed capital and human capital inputs (lows of 0.4 – 0.5 and highs of 0.8 – 1.0), due to the highly technical

nature of the specialized fixed capital and human capital inputs, but a nearly perfectly elastic supply for other mobile inputs (a value of 5). For the supply elasticities for wine marketing inputs, we have used a less-than-perfectly elastic value of 2.

There are no empirical estimates for elasticities of input substitution between primary and other inputs in the winemaking and wine marketing sectors, yet the results of interest in this study hinge on these elasticity values. Wohlgenant (1993) has used 0.72 for USA beef and 0.35 for USA pork as a base case and half those values as an alternative case, based on an earlier empirical study (Wohlgenant 1989). Mullen *et al.* (1989) have used 0.1 for Australian wool. We have used a value of 0.1 for all sectors in the present study. Diewert (1981) pointed out that industry level production function generally exhibits more input substitutability than the plant level production function. For the input substitution between the two grape types in the non-premium winemaking sector, we have used an elasticity of 0.15. Both a substantial drop in the price ratio of warm-climate red winegrape prices to Sultana between 1997 and 2001 and prohibition in 2000 of the mislabelling of grape varieties on wine bottles and casks have reduced Sultana usage in wine. Nonetheless, Sultana remains important in non-premium production, making a small input-substitution parameter for grapes into non-premium production defensible (ABS 2001).⁷

There are 15 exogenous variables in the model that can be used to shift the various demand and supply schedules and, thus, to model the impacts of various R&D and promotion investments on various industry sectors. In the present study, we concentrate on estimating the impacts of five R&D and promotion scenarios:

1. Cost-reducing R&D in premium grape production (t_{xp});
2. Cost-reducing R&D in premium winemaking (t_{xp2});
3. Quality enhancing R&D for premium wine (n_{Qpd} and n_{Qpe});
4. Premium wine promotion in the domestic market (n_{Qpd}); and
5. Premium wine promotion in the export market (n_{Qpe}).

In each case, a 1% vertical parallel shift of the relevant supply or demand curve is assumed. In other words, we examine the impacts of a 1% cost reduction in the relevant sector in the case of cost-reducing R&D and a 1% increase in consumers' willingness to pay in the case of promotion or product quality improvement. The choice of a 1% shift is arbitrary. While the total welfare gain in dollar terms in each scenario will be proportional to

⁷ A back-of-the-envelope calculation from the observed relative prices and usage between 1997 and 2001 indicates a substitution elasticity of 0.3–0.4. Policy change about mislabelling for non-premium wine would have been the main factor driving the changes in usage. This makes the assumed value of 0.15 seem reasonable.

the initial percentage shift, the distribution of the total benefit among industry groups is independent of the size of the initial shift (i.e. 1% here), as long as the shift is assumed parallel and relatively small in comparison with the equilibrium price level (Zhao *et al.* 2000b, p. 84).

4. Results for alternative R&D and promotion investments

With specified values for the base equilibrium, market elasticities and exogenous shifters, the equilibrium displacement model in equations 1'–37' in the Appendix is solved to obtain the percentage changes in all price and quantity variables for each policy scenario. Changes in economic surpluses for each of the industry groups involved and changes in wine tax revenues are then calculated. The results for the five scenarios are summarized in table 3. For each case, total economic welfare gains in millions of Australian dollars and the proportional distribution among grapegrowers, wineries, retailers, domestic and overseas consumers, and government wine tax revenues are provided. These include the effects on the recently introduced WET and the GST.⁸ In the interest of brevity, the price and quantity changes for each scenario are not presented, but they are available from the authors.

Some qualifications should be noted in examining the results. The total welfare benefits in dollar terms relate to 1% shifts in the relevant supply or demand curves. The relative costs that would be required to bring about the 1% shifts for alternative scenarios are not known and hence are not discussed in the present study. That is, we cannot say how costly reducing grape production costs by 1% through R&D is compared with increasing consumers' willingness-to-pay by 1% via promotion. Project-level cost–benefit analysis for R&D and empirical studies of wine advertising would be necessary in order to compare returns from alternative investments in dollar terms. In general, the total welfare gain for a 1% shift is related directly to the value of the market where the initial shift is involved. For example, looking at the total welfare gains in table 3 for grape R&D (approximately \$14 million) compared with export promotion (approximately \$35 million), we note that we need a 3% cost reduction in premium grape production in order to gain the same total welfare gain in dollars as from a 1% increase in overseas consumers' willingness to pay.

However, the distribution of the total welfare gains among industry groups is independent of the size of the initial shift (Zhao *et al.* 2000b, p. 84). Hence, it is meaningful to compare the welfare distributions across

⁸ See Wittwer and Anderson (2002) for an analysis of those tax changes.

Table 3 Total economic welfare changes (in 2001 \$A million) and shares of total welfare changes (in percentage) to various groups from alternative investment scenarios: low- and higher-elasticities cases

Non-government welfare gains (% shares)	Scenario 1 Premium grape cost-reducing R&D		Scenario 2 Premium wine cost-reducing R&D		Scenario 3 Premium wine quality enhancing R&D		Scenario 4 Premium wine domestic promotion		Scenario 5 Premium wine export promotion	
	Low	High	Low	High	Low	High	Low	High	Low	High
Supply elasticities										
Total welfare gain (\$A million)	13.6	13.7	20.8	20.9	73.3	73.7	37.5	38.9	34.5	34.8
Distributions (%)										
ΔPS_{xp}	42.9	33.2	23.7	22.6	22.6	19.5	2.2	2.3	45.0	38.4
ΔPS_{xmp}	1.2	2.2	0.5	1.4	0.4	1.2	-0.2	0.0	1.1	2.4
$\Delta PS_{xp} + \Delta PS_{xmp}$ grape producers subtotal	44.1	35.5	24.2	24.0	23.0	20.7	2.0	2.3	46.1	40.8
ΔPS_{xp2} (Premium wineries)	35.6	32.7	57.5	45.7	35.9	30.0	3.2	3.8	71.2	58.7
ΔPS_{xnp3} (Non-premium wineries)	0.9	0.6	-0.7	-0.6	-0.8	-0.6	-1.6	-0.8	-0.5	-0.4
Wineries subtotal	36.5	33.3	56.8	45.1	35.1	29.3	1.7	3.1	70.7	58.3
$\Delta PS_{xp3} + \Delta PS_{xnp4}$ mobile factors gains	2.5	4.1	2.5	4.2	2.4	3.6	-0.1	0.3	4.9	7.2
ΔPS_{ydp2}	0.6	1.1	0.8	1.3	3.1	3.4	10.9	10.7	-5.3	-4.7
ΔPS_{ynpd2}	0.1	0.1	-0.2	-0.3	-0.4	-0.5	-1.3	-1.1	0.5	0.4
ΔPS_{ype2}	1.9	3.1	2.0	3.3	1.6	2.6	-1.1	-0.8	4.5	6.3
Marketing sector subtotal	2.6	4.3	2.6	4.3	4.4	5.6	8.5	8.7	-0.4	2.1

Table 3 *Continued*

Non-government welfare gains (% shares)	Scenario 1 Premium grape cost-reducing R&D		Scenario 2 Premium wine cost-reducing R&D		Scenario 3 Premium wine quality enhancing R&D		Scenario 4 Premium wine domestic promotion		Scenario 5 Premium wine export promotion	
$\Delta CS_{Xdt d}$	-0.3	-0.6	-0.1	-0.4	-0.1	-0.3	0.1	0.0	-0.3	-0.7
ΔCS_{Qpd}	5.9	9.7	6.1	10.1	18.2	21.1	77.6	74.4	-44.5	-38.4
ΔCS_{Qnpd}	1.3	1.7	-0.4	-0.6	0.1	-0.2	2.4	2.2	-2.8	-2.8
Domestic consumers subtotal	6.9	10.8	5.6	9.0	18.2	20.6	80.1	76.6	-47.6	-41.9
ΔCS_{Xdte}	-0.5	-0.9	-0.2	-0.6	-0.2	-0.5	0.1	0.0	-0.5	-1.0
ΔCS_{Qpe}	8.8	14.7	9.5	15.7	6.7	11.2	-5.2	-3.7	19.3	28.0
ΔCS_{Ynpe}	0.2	0.2	-0.1	-0.1	-0.1	-0.1	0.2	0.1	-0.3	-0.3
Overseas consumers subtotal	8.5	14.0	9.2	15.0	6.5	10.7	-4.9	-3.6	18.5	26.7
Tax revenue changes										
Wholesale sales tax	-1.0	-1.6	-0.8	-1.2	6.6	6.2	6.7	6.7	6.4	5.6
GST	-0.1	-0.3	-0.2	-0.3	3.8	3.7	6.0	5.9	1.3	1.2
Tax subtotal	-1.2	-1.9	-1.0	-1.5	10.4	9.9	12.7	12.6	7.7	6.8
Total percentage	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: authors' model results.
GST, Goods and Services Tax.

alternative scenarios even without knowledge of the costs involved in the initial 1% shifts.⁹

What do the results reveal? Consider the first column of table 3. It shows how a 1% shift downwards in the premium grape supply curve because of productivity enhancing R&D would benefit mostly, but not only, premium producers. If supply response is small, 44% (\$5.9 million) of the welfare gains would go to the grapegrowers and 37% to the makers of premium wine, whereas most of the rest is shared with domestic and overseas consumers (7 and 9%, respectively). Consumers benefit because they enjoy lower prices and higher quantities as a result of lower production costs. The total welfare gain is \$13.7 million per year. To provide some perspective, this is roughly the budget of the GWRDC for 2002–2003. The *ad valorem* tax revenue from wine is reduced by approximately \$0.2 million because the increased quantity less than compensates for the reduced price, due, in part, to the relatively low price elasticity of demand assumed, so the wholesale and retail values for wine are both reduced as a result of the cost reduction. If the supply elasticities are higher, the net welfare gain per year is much the same, but a larger share (almost one-third) goes to consumers at the expense of grapegrowers, whose share falls from 44 to 36%, yet the share to winemakers is little different (from 36 to 33%).

If, instead, the cost-reducing R&D is directed towards premium wine-making rather than grape production, the majority of the short-run welfare gains (57%) goes to wineries and only 24% (\$5.0 million) goes to grapegrowers, with again, 15% going to consumers. The net benefit of that shock is \$21 million per year, of which 9% goes to consumers abroad.¹⁰ The total dollar benefit for a 1% reduction in winemaking inputs is greater than that for a 1% cost reduction in the grape R&D scenario (\$14 million per annum), because of the large additional value added in the supply chain by the wineries. The share of the gain to wineries is smaller (45%) when higher supply elasticities are used. The consumers' share in that case is 24%, equalling the grapegrowers' share, which is similar in the low- and higher-elasticity cases.

If, as a result of quality enhancing R&D anywhere along the chain of premium wine production, consumers are willing to pay more for a better

⁹ Were the supply curve to shift in a non-parallel way, the welfare gain to producers would be different in aggregate terms and in its distribution among producers (see Lindner and Jarrett 1978).

¹⁰ For simplicity, we assume throughout that, in the time-frame considered in the present report, there are no beneficial spillovers to producers abroad in terms of the new technologies lowering their costs of production or in terms of Australian generic promotion affecting (positively or negatively) the demand for non-Australian wine.

Australian premium wine in both domestic and overseas markets, then grape producers (23%, \$16.9 million), wineries (35%) and domestic consumers (18%) all gain significant shares in the low-elasticity case. This also holds in the higher-elasticity case, with some of the benefits shifting from grape and wine producers to overseas consumers, whose share rises from 7 to 11% of the total \$73 million per year gain. Note that overseas consumers receive a lower proportion of total benefits from quality enhancing research than from the cost-reducing research shown in the first two scenarios. This is because scenario 3 involves simultaneous shifts in both domestic and export demand curves. The gross benefits to foreign consumers from better wine in overseas markets are offset by the increased demand in the domestic market, which forces the export price up and, thereby, makes overseas consumers worse off than they would be if there was no demand response in the home market.

This can be seen by turning to the effects of promotion on just one of those two markets for one of the two wine types. In the case of just domestic promotion of premium wine (a market that accounts for barely one-quarter of the total volume of Australian wine industry sales), only approximately one-quarter of the gains from such promotion would accrue to producers, retailers and tax revenues (see the fourth column of table 3). Nearly 80% of the welfare gains go to domestic consumers, due to the taste change effect or improved product knowledge as a consequence of promotion.¹¹ Overseas consumers, in contrast, are worse off because of the higher price of Australian wine generated by that domestic promotion campaign. The opposite occurs with just overseas promotion, as in the final scenario.

The final scenario is of particular interest to those engaged in the industry's efforts to boost marketing abroad of Australian premium wine (WFA and AWBC 2001), because the distributional effects of such an initiative are very different from the effects of R&D and domestic promotion. Specifically, in the low-elasticity case, grapegrowers gain nearly half of the benefits (46%, \$15.9 million) and premium winemakers gain more than half of the benefits, largely because of the high priced elasticity of export demand (-5.0 , compared with -0.8 for domestic demand) relative to the elasticity of supply of specialised inputs in these sectors. In contrast, non-premium winemakers lose slightly from such promotion. Certainly overseas consumers benefit in the willingness-to-pay sense, enjoying 19% of the total measured

¹¹ Controversies have long surrounded the question of how advertising changes consumers' preferences and, thus, their welfare. Although there are issues relating to the empirical implementations of alternative notions (Alston *et al.* 1999), there seems to be consensus that consumers gain welfare from advertising either because their knowledge about a product has changed (thus, product characteristics have changed that are objects in their decision functions) or their taste ordering has changed (thus, parameters in the decision functions have changed). See Dixit and Norman (1979).

welfare gain in the low-elasticity case.¹² These percentages add to more than 100 because domestic consumers lose substantially from the price-raising effect of the promotion abroad and its impact in reducing supplies on the domestic market. In the higher-elasticity case, the effects are similar but with more benefit/less loss to consumers and less benefit to both grape-growers and winemakers.

In comparing the benefit distributions from alternative investment scenarios, the grape and wine producers would prefer production research and export promotion. They would also prefer export to domestic promotion: the very different effects on producers from the two promotion scenarios are due to the differences in demand responsiveness in the two markets. Unlike domestic consumers, overseas consumers are highly price elastic in their demands and, consequently, enjoy only a small boost in welfare from a demand shift. As a result, the benefit flows back to producers. Between the two producer groups, grapegrowers would prefer grape production R&D and winemakers would prefer wine production R&D, due to the non-zero input substitution assumed. The benefits from quality enhancing research are more evenly shared among the two producer groups, the two consumer groups and the tax office than that from cost-reducing production R&D and promotion. The government gains significant wine tax revenue from improved grape and wine quality and promotion, but loses slightly from new cost-reducing grape and wine production technologies.

There are interesting differences between the results of the present study and similar studies for other agricultural industries, such as beef or pork (e.g. Wohlgenant 1993; Zhao *et al.* 2000b). Post-farm processors and marketers collect insignificant shares of welfare gains from R&D and promotion if the supplies of processing and marketing inputs are assumed highly elastic. The processors in the present study, namely the wineries, are estimated to gain a significant share of benefits, partly because of the specialised skills required in winemaking and, thus, the inelastic supply elasticities assumed for winemaking inputs. This raises the more general question of how sensitive the results are to other elasticities.

5. Sensitivity analysis

As discussed in the Introduction, the value of the elasticity of substitution between farm and non-farm inputs and its relationship with the sizes of other

¹² The 19% of \$35 million benefit to consumers abroad from overseas promotion (scenario 5), less their 5% of \$38 million loss from domestic promotion (scenario 4), approximates the net gain to overseas consumers of 6.5% of \$73 million from the outward shift in the demand curve in both domestic and export markets following quality enhancing R&D (scenario 3).

market elasticities play important roles in estimating the distribution of benefits. The higher this elasticity is above zero, the greater the grapegrowers' interest in investing in farm research compared with post-farm research and promotion, *ceteris paribus*. Furthermore, the relative sizes of the input substitution elasticities in individual post-farm sectors are also likely to be important in determining the returns to farmers from research at different post-farm stages. With a multistage model involving a processing sector and a marketing/distribution sector, Holloway (1989) derived analytical conditions for farmers to gain from various types of post-farm research. In particular, he showed that when input substitution elasticities are the same for the two post-farm sectors ($\sigma_p = \sigma_d$), farmers will lose from processing or distribution research under the condition that those elasticities are bigger than the absolute value of the retail demand elasticity $|\eta|$. However, if $\sigma_p \neq \sigma_d$, the condition for farmers to lose from marketing/distribution research remains $\sigma_d > |\eta|$, but the condition for the processing research involves $(\sigma_d - \sigma_p)$ and its relationship with other parameters, such as retail demand η , the elasticity of supply of distribution inputs ε_d and cost shares in the distribution sector. For example, Holloway (1989) showed that farmers can gain significantly from distribution research but, at the same time, lose significantly from processing research if σ_p is large and σ_d is small, even when σ_p is smaller than $|\eta|$.

These previous findings have potential implications for the estimated returns to grape-growers from winemaking research (processing) and wine marketing research in the present study. Even though the horizontal disaggregation into differentiated products in our model makes Holloway's analytical conditions not directly applicable, his results for a single product model nonetheless suggest the potential importance of key parameters. Table 4 shows the sensitivity of our baseline results to such elasticity changes. We focus on the results for our first three scenarios in table 3, which relate to a supply shift in grape production (farm research), a supply shift in wine-making inputs (processing research) and final demand shifts due to quality change (or promotion), all along the premium product chain.

Cases 1–3 in table 4 assume equal input substitution elasticities for all post-farm sectors for both premium and non-premium products. The results show how the welfare distributions change as the value for the equal input substitution elasticities changes from zero (case 2) to 0.1 (baseline in case 1) and then to 0.5 (case 3). When fixed proportions are assumed in case 2, the distributions of benefits are very similar to the baseline case across all three scenarios and all parties are relatively indifferent as to where the investments occur. The shares are not exactly the same as they would be in the single product case, because only the premium curves are shifted in our multiproduct model and the benefits to producers relate to the sum of both premium and non-premium products. When we move to

Table 4 Sensitivity of welfare shares (%) going to grape-growers, winemakers, domestic consumers and export consumers to different values of pertinent elasticities

Alternative elasticities	Scenario 1 (Premium grape cost-reducing research)				Scenario 2 (Premium wine cost-reducing research)				Scenario 3 (Premium wine quality enhancing research)			
	Grape	Wine	DC	EC	Grape	Wine	DC	EC	Grape	Wine	DC	EC
Case 1 (Baseline) All $\sigma_p = 0.1$, $\sigma_d = 0.1$ $\eta = (-5, -7, -0.8, -0.9, 0.3, 0.11)$	35.5	33.3	10.8	14.0	24.0	45.1	9.0	15.0	20.7	29.3	20.6	10.7
Case 2 All $\sigma_p = 0$, $\sigma_d = 0$ $\eta = (-5, -7, -0.8, -0.9, 0.3, 0.11)$	27.7	39.4	11.1	14.6	28.3	40.0	9.0	15.1	20.9	29.6	20.6	10.3
Case 3 All $\sigma_p = 0.5$, $\sigma_d = 0.5$ $\eta = (-5, -7, -0.8, -0.9, 0.3, 0.11)$	54.5	19.1	9.5	12.5	13.8	57.8	9.3	14.3	19.2	27.9	20.3	11.8
Case 4 All $\sigma_p = 1.0$, $\sigma_d = 1.0$ $\eta = (-1, -1, -0.8, -0.8, 0.2, 0.08)$	57.2	-0.5	18.2	27.0	-0.4	52.6	19.4	30.3	9.9	14.6	29.2	28.9
Case 5 All $\sigma_p = 1.3$, $\sigma_d = 1.3$ $\eta = (-2, -3, -0.8, -0.8, 0.2, 0.08)$	65.8	2.0	13.5	19.3	1.5	61.9	14.9	22.3	12.9	19.0	25.2	22.7
Case 6 All $\sigma_p = 1.3$, $\sigma_d = 0.1$ $\eta = (-2, -3, -0.8, -0.8, 0.2, 0.08)$	65.3	0.1	12.7	20.8	0.1	60.6	14.1	23.9	13.2	19.6	25.9	21.8
Case 7 All $\sigma_p = 1.3$, $\sigma_d = 0.05$ $\eta = (-2, -3, -0.8, -0.8, 0.2, 0.08)$	65.3	-0.1	12.6	20.9	-0.02	60.6	14.0	24.0	13.3	19.6	26.0	21.8
Case 8 All $\sigma_p = 1.3$, $\sigma_d = 0$ $\eta = (-2, -3, -0.8, -0.8, 0.2, 0.08)$	65.2	-0.2	12.6	21.0	-0.1	60.5	14.0	24.1	13.3	19.6	26.0	21.7

σ_p , any input substitution elasticities in the processing/winemaking sectors; σ_d , any input substitution elasticities in the marketing sectors; $\eta = (\eta_{(Qpe, ppe)}, \eta_{(Ynpe, vnpe)}, \eta_{(Qpd, ppd)}, \eta_{(Qnpe, pnpe)}, \eta_{(Qnpe, ppe)}, \eta_{(Qpd, pnpe)})$, final wine demand elasticities for, respectively, own-price export premium, own-price export non-premium, own-price domestic premium, own-price domestic non-premium, cross-price for domestic non-premium, cross-price for domestic premium; DC, domestic consumers; EC, export consumers.

case 1 and then to case 3 as the input substitution elasticities increase, it is clear that grape-growers will increasingly prefer grape cost-reducing research, wineries prefer wine cost-reducing research and consumers prefer improved final product quality. Note that because the value of 0.5 in case 3 is still smaller than the final demand elasticities (-0.8 for domestic premium and -5 for export premium), grape-growers still gain a positive share of returns from wine research.

In cases 4–8 in table 4, we investigate the possibility of grape-growers losing welfare from wine research as we allow the input substitution elasticities to be different for the two post-farm sectors and the final demand elasticities to be smaller. As implied by the previous studies, the relationship between the input substitution elasticities for the winemaking (processing) sectors and marketing sectors, and their relative sizes in comparison with the final demand elasticities, are vital. Recall that we have used very elastic demand elasticities for export premium wine ($\eta_{(Q_{pe}, ppe)} = -5$ for export compared with $\eta_{(Q_{pd}, ppd)} = -0.8$ for domestic) in the baseline model and two-thirds of Australian premium wine is exported. As Australian wine builds its reputation in international markets and differentiates itself from wines of other countries, it may be that the elasticity of demand overseas for Australian premium wine becomes lower than the value we have chosen. In case 4, we use a set of much lower demand elasticities (with -1 for export premium and -0.8 for domestic premium) and an equal input substitution elasticity of 1.0 for all post-farm sectors. As expected, under such extreme assumptions, grape-growers would lose from wine cost-reducing research and wineries would lose from grape cost-reducing research.

Turning to cases 5–8, we assume a set of perhaps more realistic wine demand elasticities that are higher than those in case 4: -2 and -3 for export premium and non-premium, respectively, and -0.8 and -0.5 for domestic premium and non-premium, respectively. Grape-growers are still gaining positive returns from wine research when input substitution elasticities are assumed to be 1.3 for all post-farm sectors in case 5 and when the input substitution elasticity for wine marketing sectors are assumed to be 0.1 in case 6. However, when the input substitution elasticities in wine marketing sectors are further lowered to 0.05 (case 7) and then zero (case 8), grape-growers start to lose out from winemaking research.

So what can we conclude about the robustness of our results for the Australian wine industry from the sensitivity analysis in table 4, bearing in mind that we have limited knowledge about the sizes of the input substitution elasticities and even the wine demand elasticities? If we believe that the possibility for input substitution is close to zero in both the winemaking and wine marketing sectors, then the interests of individual sectors in the industry in choosing where along the vertical chain to invest research or

promotion funds will be closely aligned with total industry welfare gains. In contrast, if input substitution elasticities are larger than the baseline value of 0.1 and the final demand elasticities are smaller than the base values, each group will receive an even higher share than suggested in the base scenario from investment in its own sector: grape-growers will even more strongly prefer grape research, winemakers will prefer winemaking research and consumers will prefer quality improvement or promotion (see, for example, case 3). However, in the case of the Australian wine industry, we believe that the relationships between input substitution and final demand are unlikely to be such that grape-growers will lose from cost-reducing wine research or that winemakers will lose from cost-reducing grape research. The majority of Australian premium wine is exported and exported products from small countries tend to be demand elastic. Although it could be argued that the input substitution elasticities for winemaking and marketing sectors are likely to be larger than, say, 0.1, we believe it is unlikely that they are larger than the export demand elasticity for Australian wine. In addition, it is difficult to argue that the input substitution within the wine-making sector is significantly larger than that within the marketing sector (it would seem to be easier to argue the other way around), in which case the negative returns to growers in cases 7 and 8 are not relevant.

6. Implications and conclusions

Numerous qualifications need to be kept in mind in interpreting the base results. Obviously the numbers depend heavily on the elasticities assumed (see table 2). The sensitivity analysis summarised in table 4 shows how the baseline results will change for alternative values of key elasticities. It illustrates Holloway's (1989) conclusion, with a vertically and also horizontally disaggregated model, that the returns to the farm sector from alternative stages of post-farm research depend crucially on how the input substitution elasticities in post-farm sectors compare with the final demand elasticities and how the input substitution elasticities in different sectors compare with one another. Systematic accounting for uncertainty in market parameters, as undertaken in Zhao *et al.* (2000a), would provide further insights. In addition, this model captures only partial equilibrium effects within the Australian industry. The feedback from other related sectors in demand (such as beer and spirits), the spillover of new technologies to other industries (including the grape and wine industry abroad) and any social and environmental impacts (both positive and negative) are left unmeasured. However, the model does capture the change in wine tax revenue.

The present study has also ignored the impacts of any costs incurred in R&D and promotion. Both generic R&D and promotion are funded, in

part, by producer levies, which, in effect, add to the production costs and shift the supply curves upwards. The net impacts to all groups concerned are determined by the distributions of both benefits and costs. It is assumed here that the magnitude of such shifts are small in comparison with the shifts resulting from R&D-induced productivity gains and the increases in willingness-to-pay due to quality enhancing R&D or generic promotion. This assumption is supported by the estimated high cost–benefit ratios in GWRDC research programmes (McLeod 2002). Similarly, costs in extending and adopting research outcomes are not considered. For example, in the case of implementing quality enhancing technologies, there may be extra costs in switching to different grape varieties or clones or buying new equipment for wineries.

The results suggest that the major direct winners from R&D within the grape and wine industry's markets will be producers, and more so as the industry becomes increasingly export focused over the next decade. This contrasts with findings for other industries: according to Baumol (2002), on average across all USA industries, producers receive only approximately one-quarter of the benefits from R&D. In addition, even though growers and winemakers contribute approximately 50% of the R&D funds in the form of statutory levies, they eventually offload some of the burden to consumers through the incidence of the levy, with the proportions as estimated in the first two columns of table 3 (which includes overseas consumers, incidentally). So the producers' real contribution is significantly less than 50% (Zhao 2002). From an Australian national point of view, producer levy funding of R&D has the advantage of making overseas consumers share the incidence of costs, as well as the benefits, of research.

Finally, with the industry reconsidering the R&D levy in light of the apparently high rewards from research to date (McLeod 2002) and the fact that the current levy is well below the 0.5% threshold that attracts maximum government matching funds, now is the time to question the method of levying in addition to raising its level. To date, it has been a weight-based measure, so research intensity has declined as a percentage of the gross value of production over the past decade as the price of wine has risen with quality improvements and with increased demand in export markets. One way to prevent this continuing is to switch to a value-based *ad valorem* levy rate.¹³ In addition, because much of the R&D and promotion is focused on premium products, whereas non-premium producers pay a significant amount of the costs through the gravimetric levy, such a change would seem to be a more equitable way to levy producers.

¹³ See James and Alston (2002) for a discussion of the impacts of *ad valorem* versus per unit taxes for quality differentiated products.

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Appendix

The model in equilibrium-displacement form

In the following, $E(.) = \Delta(.)/(.)$ represents a small relative change of a variable (.).

Input supply to premium wine and non-premium wine sectors

$$EX_p = \varepsilon_{(X_p, wp)}(Ew_p - t_{Xp}) + \varepsilon_{(X_p, wmp)}(Ew_{mp} - t_{Xmp}) \quad (1')$$

$$EX_p = \rho_{X_{p1}} EX_{p1} + \rho_{X_{np1}} EX_{np1} \quad (2')$$

where $\rho_{X_{p1}} = X_{p1}/(X_{p1} + X_{np1})$ and $\rho_{X_{np1}} = X_{np1}/(X_{p1} + X_{np1})$ are quantity shares.

$$EX_{p2} = \varepsilon_{(X_{p2}, wp2)}(Ew_{p2} - t_{Xp2}) \quad (3')$$

$$EX_{p3} = \varepsilon_{(X_{p3}, wp3)}(Ew_{p3} - t_{Xp3}) \quad (4')$$

$$EX_{mp} = \varepsilon_{(X_{mp}, wmp)}(Ew_{mp} - t_{Xmp}) + \varepsilon_{(X_{mp}, wp)}(Ew_p - t_{Xp}) \quad (5')$$

$$EX_{mp} = \rho_{np2} EX_{np2} + \rho_{X_{dtd}} EX_{dtd} + \rho_{X_{dte}} EX_{dte} \quad (6')$$

where $\rho_{X_{np2}} = X_{np2}/(X_{np2} + X_{dt})$ and $\rho_{X_{dt}} = X_{dt}/(X_{np2} + X_{dt})$ are quantity shares.

$$EX_{np3} = \varepsilon_{(X_{np3}, w_{np3})}(Ew_{np3} - t_{X_{np3}}) \quad (7')$$

$$EX_{np4} = \varepsilon_{(X_{np4}, w_{np4})}(Ew_{np4} - t_{X_{np4}}) \quad (8')$$

Demand for drying and table grapes

$$EX_{dtd} = \eta_{(X_{dtd}, w_{mp})}(Ew_{mp} - n_{X_{dtd}}) \quad (9')$$

$$EX_{dte} = \eta_{(X_{dte}, w_{dte})}(Ew_{mp} - n_{X_{dte}}) \quad (10')$$

Output-constrained input demand of the premium wine sector

$$EX_{p1} = -(\kappa_{p2}\sigma_{(X_{p1}, X_{p2})} + \kappa_{p3}\sigma_{(X_{p1}, X_{p3})})Ew_p + \kappa_{p2}\sigma_{(X_{p1}, X_{p2})}Ew_{p2} + \kappa_{p3}\sigma_{(X_{p1}, X_{p3})}Ew_{p3} + EY_p \quad (11')$$

$$EX_{p2} = \kappa_{p1}\sigma_{(X_{p1}, X_{p2})}Ew_p - (\kappa_{p1}\sigma_{(X_{p1}, X_{p2})} + \kappa_{p3}\sigma_{(X_{p2}, X_{p3})})Ew_{p2} + \kappa_{p3}\sigma_{(X_{p2}, X_{p3})}Ew_{p3} + EY_p \quad (12')$$

$$EX_{p3} = \kappa_{p1}\sigma_{(X_{p1}, X_{p3})}Ew_p + \kappa_{p2}\sigma_{(X_{p2}, X_{p3})}Ew_{p2} - (\kappa_{p1}\sigma_{(X_{p1}, X_{p3})} + \kappa_{p2}\sigma_{(X_{p2}, X_{p3})})Ew_{p3} + EY_p \quad (13')$$

Output-constrained input demand of the non-premium wine sector

$$EX_{np1} = -(\kappa_{np2}\sigma_{(X_{np1}, X_{np2})} + \kappa_{np3}\sigma_{(X_{np1}, X_{np3})} + \kappa_{np4}\sigma_{(X_{np1}, X_{np4})})Ew_p + \kappa_{np2}\sigma_{(X_{np1}, X_{np2})}Ew_{mp} + \kappa_{np3}\sigma_{(X_{np1}, X_{np3})}Ew_{np3} + \kappa_{np4}\sigma_{(X_{np1}, X_{np4})}Ew_{np4} + EY_{np} \quad (14')$$

$$EX_{np2} = -(\kappa_{np1}\sigma_{(X_{np1}, X_{np2})} + \kappa_{np3}\sigma_{(X_{np2}, X_{np3})} + \kappa_{np4}\sigma_{(X_{np2}, X_{np4})})Ew_{mp} + \kappa_{np1}\sigma_{(X_{np1}, X_{np2})}Ew_p + \kappa_{np3}\sigma_{(X_{np2}, X_{np3})}Ew_{np3} + \kappa_{np4}\sigma_{(X_{np2}, X_{np4})}Ew_{np4} + EY_{np} \quad (15')$$

$$EX_{np3} = -(\kappa_{np1}\sigma_{(X_{np1}, X_{np3})} + \kappa_{np2}\sigma_{(X_{np2}, X_{np3})} + \kappa_{np4}\sigma_{(X_{np3}, X_{np4})})Ew_{np3} + \kappa_{np1}\sigma_{(X_{np1}, X_{np3})}Ew_p + \kappa_{np2}\sigma_{(X_{np2}, X_{np3})}Ew_{mp} + \kappa_{np4}\sigma_{(X_{np3}, X_{np4})}Ew_{np4} + EY_{np} \quad (16')$$

$$EX_{np4} = -(\kappa_{np1}\sigma_{(X_{np1}, X_{np4})} + \kappa_{np2}\sigma_{(X_{np2}, X_{np4})} + \kappa_{np3}\sigma_{(X_{np3}, X_{np4})})Ew_{np4} + \kappa_{np1}\sigma_{(X_{np1}, X_{np4})}Ew_p + \kappa_{np2}\sigma_{(X_{np2}, X_{np4})}Ew_{mp} + \kappa_{np3}\sigma_{(X_{np3}, X_{np4})}Ew_{np3} + EY_{np} \quad (17')$$

Market-clearing condition/supply of premium and non-premium wholesale wine

$$Ev_p = \kappa_{p1}Ew_p + \kappa_{p2}Ew_{p2} + \kappa_{p3}Ew_{p3} \quad (18')$$

$$Ev_{np} = \kappa_{np1}Ew_p + \kappa_{np2}Ew_{mp} + \kappa_{np3}Ew_{np3} + \kappa_{np4}Ew_{np4} \quad (19')$$

Destination of wine at the cellar door

$$EY_p = \theta_{pd}EY_{pd1} + \theta_{pe}EY_{pe1} \quad (20')$$

$$EY_{np} = \theta_{npd}EY_{npd1} + \theta_{npe}EY_{npe} \quad (21')$$

Supply of wine marketing inputs

$$EY_{pd2} = \varepsilon_{(Y_{pd2}, v_{pd2})}(Ev_{pd2} - t_{Y_{pd2}}) \quad (22')$$

$$EY_{pe2} = \varepsilon_{(Y_{pe2}, v_{pe2})}(Ev_{pe2} - t_{Y_{pe2}}) \quad (23')$$

$$EY_{npd2} = \varepsilon_{(Y_{npd2}, v_{npd2})}(Ev_{npd2} - t_{Y_{npd2}}) \quad (24')$$

Output-constrained input demand of the wine marketing sectors

$$EY_{pd1} = -\lambda_{pd2}\sigma_{(Y_{pd1}, Y_{pd2})}Ev_p + \lambda_{pd2}\sigma_{(Y_{pd1}, Y_{pd2})}Ev_{pd2} + EQ_{pd} \quad (25')$$

$$EY_{pd2} = \lambda_{pd1}\sigma_{(Y_{pd1}, Y_{pd2})}Ev_p - \lambda_{pd1}\sigma_{(Y_{pd1}, Y_{pd2})}Ev_{pd2} + EQ_{pd} \quad (26')$$

$$EY_{pe1} = -\lambda_{pe2}\sigma_{(Y_{pe1}, Y_{pe2})}Ev_p + \lambda_{pe2}\sigma_{(Y_{pe1}, Y_{pe2})}Ev_{pe2} + EQ_{pe} \quad (27')$$

$$EY_{pe2} = \lambda_{pe1}\sigma_{(Y_{pe1}, Y_{pe2})}Ev_p - \lambda_{pe1}\sigma_{(Y_{pe1}, Y_{pe2})}Ev_{pe2} + EQ_{pe} \quad (28')$$

$$EY_{npd1} = -\lambda_{npd2}\sigma_{(Y_{npd1}, Y_{npd2})}Ev_{np} + \lambda_{npd2}\sigma_{(Y_{npd1}, Y_{npd2})}Ev_{npd2} + Eq_{npd} \quad (29')$$

$$EY_{npd2} = \lambda_{npd1}\sigma_{(Y_{npd1}, Y_{npd2})}Ev_{np} - \lambda_{npd1}\sigma_{(Y_{npd1}, Y_{npd2})}Ev_{npd2} + EQ_{npd} \quad (30')$$

Market-clearing condition for the marketing sectors

$$Ep_{pd} = \lambda_{pd1}Ev_p + \lambda_{pd2}Ev_{pd2} \quad (31')$$

$$Ep_{pe} = \lambda_{pe1}Ev_p + \lambda_{pe2}Ev_{pe2} \quad (32')$$

$$Ep_{npd} = \lambda_{npd1}Ev_{np} + \lambda_{npd2}Ev_{npd2} \quad (33')$$

Final demand for wine

$$EY_{npe} = \eta_{(Y_{npe}, v_{npe})}(E_{v_{np}} - n_{Y_{npe}}) \quad (34')$$

$$EQ_{pd} = \eta_{(Q_{pd}, p_{pd})}(E_{p_{pd}} - n_{Q_{pd}}) + \eta_{(Q_{pd}, p_{npd})}(E_{p_{npd}} - n_{Q_{npd}}) \quad (35')$$

$$EQ_{pe} = \eta_{(Q_{pe}, p_{pe})}(E_{p_{pe}} - n_{Q_{pe}}) \quad (36')$$

$$EQ_{npd} = \eta_{(Q_{npd}, p_{pd})}(E_{p_{pd}} - n_{Q_{pd}}) + \eta_{(Q_{npd}, p_{npd})}(E_{p_{npd}} - n_{Q_{npd}}) \quad (37')$$