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The returns to promotion of healthy choices in Tasmania: *are you in the dark about the power of mushrooms*?

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The Australian Mushroom Growers Association (AMGA) has recently developed a revised marketing strategy to promote mushrooms using messages based on scientific findings about the nutrition and health consequences of regularly incorporating mushrooms into meals. This article evaluates impacts based on a test-market experiment in Tasmania. We use a difference-in-differences econometric methodology to quantify the programme-induced shifts in demand, and we use the resulting estimates in a supply and demand modelling framework to quantify the effects of promotion-induced demand shifts on prices, quantities, and measures of economic well-being. We estimate a conservative benefit–cost ratio for Tasmanian producers of 7.6:1 if they were to bear the entire cost and 11.4:1 if the programme were financed by a levy on production (or spawn). The aggregate benefit–cost ratio, including benefits to consumers is also 11.4:1.

1. Introduction

Governments in Australia and elsewhere are interested in the potential for promotional programmes to encourage healthier diets, with a higher proportion of fresh fruits and vegetables, including mushrooms. Demand response to promotion is also of interest to industry participants. The Australian Mushroom Growers Association (AMGA) has recently developed a revised marketing strategy, aiming to reposition mushrooms in the minds of consumers. The core of the strategy is the concept contained in the slogan 'Are You in the Dark about the Power of Mushrooms?', which is to replace 'Mushrooms, the Healthy All-Rounder'. Retaining the emphasis on the versatility of mushrooms, the new concept emphasises healthfulness, and the strategy is to introduce a series of messages based on scientific findings about the nutrition and health consequences of regularly incorporating mushrooms into meals.

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With this strategy in mind, a test-market experiment was undertaken in Tasmania in late 2010 and early 2011. The project was financed jointly by the AMGA, the mushroom industry statutory levy, and the Commonwealth government, which contributed $200,000 under its programme on 'Promoting Australian Produce'. This article documents the results from that test-market experiment and derives estimates of the benefits to producers and consumers. We use a difference-in-differences econometric methodology to quantify the programme-induced shifts in demand (Cameron and Trivedi 2005; Angrist and Pischke 2009), and we use the resulting estimates in a supply and demand modelling framework to quantify the effects of promotion-induced demand shifts on prices, quantities, and measures of economic well-being.

2. Background: overview of the industry and the market experiment

The total mushroom industry in Australia is made up of domestic and imported white button mushrooms or Swiss brown types (both *Agaricus bisporus*), domestic and imported exotic mushrooms, and dried and in-liquid value-added products. Most mushrooms produced and consumed in Australia are *Agaricus* types, sold in fresh form; exotic mushrooms are produced in very small quantities (see American Mushroom Growers Association, 2009 for details). In 2009/2010, domestic *Agaricus* production totalled 65,000 tonnes valued at $310 million at the farm gate; in the same year, the total market (domestic and imported mushrooms of all types) was 71,681 tonnes with a gross value at first point of sale of $420 million (Greg Seymour, AMGA, pers. comm.). Domestic producers dominate the market for fresh *Agaricus*, which is distinct from the markets for imported and domestic exotic mushrooms, and dried and in-liquid value-added products. Fresh *Agaricus* mushrooms imported from New Zealand (phyto-sanitary trade restrictions and quarantines prevent fresh mushrooms from being imported from other countries) accounted for only 6.3 per cent of the total volume of imports and 0.5 per cent of the total Australian mushroom market in 2009/2010 (Greg Seymour, AMGA, pers. comm.). The analysis of this paper is focused on the domestic fresh *Agaricus* industry.

The AMGA was established in 1961 to provide services for the industry, such as public relations, research and development, and generic market promotion. The Association's activities are funded by a voluntary levy. In addition, a statutory levy of $2.16 for every kilogram of mushroom spawn purchased is collected from *Agaricus* growers by the Australian government, mostly used to fund mushroom marketing and promotion programmes (75 per cent of revenue) (see American Mushroom Growers Association 2011).

The AMGA conducted the test-market experiment in Tasmania because the State is isolated from the Australian mainland with respect to geography, its mushroom supply, and its media network. Before the experiment, the AMGA spent about $47,500 of levy revenues per year in Tasmania, an amount proportional to the rate of promotional spending per capita on the

Australian mainland. During the experiment the AMGA planned to spend $50,000 over six months, or double the recent rate of spending for promotion programmes in Tasmania.

The 'Power of Mushrooms' marketing experiment in Tasmania included six different media components: (i) television commercials, (ii) radio commercials, (iii) product demonstrations in stores and at local festivals (e.g., Taste of Tasmania), (iv) point-of-sale advertising materials in certain stores (e.g., 'Power of Mushrooms' brown paper bags and shelf talkers, posters, shelf stripping and box cards), (v) a public relations campaign, and (vi) the 'Power of Mushrooms' Web site. Not all retail food locations that sell fresh mushrooms displayed the 'Power of Mushrooms' in-store, point-of-sale advertising materials (e.g., posters, shelf talkers, mushroom bags, etc.). One major supermarket chain (supermarket-W) did not promote mushroom consumption with point-of-sale 'Power of Mushrooms' materials and received a small quantity of pre-packaged mushrooms from an alternative supplier (Greg Seymour, AMGA, pers. comm.). Stores in another major supermarket chain (supermarket-X), some locations for a third chain (supermarket-Y), and several independently owned food markets displayed point-of-sale advertising materials at some stage during the experiment period ('treated stores'). Supermarket-X stores displayed 'three mushrooms a day' point-of-sale materials of their own design, and only during the month of February. We exploit this variation in treatments among stores in our statistical analysis.

3. Difference-in-differences measures of impact

A successful promotion programme causes mushroom sales to increase in stores where promotion is conducted ('treatment stores'), relative to stores where no promotion is undertaken ('control stores'), during the period when the promotion campaign is being run ('treatment period'). We use a difference-in-differences (DnD) methodology to quantify the 'treatment' effect associated with the programme. Treatment stores differed from others in that they displayed point-of-sale promotion materials including posters, and 'Power of Mushrooms' mushroom bags, but when comparing stores within Tasmania, we cannot control for some effects. Specifically, the market-wide promotion campaign included television advertisements, radio advertisements, and a public relations component that potentially had an effect on the demand for mushrooms for all consumers, not just the consumers who shopped in treatment stores. However, we also use a variant of the same approach to compare the Tasmanian market (with and without the treatment) against the control of the mainland Australian market. When comparing Tasmania versus mainland Australia, we have a complete separation between the treated and untreated cases, but we have much less information upon which to base the DnD evaluation.

3.1. A DnD model of mushroom shipments in Tasmania

The sole mushroom producer in Tasmania provided data on weekly wholesale shipments or orders by buyer for the period September 2009 through April 2011. These shipments were predominantly (99 per cent by volume) *Agaricus* throughout the treatment and pre-treatment periods. One external supplier from mainland Australia supplied pre-packed *Agaricus* to Supermarket-W, and our data do not include these quantities. However, this external supplier reported a huge increase in sales to Tasmania during the experiment (Greg Seymour, AMGA, pers. comm.), such that we can reasonably assume that any measured effect on observed shipments from the Tasmanian producer were not at the expense of reduced imports from the mainland. The Tasmanian mushroom producer shipped to 33 buyers categorised as fruiterers or greengrocers, wholesalers, supermarkets, cash sales, or small shops. The numbers of units shipped to each buyer were converted to total kilograms by buyer and week using information on the unit weight and mushroom type (e.g., loose white *Agaricus* caps) taken from the product codes provided by the mushroom producer. Table 1 describes the data in detail. These data enable us to compare treated and untreated mushroom buyers within Tasmania, which is the 'treated market'.

Table 2 shows summary statistics for weekly shipments to Supermarket-X (which had some in-store promotion related to the programme), Supermarket-W (which did not participate in the programme) and others, some of which did participate, comparing the treatment period and the corresponding period from the year previously (i.e., the pre-treatment period). In the last column, the table shows the percentage difference in shipments between the treatment and pre-treatment periods, which is generally positive, and might reflect the market-wide effects of the mass-media elements, and the last rows of that column show the difference-in-differences for Supermarket-X relative to Supermarket-W and others, which reflects the additional impact of the in-store elements that varied among retailers. The regression analysis, which follows, accounts for other covariates and variation in the details of the treatment, week by week.

We estimated a linear model of wholesale mushroom demand ($QM_{i,t}$, all fresh mushroom shipments to wholesale buyer i in week t) as a function of (i) an indicator or dummy variable that takes a value of one if the 'Power of Mushrooms' promotion experiment took place in week t, and zero otherwise, $Treat_t$; (ii) an indicator variable that takes a value of one if store i used in-store point-of-sale promotion materials (e.g., 'Power of Mushrooms' paper bags or posters), $InStore_i$; (iii) a variable representing the interaction effect that takes a value of one if store i used point-of-sale promotion materials and the 'Power of Mushrooms' experiment took place at time t, $InStore_i.Treat_t$; (iv) a variable to represent the type of wholesale buyer, $Type_i$; (v) a variable to represent the region within Tasmania served by the wholesale buyer, $City_i$;

Table 1 Shipments of mushrooms in Tasmania: data description

Variable	Description
Continuous variables	
Total mushroom shipments	Calculated volume of shipments to buyer *i* in week *t* in kilograms
Dichotomous indicator variables	
Public relations	Takes the value 1 if PR component of ad campaign occurred in month *m*
Event	Takes the value 1 if an event occurred as a part of ad campaign in month *m*
Point-of-sale	Takes the value 1 if point-of-sale component of ad campaign occurred in month *m*
Radio	Takes the value 1 if a radio commercial aired as a part of ad campaign in month *m*
Television	Takes the value 1 if a television commercial aired as a part of ad campaign in month *m*
InStore	Takes the value 1 if the shipment was to Supermarket-X
InStore × point-of-sale	Interaction between Supermarket-X indicator and point-of-sale indicator
Special	Takes the value 1 if the mushrooms were on special at store *i* in week *t*
Fruiterer or greengrocer	Takes the value 1 if mushroom shipment data indicate the shipment was to a fruiter or greengrocer
Small shops	Takes the value 1 if mushroom shipment data indicate the shipment was to a small shop
Supermarkets	Takes the value 1 if mushroom shipment data indicate the shipment was to a supermarket chain
Wholesaler	Takes the value 1 if mushroom shipment data indicate the shipment was to a wholesaler
Cash sales	Takes the value 1 if mushroom shipment data indicate the shipment was to cash sales
No buyer type	Takes the value 1 if mushroom shipment data do not indicate the type of buyer
Customer region	
Hobart	Takes the value 1 if mushroom shipment data indicate buyer *i* serves Hobart
Launceston	Takes the value 1 if mushroom shipment data indicate buyer *i* serves Launceston
NW coast	Takes the value 1 if mushroom shipment data indicate buyer *i* serves the NW coast
Local cash	Takes the value 1 if mushroom shipment data indicate the buyer is local
Multiple 1	Takes the value 1 if mushroom shipment data indicate the buyer serves multiple regions within Tasmania
Multiple 2	Takes the value 1 if mushroom shipment data indicate the buyer serves multiple regions within Tasmania
Multiple 3	Takes the value 1 if mushroom shipment data indicate the buyer serves multiple regions within Tasmania

(vi) and, an indicator variable that takes a value of one if store *i* had a special or price promotion on mushrooms at time *t*, $Special_{i,t}$.

We did not have suitable data on buyer-specific prices paid to the producer, or on retail prices, that we could include in the statistical model. The omission of prices could lead to omitted variables bias if prices changed during the

Table 2 Average weekly shipments of mushrooms in Tasmania

	Pre-treatment (September 2009–March 2010)	Treatment (September 2010–March 2011)	Difference (Treat versus Pre-treat.)	Difference (Treat versus Pre-treat.)
	kg/week	kg/week	kg/week	percent
Total Shipments, All Stores	**10,205.91**	**11,255.66**	**1049.75**	**10.29**
Average Sales per Store				
Supermarket Chains	**9153.07**	**10,197.69**	**1044.62**	**11.41**
Supermarket-X	3193.87	3623.05	429.18	13.44
Supermarket-W	5959.20	6574.64	615.44	10.33
Non-Supermarket Buyers	**1052.84**	**1057.97**	**5.14**	**0.49**
Wholesaler	709.02	735.88	26.86	3.79
Cash sales	53.77	48.36	−5.41	−10.07
Fruiterer or Greengrocer	170.89	154.98	−15.90	−9.31
Small shops	55.49	56.24	0.75	1.35
Other or no type	63.67	62.51	−1.16	−1.83
Difference-in-Difference				
Supermarket-X versus Supermarket-W				3.11
Supermarkets versus Others				10.92

Notes: Supermarket-Y and other retailers are supplied by the ‘Non-Supermarket Buyers’ and their volumes are not identified separately in these data. Numbers in bold are subtotals.

experiment in ways that were correlated with the treatment effects of interest. We expect that any such biases would be small, and if they exist are likely to result in understatement of the effects of promotion. Intuitively, if the treatment causes an increase in demand and that causes sellers to increase prices, the implication will be a smaller observed increase in sales in response to the treatment than if prices did not increase (i.e., a positive correlation between promotion and prices in conjunction with a negative impact of price on sales implies a downward bias in the estimated sales response to promotion).

Table 3 includes the results from estimating this first regression model using ordinary least squares (OLS) in column 1. In this model, the coefficient on the interaction term $InStore_i \cdot Treat_t$, roughly captures the effect of in-store, point-of-sale advertising and promotion activities or materials on the total quantity of mushrooms shipped (in kilograms), whereas the coefficient on $Treat_t$ captures the effect of the market-wide promotion campaign in stores without point-of-sale promotion. The results imply positive and statistically significant values for both of these treatment effects (we obtained very similar results if we included additional data for a longer pre-treatment period, September 2009 through August 2010 rather than March 2010). Supermarket-X received an average weekly shipment of mushrooms of 3404.82 kg (3193.87 kg in the pre-treatment period and 3623.04 kg in the treatment period, see row 3 of Table 2); thus, the treatment effect represents an increase by 14.4 per cent (458.8/3193.87 = 0.144) in the volume of mushroom shipments

Table 3 Difference-in-difference regressions, models of mushroom shipments

	OLS		FGLS	OLS		FGLS
	(1)	(2)	(3)	(4)	(5)	(6)
Promotion campaign component						
Treat (or point-of-sales)	23.44	19.55	99.29**	11.32	10.70	41.41
	(12.15)	(11.94)	(18.90)	(27.82)	(26.37)	(31.32)
Public relations				33.19	26.22	68.96**
				(18.80)	(18.58)	(19.11)
Event				6.222	5.031	64.96*
				(24.73)	(24.14)	(26.07)
Radio				−17.42	−14.67	−43.72
				(24.96)	(23.47)	(30.20)
Television				12.66	10.19	79.46**
				(18.92)	(18.35)	(21.66)
InStore	−3082**	−2433**	−3044**	−2899**	−2254**	−2897**
	(58.58)	(84.94)	(46.71)	(140.5)	(268.6)	(39.22)
InStore × Treat	458.8**	391.7**	379.2**	621.7**	506.3**	581.5**
(or point-of-sales)	(68.80)	(67.99)	(55.44)	(99.21)	(126.2)	(111.9)
Special	1709**	1739**	1697**	1710**	1739**	1705**
	(85.96)	(83.81)	(70.56)	(316.9)	(327.2)	(71.02)
Mushroom shipments (t−1)		0.218**			0.224**	
		(0.0202)			(0.0855)	
Buyer type						
Small shops	−15.38	−12.06	−74.99	−15.38	−11.96	−80.74
	(21.04)	(20.66)	(78.12)	(10.48)	(9.090)	(81.19)
Supermarkets	5995**	4653**	5950**	5995**	4615	5946**
	(61.64)	(138.7)	(266.0)	(127.3)	(505.5)**	(294.6)
Wholesaler	356.1**	279.1	466.6**	356.1**	276.8	465.1**
	(16.00)	(17.29)**	(49.44)	(15.07)	(32.34)**	(49.40)
Cash sales	9.290	7.093	−35.87	9.290	7.040	−37.23
	(38.18)	(37.50)	(81.22)	(5.947)	(5.468)	(84.86)
No buyer type	−18.55	−14.91	−64.57	−18.55**	−14.80**	−68.55
	(38.18)	(37.50)	(262.7)	(6.139)	(5.279)	(291.7)

Table 3 (*Continued*)

	OLS		FGLS	OLS		FGLS
	(1)	(2)	(3)	(4)	(5)	(6)
Customer region						
Launceston	−212.3**	−167.0**	−194.2**	−212.3**	−165.6**	−193.3**
	(18.34)	(18.51)	(43.56)	(12.15)	(20.17)	(46.25)
NW coast	−321.3**	−251.7**	−131.7	−321.3**	−249.7**	−135.7*
	(19.44)	(20.16)	(68.22)	(15.85)	(30.08)	(68.21)
Local cash	−253.4**	−198.6**	−205.4**	−253.4**	−197.0**	−204.2**
	(20.57)	(20.83)	(76.18)	(7.380)	(22.20)	(78.12)
Multiple 1	90.69*	71.33*	−16.68	90.69**	70.75**	−15.43
	(36.65)	(36.04)	(51.94)	(25.36)	(25.79)	(51.93)
Multiple 2	1685**	1325**	1580**	1685**	1314**	1581**
	(36.65)	(49.44)	(61.52)	(48.71)	(150.2)	(60.80)
Multiple 3	−173.3**	−134.1**	−124.9	−173.3**	−133.0**	−121.2
	(52.07)	(51.25)	(264.8)	(38.87)	(42.50)	(293.6)
Constant	283.7**	221.4**	243.7**	279.0**	216.3**	228.5**
	(13.57)	(14.57)	(25.05)	(9.228)	(24.40)	(25.83)
Observations	1888	1856	1888	1888	1856	1888
R^2	0.958	0.960		0.957	0.960	
Combined effect on sales (% of pre-treatment sales)	0.151	0.129	0.150	0.209	0.170	0.248

Note: Standard errors in parentheses, $^{**}P < 0.01$, $^{*}P < 0.05$. OLS, ordinary least squares estimates. Columns 3 and 6 contain the results for a linear panel model fitted with feasible generalised least squares (FGLS) and a panel-specific AR(1) autocorrelation structure.

to Supermarket-X stores. The combined effect of the in-store, point-of-sale, and market-wide advertising components represents an increase in mushroom shipments to Supermarket-X stores by 15.1 per cent ([458.8 + 23.44]/3193.87 = 0.151). Our estimated treatment effects could be attenuated towards zero because we did not have information on price promotions during the pre-treatment period, and shipments were significantly larger when mushrooms were on special during weeks in the treatment period. Column 2 contains the results for the specification including the lagged dependent variable ($QM_{i,t-1}$), and column 3 contains the results for the model estimated using feasible generalised least squares (FGLS) and a panel-specific AR(1) autocorrelation structure. The lagged dependent variable and FGLS models imply a combined effect of 12.9 and 15.0 per cent ([391.7 + 19.55]/3193.87 = 0.129 and [379.2 + 99.29]/3193.87 = 0.150) on total mushroom shipments to Supermarket-X, respectively. The in-store and market-wide effects were both statistically significant at the 1 per cent level in the FGLS model (see the last row of Table 3). The in-store, point-of-sale effects remained relatively stable across the three different specifications, suggesting that the presence of autocorrelation did not influence the estimates in which we were most interested, and correcting for autocorrelation does not change the principal finding.

Alternatively, we can model the effects of each component of the promotion campaign by including indicator variables that take a value of one if that component of the 'Power of Mushrooms' promotion experiment was underway at time t. For example, radio advertisements were conducted in two of the six months of the promotion campaign, and therefore, the variable $Radio_t$ takes a value of one in those months and zero in all other months. The promotion campaign also included a public relations component, PR_t, special events, $Event_t$, in store point-of-sale merchandising, POS_t, and television advertising, TV_t in some months (Supermarket-X displayed in-store, point-of-sale advertising materials during February, 2011 only, thus $POS_t = 1$ only in February, 2011). Table 3 includes the results from estimating this second regression model in columns 4–6 (again, we obtained very similar results if we included additional data for a longer pre-treatment period, September 2009 through August 2010). The treatment effect implies an increase by 19.5 per cent (621.7/3193.87 = 0.195) in the volume of mushroom shipments to Supermarket-X locations. The combined effect of the in-store, point-of-sale, and market-wide promotion components implies an increase by 20.9 per cent (667.67/3193.87 = 0.209) in the volume of mushroom shipments to Supermarket-X stores. The coefficient on $InStore_i.POS_t$ is significant at the 1 per cent level. The lagged-dependent-variable and FGLS models imply a combined effect of 17.0 and 24.8 per cent (543.8/3193.87 = 0.170 and 792.6/3193.87 = 0.248) on total mushroom shipments to Supermarket-X, respectively. Unlike the base and lagged dependent variable specifications estimated by OLS (columns 4 and 5), the FGLS estimation (column 6) suggests that the public relations, television, and special event components of the advertising campaign increased weekly mushroom shipments significantly. We interpret these results as evidence that the promotion as a whole significantly increased mushroom shipments and that both the in-store, point-of-sale and the market-wide components affected mushroom demand. That is, Supermarket-X, the only mushroom buyer we can specifically identify in our data as having point-of-sale mushroom promotion, had significantly larger volumes of mushroom shipments during the 'treatment period'.

3.2. Supermarket-X national market data

In addition to the within-Tasmania comparisons of wholesale shipments, we use aggregate market data from Supermarket-X, comparing year-on-year changes in retail sales for various time periods, all ending on April 3, 2011 when the test-market period ended, between Tasmania and mainland Australia. Recall, the data for Supermarket-X in Tasmania reflected the full treatment effect, including both in-store and mass media elements, whereas data for Supermarket-X on the mainland did not include any treatment effect but did have the same parent company and many store characteristics in common: a suitable control.

Information on retail sales by supermarket-X was provided by one of their suppliers. The data include information regarding both the Tasmanian and national markets on the value of fresh mushroom sales (all types) and the number of units sold for periods of 1, 4, 13, 26, and 52 weeks, all ending April 3, 2011. The supplier also provided information on the percentage changes in the value and number of units sold, relative to the same period one year previously, for the Tasmanian and national markets. Using these data, we can compare the growth in mushroom sales for Supermarket-X on the Australian mainland (the 'untreated market') versus the growth in mushroom sales for Supermarket-X in the Tasmanian market (the 'treated-market'). The year-on-year change is the difference between the most-recent observation for the period ending on April 3, 2011 (be it 1, 4, 13, 26 weeks, or 52 weeks) and the observation for the corresponding period, one year previously. Comparing this difference between Tasmania and the mainland is a difference-in-differences. Expressing the changes as percentage changes is a way of adjusting for the relative sizes of the two markets to make the figures comparable.

The figures reported in Table 4 include measures of differences (or proportional growth), and differences-in-differences, for (i) the value of sales, (ii) the number of units sold, and (iii) the unit value (we estimated the proportional growth in unit value as the proportional growth in total value minus the proportional growth in the number of units, an approximation that is reasonably close for growth rates of the magnitudes being measured here). As the table shows, in every time period (be it 1, 4, 13, 26 weeks, or 52 weeks), relative to the mainland markets, we saw greater increases in the value of sales in Tasmania (i.e., the value of sales increased by a greater proportion in Tasmania). In three of the five cases, this greater increase in the value of sales

Table 4 Difference-in-differences: gross comparison, Mainland Australia versus Tasmania

	Period ending on April 3, 2011				
	1 week	4 weeks	13 weeks	26 weeks	52 weeks
	Australian Mainland market				
Value of Sales ($'000)	1771.6	7071.6	22,346.7	43,849.7	89,987.5
Percent change in value of sales on one year ago (%)	9.2	6.4	5.9	8.3	7.3
Unit sales (thousand units)	288.0	1184.8	3742.2	7511.4	15,368.0
Percent change in units sold on one year ago (%)	1.6	2.6	2.7	6.3	4.7
Percent of change in value per unit on one year ago (%)	7.6	3.8	3.2	1.9	2.6
	Tasmanian market				
Value of sales ($'000)	39.0	153.7	490.6	902.8	1800.5
Percent change in value of sales on one year ago (%)	19.7	15.9	18.6	12.6	10.9
Unit sales (thousand units)	5.4	20.5	67.0	123.3	250.7
Percent change in units sold on one year ago (%)	21.9	7.7	10.8	5.5	6.1
Percent change in value per unit on one year ago (%)	−2.2	8.2	7.8	7.1	4.8
	Difference in differences: Tasmania minus Mainland Australia				
Difference in percent change in value of sales (%)	10.6	9.4	12.7	4.3	3.5
Difference in percent change in units sold (%)	20.3	5.0	8.0	−0.8	1.4
Difference in percent change in value per unit (%)	−9.8	4.4	4.6	5.1	2.2

reflected a greater increase in both volume (the number of units sold) and the value per unit sold. In the case shown in column 1, representing the week ending April 3, 2011, the result showed a relative decrease in price (or unit value) that was more than offset by a relative increase in volume in Tasmania. This was an anomalous week, owing to problems with the production of shiitake and gourmet varieties, and should be discounted accordingly.

In the case shown in column 4, representing the 26 weeks ending April 3, 2011, the result showed a relative decrease in volume that was more than offset by a relative increase in price (or unit value) in Tasmania. This latter outcome indicates we had both a relative increase in demand and a relative decrease in supply in Tasmania. It serves to remind us that these market-level data potentially reflect the interaction of differential shifts of both supply and demand, and that some further work is necessary to distil an understanding and measure of the impact of the treatment as distinct from other market adjustments that were also taking place. In the benefit–cost analysis, we use the results from the comparison with the mainland as our primary measure of the total impact. Corroboration is provided by the analysis of the more detailed data on wholesale shipments in Tasmania, with its formal statistical inference.

4. Benefit–cost analysis

In this section, we use the results from the previous section as measures of the impact of promotion on demand, in a supply and demand modelling framework, to infer measures of benefits to producers and consumers in Tasmania, and for Australia as a whole if the Tasmanian test-market programme were to be scaled up to the national market. Then we compare these measures of benefits with the costs of the programme to infer benefit–cost ratios.

4.1. Concepts and measures of benefits and their distribution

Figure 1 represents supply and demand for mushrooms in Tasmania, with and without the increase in demand in response to the test-market experiment (it does not show the impact of the collection of a levy to finance that expenditure). The initial equilibrium in the market is given by the intersection of initial supply, S_0 with initial demand, D_0 at the point E_0. After an increase in demand, represented as an increase in consumers' willingness to pay for the product by r per unit, the new equilibrium is at the point E_1, with a new price and quantity, P_1 and Q_1. So what we observe in the market is the increase in price from P_0 to P_1 and the increase in quantity from Q_0 to Q_1.

This information is sufficient to enable us to measure the producer benefits from this demand shift, but to measure the total benefits, we also want to know the size of the demand shift, which can be inferred if we know the magnitude of the elasticity (and thus the price slope) of demand, $\eta > 0$. Specifically, let $\mathrm{E}(Q) = \Delta Q/Q_0$ and $\mathrm{E}(P) = \Delta P/P_0$ denote the proportional

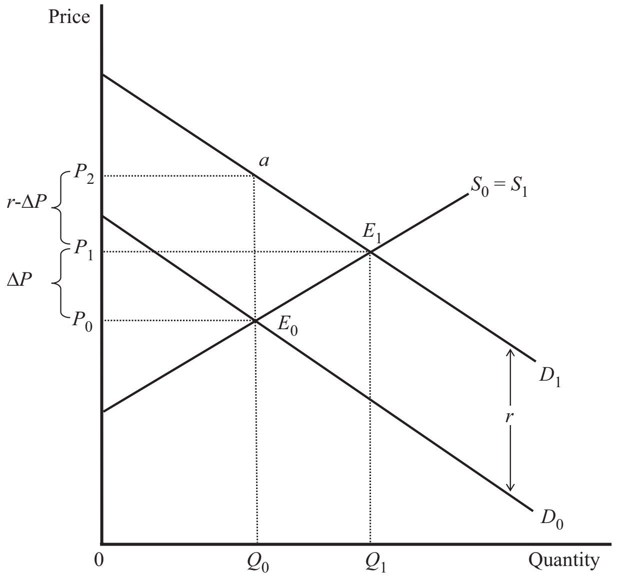

Figure 1 Interpreting Test-Market Data in a Commodity Market Model Framework.

changes in quantity and price relative to the initial equilibrium, which we observe as a result of the market experiment that causes a vertical displacement of demand by a proportion, $\rho = r/P_0$. Then we can estimate the proportional shift up in demand as:

$$\rho = \mathrm{E}(P) + (1/\eta)\mathrm{E}(Q). \tag{1}$$

For small changes (say, $\rho < 20$ per cent), we can approximate the changes in producer surplus (ΔPS), consumer surplus (ΔCS) and national economic surplus ($\Delta NS = \Delta PS + \Delta CS$) using:

$$\Delta PS \approx \mathrm{E}(P)P_0Q_0, \tag{2}$$

$$\Delta CS \approx \{\rho - \mathrm{E}(P)\}P_0Q_0 = (1/\eta)\mathrm{E}(Q)P_0Q_0, \text{and} \tag{3}$$

$$\Delta NS \approx \rho\, P_0Q_0 = \{\mathrm{E}(P) + (1/\eta)\}P_0Q_0. \tag{4}$$

Alston *et al*. (2003), Tremblay and Tremblay (1995), and Alston *et al*. (2007) discuss these measures, in particular the measure of consumer welfare change, which they argue is appropriate for promotion-induced demand shifts associated with signals about product quality.

4.2. The elasticity of demand for mushrooms

Estimates of elasticities of demand for mushrooms are scarce. The Centre for International Economics (CIE) (2008) published an estimate of 1.351 for Australia based on a model of demand for mushrooms within a system of equations for fresh vegetables, conditioned by expenditure on fresh vegetables. This estimate might not well represent demand response in a market setting, in which total expenditure on fresh vegetables may vary in response to price changes (see Okrent and Alston 2011 for details). Hazeldine and Huang (1990) estimated an elasticity of 1.02 for mushrooms from British Columbia, Canada, but this estimate was significantly influenced by international trade, and might not well represent market conditions in Australia.

We estimated a simple price-dependent demand model for domestically produced mushrooms in Australia using annual data for the period 1990/1991 (denoted 1991) to 2009/2010 (denoted 2010) provided by the AMGA. The dependent variable in the model was the price of mushrooms and the explanatory variables included per capita consumption of (domestically produced) mushrooms, per capita income, and AMGA promotion expenditure (both the expenditure and its square root), with all of the monetary variables (i.e., price, income and promotion) deflated by the GDP deflator, based in 2010 (macroeconomic data obtained from the Australian Bureau of Statistics 2010). Based on an inspection of the data and some experimentation with the

Table 5 Price-dependent mushroom demand model

	Parameter estimates	
	(1)	(2)
Per capita consumption (kg/year)	−1.45**	−1.64**
	(0.444)	(0.427)
Promotion expenditures (real 2010 millions $/ year)	3.97*	6.11**
	(1.317)	(1.134)
Square-root of promotion expenditures (real 2010 millions $/ year)	−8.88*	−14.33**
	(3.076)	(2.765)
1 year lagged price (real 2010$)		0.438
		(0.210)
Income per capita (real 2010 $1000)	0.039	0.05*
	(0.020)	(0.02)
Year 1991–1994 indicator	−1.06**	−1.30**
	(0.311)	(0.258)
Year 1995–1997 indicator	−1.28**	−1.40**
	(0.228)	(0.161)
Constant	13.16**	14.23**
	(2.363)	(1.752)
Observations	20	19
Durbin–Watson test statistic	1.34	
Alternative Durbin test statistic	1.37	0.43
Breush–Godfrey test statistic	2.05	0.79
R^2	0.71	0.81

Note: Robust standard errors in parentheses, $^{**}P < 0.01$, $^{*}P < 0.05$.

model, the preferred specification included separate indicator variables for the first four years of data (1991–1994) and for the next three years of data (1995–1997). The latter period, in particular seemed to exhibit a structural shift in price and promotion. We also tried a variant of the same model in which we included the lagged value of the dependent variable. Table 5 reports the estimates for these two models.

The two models in Table 5 fit the data reasonably well, and the parameters imply elasticities that conform to expectations. Specifically, an increase in mushroom consumption (quantity) results in a significant decrease in the price of mushrooms, and an increase in promotion expenditures results in a significant increase in the price of mushrooms. Both the Durbin–Watson and Breusch-Godfrey tests for autocorrelation of the residuals were applied. The Durbin–Watson test statistic fell between the upper and lower bounds of the critical value (5 per cent level of significance lower bound = 0.32, upper bound = 2.38 for $K = 8$, $N = 19$); thus, the test was inconclusive. That is, we can neither reject nor fail to reject the null hypothesis that the errors do not exhibit autocorrelation based on the Durbin–Watson test. However, the test statistics for the Breusch–Godfrey test and the alternative Durbin test (both have a chi-squared distribution) fall below the respective critical values, suggesting that the errors do not exhibit autocorrelation.

Table 6 Benefits from demand enhancement in the Australian mushroom market

	Period ending on April 3, 2011		
	13 weeks (1)	26 weeks (2)	52 weeks (3)
Measures of impact from the difference-in-differences, Tasmania versus Mainland			
(1) $100 \times \{E(PQ)\}(\%)$	12.7	4.3	3.5
(2) $100 \times E(Q)(\%)$	8.0	−0.8	1.4
(3) $100 \times E(P) = 100 \times \{E(PQ) - E(Q)\}$ (%)	4.6	5.1	2.2
$100 \times \rho = 100 \times \{E(P) + (1/\eta)E(Q)\}$			
(4a) with $\eta = 1.3$ (%)	10.8	4.5	3.3
(4b) with $\eta = 2.4$ (%)	7.9	4.8	2.8
(5) Tasmanian market value of sales, $V_0 = P_0Q_0$ (\$′000)	4334	8667	17,334
Measures of benefits (\$ ‘000) with $\eta = 1.3$			
(6a) $\Delta PS \approx E(P)P_0Q_0$	199	442	381
(7a) $\Delta CS \approx \{\rho - E(P)\}P_0Q_0$	267	−53	187
(8a) $\Delta NS \approx \rho P_0Q_0$	466	389	568
Measures of benefits (\$ ‘000) with $\eta = 2.4$			
(6b) $\Delta PS \approx E(P)V_0$	199	442	381
(7b) $\Delta CS \approx \{\rho - E(P)\}V_0$	144	−29	101
(8b) $\Delta NS \approx \rho V_0$	344	413	482
(9) Australian market value of sales, $V_0 = P_0Q_0$(\$′000)	190,615	381,231	762,462
Measures of benefits (\$ ‘000) with $\eta = 1.3$			
(10a) $\Delta PS \approx E(P)P_0Q_0$	8768	19,443	16,774
(11a) $\Delta CS \approx \{\rho - E(P)\}P_0Q_0$	11,730	−2346	8211
(12a) $\Delta NS \approx \rho P_0Q_0$	20,498	17,097	24,985
Measures of benefits (\$ ‘000) with $\eta = 2.4$			
(10b) $\Delta PS \approx E(P)V_0$	8768	19,443	16,774
(11b) $\Delta CS \approx \{\rho - E(P)\}V_0$	6354	−1271	4448
(12b) $\Delta NS \approx \rho V_0$	15,122	18,172	21,222

Note: Estimates of benefits are based on an approximation. They do not include benefits from savings in public health-care costs.

We computed own-price elasticities of demand at every data point for each model, and, in the case of the lagged-dependent-variable model, we computed both short-run and long-run elasticities. These elasticities have become smaller (i.e., less elastic) over the past 20 years. Taking the average across all years, model 1 implies an own-price elasticity of demand of 1.5, while model 2 implies an elasticity of 1.3 in the short run and 2.4 in the long run. In our benefit–cost analysis, we use an estimate of $\eta = 1.3$ as our baseline. We also try an estimate of $\eta = 2.4$, to illustrate the impact of varying this parameter.

4.3. Benefits from the test-market experiment

We combined our estimates of the elasticity of demand with the data in Table 4, to compute the approximate measures of benefits from the test-market programme. The first three rows of Table 6 correspond to the last three rows of the last three columns of Table 4, comparing growth in sales by

Supermarket-X supermarkets in the Tasmania and mainland Australia for intervals of 13, 26 and 52 weeks ending April 3, 2011. Consider the last column in Table 6, column 3, which refers to the 52-week period ending April 3, 2011. The entries in rows 2 and 3 measure the proportional increases in quantity and price attributable to the test-market promotion (i.e., the difference in the change, relative to the previous year, between the test market and the control). In this case, we have $E(P) = 0.022$ (or 2.2 per cent) and $E(Q) = 0.014$ (or 1.4 per cent). In row 4a, assuming the value of the demand elasticity is $\eta = 1.3$, combined with the entries in rows 2 and 3, implies an estimate of $\rho = 0.022 + (1/1.3)\,0.14 = 0.033$ (or 3.3 per cent); alternatively, in row 4b, assuming $\eta = 2.4$ implies $\rho = 0.028$ (or 2.8 per cent). These are alternative measures of the proportional increase in Tasmanian consumers' per unit willingness to pay for mushrooms, expressed over the entire 52-week period, as a result of the test-market experiment during part of that period.

Using equations (2–4) and an estimated annual retail value of production and consumption of Australian mushrooms in Tasmania of $P_0Q_0 = \$17.3$ million, with $\rho = 0.033$ and a proportional increase in price of $E(P) = 0.022$, in row 6a, we obtain: $\Delta PS \approx 0.022 \times \$17.3$ million = \$381,360 as a measure of the benefits to producers in Tasmania; in row 7a, we obtain $\Delta CS \approx 0.011 \times$ \$17.3 million = \$186,680 as a measure of the benefits to consumers in Tasmania; and in row 8a, we obtain $\Delta NS \approx 0.033 \times$ \$17.3 million = \$568,040 as a measure of the combined benefits to producers and consumers in Tasmania. In rows 6b, 7b and 8b, we have the corresponding estimates that would apply if we used a demand elasticity of $\eta = 2.4$ rather than $\eta = 1.3$. Columns 1 and 2 of Table 4 show the corresponding computations if we applied the same approach using the data for the 13-week period or the 26-week period instead of the 52-week period. The estimates of total benefits are reasonably similar, ranging from \$343,800 to \$482,480, but the distribution of the benefits varies much more, reflecting the fact that, in the 26-week period, the price rose by more than the estimated increase in consumer willingness to pay, such that consumers were made worse off.

The last seven rows of Table 6 display the corresponding measures of benefits to producers, consumers, and in total if the same changes in demand and price, as found in the test-market experiment were applied to total Australian production and consumption of mushrooms. The results imply national benefits in the range of \$17–25 million with $\eta = 1.3$ (see row 12a). These seemingly large values for benefits follow directly, given the relatively modest but nonetheless substantial increases in demand (willingness to pay) and price, applied to a \$762 million dollar market.

We have estimated benefits to producers and Tasmania as a whole of \$381,000 and \$568,000 over the entire year as a result of the test-market experiment in the latter half of that year which cost \$50,000. The implied benefit–cost ratio for producers if they had funded the entire expenditure would be $381/50 = 7.6{:}1$. Alternatively, for Tasmania as a whole, the implied benefit–cost ratio would be $568/50 = 11.4{:}1$ for $\eta = 1.3$ ($482/50 = 9.6{:}1$ for

η = 2.4). This aggregate benefit–cost ratio also corresponds to the benefit–cost ratio for producers if the same activity had been funded by a levy on mushrooms, in which case the costs would be borne by producers in proportion to their share of the benefits. This computation is very conservative in that it ignores the fact that mushrooms were being promoted at the usual rate in mainland Australia, such that the increased demand in Tasmania should be attributed only to the additional expenditure, beyond the normal amount (assuming that the new programme and the base programme would be equally effective). In other words, the same measure of benefits should be compared with only part—roughly half of the total expenditure during the experiment. Consequently, the true benefit–cost ratios for producers and society may be twice as large—15:1 if producers bear all the cost and 22:1 if they bear in proportion to their share of benefits. Such benefit–cost ratios are very favourable (a benefit–cost ratio of anything over 1:1 is sufficient to justify an investment). As documented by Kaiser *et al*. (2005) and Alston *et al*. (2007), estimates of the average benefit–cost ratio in this range have been found in previous studies of generic commodity promotion in the United States.

4.4. Extrapolation to the national market

A full ex ante cost–benefit analysis requires deducing a measure of the cost of a scaled-up national promotional programme that would be comparable to the test-market project that gave rise to the measured impacts on demand and price. Then we can consider whether that expenditure would be funded in a lump-sum fashion, wholly from grower levy funds; in a lump-sum fashion, partly or wholly from government (or taxpayer) funds; or from a levy the incidence of which is distributed between producers and consumers, depending on elasticities of supply and demand.

In the absence of that full ex ante analysis, the benefit–cost ratios from the test-market experiment are applicable directly as reasonable initial estimates of the likely benefit–cost ratios if the same kind of programme were applied in mainland Australia. They may well understate the true benefit–cost ratio if, as seems likely, there are significant economies of size and scale such that to achieve a given market impact would cost less on the mainland than in Tasmania. Moreover, knowledge derived from the test-market experiment might enable a more effective programme to be designed for the mainland market. And the measures of benefits described earlier do not allow for any potential spillover benefits arising from improved consumer health and lower public-health-care expenditures. Thus, from many perspectives, they may be seen as conservatively low estimates.

Other considerations relate to the dynamic impacts. In many cases, the impacts of promotion on demand are temporary, and sustained investment is required to sustain a given increase in demand. The analysis here has treated the effects of the programme implicitly as fleeting—we compared the benefits within one year against the costs within the same year. If the programme effects persist for multiple years—the strategy of the AMGA does aim to generate enduring, cumulative growth with successive health information messages—then we have underestimated the benefits. On the other hand, the dynamics could work in the other direction, where it may become increasingly difficult to sustain and augment past demand growth if consumers become increasingly resistant to information about mushrooms, or if other producer groups successfully promote other foods that compete for consumers' attention and budget. These speculations and caveats notwithstanding, we regard our estimates of producer benefits as conservatively low, if anything.

5. Conclusion

In this article, we have documented that the test-market experiment in Tasmania resulted in a significant increase in consumer demand for mushrooms, reflected in both an increase in the number of units sold and an increase in the average unit value. These changes were substantial and statistically significant. Qualitative and quantitative market research suggests that this change in consumer behaviour was in response to a change in consumer perceptions of the health consequences of eating mushrooms, which was the primary message communicated in the advertising campaign. The implied benefits for producers, consumers, and the State as a whole are substantial and several times greater than the cost of the test-market experiment. We estimated a conservative benefit–cost ratio for Tasmanian producers of 7.6:1 if they were to bear the entire cost and 11.4:1 if the programme were financed by a levy on production (or spawn). The aggregate benefit–cost ratio, including benefits to consumers was also 11.4:1. This benefit–cost ratio charges all of the expenditure in Tasmania against the measured benefits. A less conservative estimate would charge only the additional expenditure associated with the experiment against the measured benefits, implying benefit–cost ratios to producers of 15:1 if they bear the entire cost and 22:1 if they bear costs in proportion to their share of benefits. These estimated benefit–cost ratios are within the typical range for generic commodity promotion programmes, as reviewed by Alston *et al*. (2007). Most previous studies did not have the advantage of a controlled experiment, as in the present study, which adds to the relative credibility of the present findings.

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