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Title:

Pricing differentials for Organic, Ordinary and Genetically Modified food.

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Abstract

Purpose: Research was undertaken to determine whether consumers are willing to buy genetically modified (GM) foods with a price advantage and other benefits, compared to organic and ordinary types of foods. This question becomes important as the volume of GM foods grown and distributed globally increases as consumer fears surrounding perceived risk decrease and consumer benefits are made explicit.

Methodology: A real market setting involved cherries sold through a roadside stall in a popular fruit-growing region of New Zealand. In contrast to survey-based experiments on choice and willingness-to-buy, which may lack credibility with some practitioners and academics, customers chose between three levels of price and three categories of fruit (organic, GM, and ordinary) in a real purchasing situation. Buyers were advised after presenting fruit for purchase that all the fruit was standard commercially-grown low spray residue fruit, that this was a university-run experiment, and that they could purchase the fruit at the lowest of the prices shown. Data were analysed with multinomial logit models. Parameter estimates are interpreted and instructive market scenarios are simulated.

Findings and Practical Implications: We conclude that (1) when the GM label is combined with a typical functional food benefit, GM fruit can indeed achieve significant market share amongst organic and ordinary fruit, even in a country where the GM issue has been highly controversial; (2) GM fruit can gain a sustainable competitive advantage from any price reduction associated with production cost savings and (3) market shares of organic fruit are least sensitive to pricing and the introduction of GM fruit.

Background

Resistance to GM foods is decreasing over time in most European countries and it is likely that this food technology will find some level of acceptance in many markets in the medium term (Gaskell, Allum and Stares, 2003, Knight, Holdsworth and Mather, 2003). Only a limited amount of research that could inform practitioners on the pricing of GM foods has been published (Boccaletti and Moro, 2000, Burton and Pearse, 2003, Moon and Balasubramanian, 2003).

These studies' designs are based on theories that consumer acceptance of GM food is based on knowledge, awareness and price of GM food (Boccaletti and Moro, 2000), including a focus on the source of the genes used in the GM process (Burton and Pearse, 2003) and ethical beliefs about the use of GM in food (Moon and Balasubramanian, 2003)

The results of these studies in aggregate suggest that:

1. There is significant resistance to GM foods compared to ordinary and organic foods.
2. Ordinary and organic foods can be successfully priced at a premium to GM foods.
3. GM foods can gain reasonable market shares if priced lower than ordinary and organic foods.

This study advances pricing knowledge by applying a more robust methodology capable of falsifying these three assertions.

Limitations of the existing literature

Limitations on the direct applicability by practitioners of this published research, include:

1. Price differences used in the research experiments (Boccaletti and Moro, 2000, Burton and Pearse, 2003, Moon and Balasubramanian, 2003) were presented as

whole dollar amounts with no reference to actual market prices. There were no market criteria presented by these prior studies for the prices used.

2. The aggregate results of the studies cited above are derived from multiple studies comprising conditional logit or probit model parameters. However, these are not directly comparable, owing to unmeasured and confounded model scale parameters related to each study's residual variance (Louviere, Hensher and Swait, 2000) and also variations in the sample populations and product categories amongst the studies.
3. The reliability of inferences for product and portfolio pricing, taken from the regression parameter estimates generated from survey-based choice and contingent valuation studies, has been criticised by several authors on the grounds that actual buying behaviour may differ from what respondents say they will do, i.e. the stated-to-revealed preference bias (Cummings, Harrison and Rutstrom, 1995, List and Gallet, 2001, Loomis, Brown, Lucero and Peterson, 1996, Lusk, 2003, Neill, Cummings, Ganderton, Harrison and McGuckin, 1994). Lusk's use of a "cheap talk" approach to reducing this stated-to-revealed preference bias was highly, but not completely, successful. However, "cheap talk did not reduce willingness-to-pay for knowledgeable consumers" (Lusk, 2003).

Usually, revealed preference choice studies have been limited to existing, operational markets and products (Louviere, Hensher and Swait, 2000). Some innovative authors have administered experiments designed to address the generic issue of differences between revealed and stated preference or willingness-to-pay studies (Bishop and Heberlein, 1979, Bohm, 1972, Dickie, Fisher and Gerking, 1987, Kealy, Montgomery and Dovidio, 1990) but only one research team (Bishop and Heberlein, 1979, Bishop and Heberlein, 1986) explored new products or services, albeit via the rather expensive method of creating an artificial market for various hunting licenses. The present study is unique to the best of the authors' knowledge in that this is an experiment containing new products administered to an existing market.

Methodology and Approach

To address the limitations outlined above, and to run an experiment containing new products administered to an existing market, a robust and efficient study was developed incorporating:

1. A designed experiment comprising three levels of price amongst three alternative categories of fruit. The design of the three price levels, specific to each category was implemented as (a) 15% price premium above the average market price, (b) average price on the day or (c) a 15% price reduction below the average price. The average price was based on local market prices on the starting day of the experiment. The $\pm$ 15% variation covered typical seasonal and product variety price fluctuations observed prior to the research being undertaken in the local fruit market.
2. A highly realistic choice setting of an actively trading and attractively advertised roadside fruit stall. An established (but disused) fruit stall was rented near a popular fruit-growing region during the time of year when the fruit is typically available, advertised and frequently purchased from local roadside stalls.
3. Cherries were chosen because they are a popular fruit when in season and commonly consumed without preparation. This characteristic makes the issue of topical spray residue highly salient.

4. An efficient experimental design, enabling alternative-specific coefficients for the three food categories and three corresponding alternative-specific price parameter coefficients, to be estimated simultaneously.

In order to successfully administer an experimental design on price into an actual retail outlet the design must be blocked into single runs. That is, each customer only makes one purchase choice in a single natural buying occasion. This is necessary to fully address limitation three: the stated-to-revealed preference bias. The choice set comprised four options. Three options were made up of the cherry produce presented for sale, differentially labelled on their price and produce type. The fourth option was for the buyer not to buy any fruit at all. This contrasts to the usual choice experiment application where complete designs or larger blocks of multiple scenarios are sequentially presented to the same respondent. The single purchase buying occasion technically limits the modelling to a single aggregate model for the whole market rather than multiple individual or several segment-aggregated choice models. However this does not limit the generalisability or applicability of the research inferences derived from the aggregate market model.

An efficient resolution III, or main-effects-only, design for three levels of alternative-specific price was found using SAS® based on its endogenous design efficiency measures, with nine runs of different price scenarios. This is a significant efficiency gain on the full factorial design of $3^3 = 27$ runs, and greatly reduces the costs of this type of experimental test market research. Dominated and implausible alternatives in the choice sets may occur as a consequence of the attribute combining process to form choice options (Morrison, Blamey, Bennett and Louviere, 1996). Cautions against using designs that include dominated alternatives because 'the respondent choices do not reveal information about trade-offs between the levels of different attributes' do exist (Carson, 1995). However, what might appear to be a dominated or implausible alternative to the researcher or a respondent may not be for another, so the options generated by the design were used as generated. This led in one run to a two-dollar price difference between two alternatives, reflecting the two extreme price points. This reflects actual market pricing that would apply where the organic product has little visual appeal and is priced accordingly, and strengthens the estimate of the maximum market demand for "organic", realised at a significant discount.

Choice experiment stimuli

A locally grown premium cherry variety was bulk purchased for the research and used as the basis for all the produce presented in the experimental design fruit stall. These cherries, although they were all the same, were presented to shoppers in the fruit stall as three different types of cherry produce labelled as follows:

1. **ORGANIC biogrow certified**
2. **LOW RESIDUE Cromwell cherries**
3. **100% SPRAY-FREE genetically engineered cherries**

'biogrow' is an intentional mis-spelling of the 'Biogro'® registered trademark for organically certified food to avoid trademark infringement.

'Cromwell' is the area local to the fruit stall location well known for good eating cherries, which are grown under integrated pest management conditions and are assured to only retain, at most, very low pesticide residue.

The '100% spray-free' designation was based on a scenario where cherries were grown from trees incorporating the *Bacillus thuringiensis* toxin (Bt) gene so that they made their own natural insecticide, and therefore did not require spraying. The produce was described as genetically engineered (GE) because this term is more widely used and understood than GM in this market.

The fruit stall was staffed by carefully briefed and trained postgraduate marketing students employed as research assistants. If shoppers asked about the 100% spray-free GE fruit, the research assistants provided the scenario information described above.
Similarly, if shoppers asked about the spray status of the 'organic' cherries, then they were advised that Bt natural insecticide could have been sprayed onto the organic fruit to inhibit insect damage, a standard pest management practice in organic fruit production.

The cherries were pre-packaged in 250g, 500g and 1Kg bags and the advertised prices were the best 'odd' price closest to the experimentally designed unit price level. To implement the designed experiment in the retail purchase context, all prices were changed to the next design run after approximately every 50 customers, contingent on being able to change the labelling when no customers were present. Dates and times of the changes along with the actual prices used were carefully recorded and are reproduced in Table I, below.

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Extending Revealed Preference studies into the new product and feature domain

In the buying situation created by the fruit stall experiment, shoppers were temporarily guided in their choice by the experimental design labels until they presented at the cash register with their chosen fruit. At that stage in the choice experiment, shoppers were informed of the experimental nature of the fruit stall, that ethical approval had been given for this experiment by a respected university, and assured that the cherries were all the same - the usual low residue local type. They were then offered the opportunity to continue with their purchase at the lowest of the prices on display. If other shoppers were present, customers presenting at the cash register were silently informed by the presentation of a laminated A4 card so as not to alert the other shoppers.

Data collection

Data collection was undertaken using an electronic cash register, which automatically time-stamped the data, allowing the individual shopper's choice and demographic data to be linked to the experimental price design for analysis. Shoppers' actual cherry choice was recorded as part of the cash register operation, but the final traded price, i.e. the lowest price of the design offered to compensate the buyers for their involvement, was also entered as the cash register transaction amount. In addition the shopper's gender and approximate age were observed, and country of residence was determined by enquiry. This information was entered by the research assistants using additional register codes associated with each transaction. Non-choice stall visits were also recorded using the same system. All register mis-key mistakes were carefully corrected and all the register transaction records were securely stored for analysis. Choices of 414 subjects were observed and recorded in this way.

Data Analysis

The discrete choice data was analysed using: 1) a conditional multinomial logit, or MNL, model, (McFadden, 1973) and 2) a more general heterogeneous, or random-slopes, logit model (Boyed and Mellman, 1980), implemented as linear and non-linear mixed models (Chen and Kuo, 2001) with further extensions (Mather, 2003). These latter models are much more general than the simpler conditional MNL model, as they have the desirable property of fitting a wide range of more general Random Utility Maximisation models to an arbitrary accuracy, restricted only by mild assumptions and notably not constrained by the strict assumption of independence of irrelevant alternatives (IIA). This broader class of models controls for unobserved sources of variation associated with conditional MNL models (McFadden and Train, 2000).

Demographic variation among buyers was explicitly modelled as stratifications or mixed effects and the three alternative-specific coefficients, or fruit produce intercepts, and their three alternative-specific price effects were estimated as significantly different from zero at the 95% confidence level.

For the heterogeneous, i.e. mixed multinomial logit models, a range of variance structures were modelled. This range included a ‘variance component’ structure, where each alternative has a different variance estimate, and an ‘unstructured variance’ structure, where, in addition to the alternative variance estimates, co-variances between alternatives are also modelled. Research has shown that where significant variance structures exist it is important to include them in a mixed model specification to avoid bias in the fixed effects estimates (Jain, Vilcassim and Chintagunta, 1994).

Additional contrasts were estimated amongst the three alternative-specific coefficients and amongst the three alternative-specific price effects. For these estimations, prices were coded as real prices, rather than level dummy coding, so the price parameter estimates reflect the effect of a dollar difference on the utility of the cherry varieties. The contrasts, or differences, were tested at the 95% confidence limit. Due to the compensatory gradients of increasing cherry produce value and increasing price sensitivity estimates from organic through ordinary to spray-free cherry produce, market simulations were necessary to evaluate and highlight the combined effects on expected market share of these parameter estimates.

Results

The ordinary, fixed-slopes multinomial logit model was estimated from 1656 observations. These comprised 4 observations for each of the 414 respondents, corresponding to 1 observation per possible alternative choice among the three fruit options and including the 'no choice' option.

The dimensions of the demographic subject effects were reduced using principle component analysis, and the resulting orthogonal principle components were specified as alternative-specific 'random coefficient' subject effects in all models, using a similar approach to that taken for specifying Random Coefficient Structural Equation Models (Haubel, Elrod and Tipps, 1999). The four component subject effects that were significant at the 95% confidence level were included in all models but are not reported on here as they only serve to control for subject demographic effects in a parsimonious way to improve the generalisability of the subsequent model inferences.

<editor: Take in table II about here please>

However all produce and price parameter estimates were significantly different from 0 at the 99.98% confidence level or better.

Contrasts or differences between pairs of relevant product and price parameter estimates were also tested for significance.

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From these results above a decreasing value gradient in the aggregate market can be seen, from organic through ordinary to spray free GE produce, controlling for, or taking out, the effect of price. An increasing price sensitivity in that same direction can also be seen. The differences between organic and ordinary parameters are the least significant, around 60% to 80% confidence levels, the differences between ordinary and GM parameters are more significant, around 88%-89% confidence level, and the differences between organic and GM parameters are highly significant, around 99.5% to 99.8% confidence levels.

These general inferences are supported by the parameter estimates of the random slopes or mixed multinomial logit models within the fixed MNL parameter estimate standard errors specified above. Several variance structures were modelled. Through the model selection process only a single-banded or variance component variance structure, i.e. a set of variance components, one for each of the produce type intercepts, without any covariances, was supported. The random intercept variance estimates in the mixed MNL models were approximately equal to unity, and the extra-dispersion scale factor (Mather, 2003) was within a binary order of unity, both confirming the functional form suitability of a single-stage, i.e. non-nested, MNL model kernel. Taken together, these results indicate that the impact of either potential unobserved variations or heterogeneous variance structures in the data is not enough to change the broad inferences gleaned from the fixed MNL model (McFadden and

Train, 2000). Note that with single-run-blocked experimental studies and supermarket scan data and short-run scan panel data studies, it is essential to check for bias due to confounded sources of unobserved variations using these mixed MNL model formulations as the lack of a repeated subject structure in the data makes it impossible to otherwise control for bias due to un-partitioned within-subject and between-subject variance. Further results from the Mixed MNL models are omitted, because in this study they do not alter the inferences generated by the fixed MNL model and therefore do not add additional information.

Market Pricing Share Simulations

Instructive aggregate market shares can be simulated from the varied market pricing scenarios using the logit functional form. These simulations assume full distribution and awareness. That is, the model strictly reflects a market situation where all three alternatives as specified are available at all outlets, and where all potential customers are aware of the availability and price.

Simulations were calculated using the multinomial logit form as follows :

$$\hat{\mathrm{M}}s_{jk} = \frac{e^{\hat{\alpha}_j + \hat{\beta}_j x_{jk}}}{\sum_i e^{\hat{\alpha}_i + \hat{\beta}_i x_{ik}}} \quad \text{where}$$

$\hat{\mathrm{M}}s_{jk}$ is the estimated market share for the jth. alternative of fruit type for the kth. scenario to be simulated, defined by a vector of 3 alternative prices.

$\hat{\alpha}_j$ ($\hat{\alpha}_i$) is the fruit type intercept estimate for the jth. (ith.) alternative, or fruit type,

$\hat{\beta}_j$ ($\hat{\beta}_i$) is the price sensitivity parameter estimate for the jth. (ith.) alternative or fruit type,

x_{jk} (x_{ik}) is the level of price, in dollars, simulated for the jth. (ith.) alternative or fruit type, defining part of the kth. scenario.

i is the index, varying from 1 to 3, over all the alternative fruit types.

<editor: Take in Table IV about here please>

While the significance of the differences between these market share estimates varies throughout Table IV above, all of the differences are at least significant at the 80% confidence level except for the differences between Ordinary and GM in the first simulation row and Organic and Ordinary in the second simulation row of Table IV. These two pairs of market share estimates are similar as the differences in value between fruit types are almost exactly compensated for by differences in value owing to price sensitivities.

The first simulation demonstrates the implication of the higher intercept estimate for ‘organic’ produce and ‘average’ market pricing, resulting in a much higher, almost dominant, market share. This is unlikely to be realised in many actual markets due to a typical lack of production volume and distribution as well as the trend to premium pricing of organic produce, due in part to higher labour costs, lower yields and reduced economies of scale.

The second simulation demonstrates the implication of the increased price sensitivity of the market to the ‘100% Spray-Free’ GE pricing. If sprays are a significant proportion of total conventional production costs, this pricing strategy may be a source of sustainable competitive advantage for GE produce with a spray-free positioning since GE produce is likely to be cheaper to produce than either organic or ordinary produce.

The third scenario demonstrates the robustness of the market shares of all three produce types in the face of a simulated price war.

The fourth scenario also highlights another impact of the increased price sensitivity for the spray-free GE produce. This shows that cartel pricing or a premium pricing strategy across all three produce types is unlikely to be a successful pricing strategy for spray-free GE produce even if sprays are a significant proportion of production costs. This may however be a beneficial strategy for organic produce, depending again on organic production cost structures and economies of production scale.

Conclusions

This study provides further evidence of relative resistance to GE produce, even when combined with a positive functional benefit of '100% Spray-Free', compared to ordinary and organic foods. However this resistance appears to be compensated by competitive pricing strategies. Depending on associated cost structures, this may lead to a sustainable competitive advantage for spray-free GM produce and reasonable market share.

Several potentially viable pricing strategies appear to exist for organic and ordinary produce such that they may maintain price premiums and reasonable market share advantages in the presence of each other and spray-free GM produce in the market.

In summary, the potential for GM produce with functional consumer benefits and reduced production costs appears promising, as does the ability of producers to maintain price premiums for organic produce, and to a lesser extent, ordinary produce. The research has successfully tested a robust methodology using an experiment containing new products administered into an existing market to generate results which practitioners can apply with some validity.

Limitations and future directions

This study used only one type of fruit, cherries, and further generalisations of these results are desirable. Researchers are encouraged to investigate other foods using the techniques developed in this study.

A limitation of the sampling and data collection technique described here is that the sample is not a true random sample of the cherry-buying population in an area but is similar to a mall-intercept sampling scheme.

Another limitation is that these experimental stalls or retail outlets are limited in operation to areas where there is little or no resistance from regulatory bodies, surrounding stallholders or other retailers to the retail operation described. It is possible that existing retail operations could be used, but the necessary experimental market, and possible loss of reputation would pose problems for a retailer.

The amount of detailed planning, preparation and initial financial resources necessary to field an experimental study of this type is much greater than that for a typical survey-based, new product pricing study. Future research might profitably combine several typical surveys with one set of data gathered using this method to augment the reliability of the combined inferences without unacceptable increases in research costs and resources.

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Table I

Nine-run, 3-price, 3-level experimental design showing the nearest odd price per 250g

Run	organic price	ordinary price	spray-free GE price	start date-time	end date-time
1	$4.45	$5.45	$5.45	16DEC03:10:30:00	16DEC03:16:33:00
2	$6.45	$5.45	$6.45	16DEC03:16:34:00	17DEC03:13:50:00
3	$6.45	$6.45	$4.45	17DEC03:13:51:00	17DEC03:19:08:00
4	$4.45	$4.45	$4.45	18DEC03:10:45:00	18DEC03:16:22:00
5	$5.45	$6.45	$5.45	18DEC03:16:23:00	19DEC03:12:33:00
6	$4.45	$6.45	$6.45	19DEC03:12:34:00	19DEC03:17:26:00
7	$6.45	$4.45	$5.45	19DEC03:17:27:00	20DEC03:14:06:00
8	$5.45	$5.45	$4.45	20DEC03:14:07:00	21DEC03:10:48:00
9	$5.45	$4.45	$6.45	21DEC03:10:49:00	21DEC03:16:16:00

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Table II

Multinomial Logit Parameter Estimates for Cherry Type and Price Sensitivity

Parameter	**Estimate**	**Std Error**	**ChiSquare**	**P(ChiSq>0 by chance)**
Organic type	4.01712	0.75064	28.6394	<0.0001
Ordinary Type	4.90652	0.88467	30.7601	<0.0001
Spray-Free GE	6.81226	0.82164	68.742	<0.0001
price organic	-0.50451	0.13748	13.4666	0.0002
price ordinary	-0.76204	0.16151	22.2614	<0.0001
price spray-free GE	-1.1112	0.15742	49.825	<0.0001

<editor note: this table is the authors' own work>

Table III

Multinomial Logit Parameter Contrasts between pairs of types and price sensitivities

Test of difference between estimates for:	**Wald Chi-Square**	**P(difference by chance)**
organic & ordinary types	0.6208	0.4308
ordinary & spray-free GM types	2.5605	0.1096
organic & spray-free GM types	6.0822	0.0137
organic & ordinary price sensitivities	1.4933	0.2217
ordinary & spray-free GM price sensitivities	2.3826	0.1227
organic & spray-free GM price sensitivities	7.7911	0.0053

<editor note: this table is the authors' own work>

Table IV

Market share simulations

Index	Scenario	Organic	Ordinary	Spray-Free GE
1	average market prices for all 3 produce types	46%	27%	27%
2	15% premium Organic, average Ordinary, 15% discount Spray-Free GE	20%	20%	60%
3	15% discount price war all 3 produce types	35%	27%	38%
4	15% cartel or premium pricing on all 3 produce types	56%	26%	18%

<editor note: this table is the authors’ own work>