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Diversification choices in agriculture: a Choice Modelling case study of sugarcane growers

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Growers in the sugarcane industry have been struggling under financial pressure for several years. One option to improve farm viability might be to diversify farm enterprise income. Choice Modelling, an economic valuation technique, was used to explore the trade-offs growers make between different attributes of diversification, and how their choices may be related to certain socio-economic characteristics. Application of the technique involved surveys of cane growers in three regions of Central Queensland. This is a novel approach to assessing grower intentions that has the potential to reveal detailed information about influences on grower choices.

Key words: choice modelling, farm diversification, sugarcane growers.

1. Introduction

Understanding the reasons why farmers diversify or switch to new crops is important if economists want to predict the speed of restructuring in industries that have been affected by external pressures (e.g., changed market conditions), or internal forces (e.g., farm agglomeration). In some cases, governments need such information to be able to design packages that assist in restructuring. In other cases, the information is important if predictions are to be made about the rate of take-up of new technology and innovations, or if new resource allocations rules (e.g., to irrigation water) are being considered (Marshall *et al*. 1997).

Economists often treat farming strategy and diversification choices as exercises in maximising behaviour and risk evaluation on the part of the farmer. However, simple rationality models are often deficient in explaining why farmers often continue to operate in suboptimal conditions when economies of scale mean that small farm sizes may be unviable, or when industry downturns make some farmers unviable (Murray-Prior and Wright 2001). The explanations for such behaviour are to be found in the non-commercial rewards that farmers enjoy, human, social and infrastructure capital that do not enable speedy adjustment to new conditions, attitudes to risk and tactical opportunities, and institutional impediments to change. All of these factors make specific predictions about structural adjustment more difficult in practice.

Social scientists have examined the potential of certain socio-economic characteristics to act as indicators of capacity to change or adopt new practices, but most of

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the emphasis has been on the adoption of more sustainable management practices rather than on the adoption of new cropping systems. There is often mixed evidence about the specific influence of some more commonly identified characteristics such as age, education and the extent of off-farm income (Cary *et al*. 2001, 2002; Productivity Commission 2003). For example, age can be seen as an impediment to change as older growers are more set in their ways (Fenton *et al*. 2000), but on the other hand they have more farming experience (Anosike and Coughenour 1990).

Economists have also shown how institutional settings and structural factors affect grower responses. The extent of restructuring in the dairy industry was a direct consequence of the separate state markets that developed for both market milk and manufacturing milk (Edwards 2003). In the sugar industry, the quota system used to provide a major barrier to farmers leaving the industry because there was no guarantee that quota could be easily regained (CIE 2002). In both the dairy and sugar industries, continued high levels of government assistance led to moral hazard problems, where exit from the industry meant giving up those levels of government support.

Differences in grower characteristics and structural factors make it difficult to predict ex ante how growers will respond to changed market conditions and opportunities to diversify. In the present paper a new approach is outlined, where a stated preference technique, Choice Modelling, is used to assess grower preferences. The technique has potential advantages in being able to assess preferences *ex ante* and in being able to specify how different attributes affect choices. In this paper, the application of Choice Modelling to diversification choices in the sugar industry is demonstrated.

This paper is organised in the following manner. A brief background to the assistance being provided to the sugar industry and the relevance of diversification is outlined in the next section. The methodology is outlined in Section 3 and the results are presented in Section 4. The results are discussed in Section 5 and conclusions drawn in the final section.

2. Need and potential for diversification in the sugar industry

In 1997, tariffs on imported sugar were removed and domestic price supports were dismantled. This left producers, in an industry that had been highly protected prior to the early 1990s, exposed to the influence of external market forces. In subsequent years, there were major falls in world market prices and adverse weather conditions in many sugar growing areas. As a result, growers in the industry have been under substantial financial pressure. In 2000, the Commonwealth Government introduced an $A83 million Sugar Industry (Cane Growers) Assistance Package, but producers in the industry continued to struggle and in 2002, further assistance packages were announced by the Commonwealth ($A150 million) and Queensland ($A30 million) governments. Hildebrand (2002), in a comprehensive review of the industry, considers many farms to be economically unviable and a key component of each package is support for regional adjustment, diversification and industry rationalisation, including measures to improve farm viability and consolidate farms into larger units (Productivity Commission 2002). Some farmers will not be able to expand and a more viable economic option might be to diversify farm enterprise income. However, little information exists to identify the

willingness of sugarcane farmers to explore diversification opportunities, and how this may vary from one region to another.

There are a variety of possible diversification options for sugarcane growers in the Central Queensland area, some sharing similar characteristics to sugarcane. For example, a variety of small horticultural crops may have similar characteristics such as reasonably low production costs and relatively quick returns. Other options such as fruit trees may have high start-up costs and a long wait before the first return. There are different attributes of diversification, such as production costs or start-up costs that may be common to an identifiable group of crops. While market information is available for some attributes such as costs and returns, other attributes such as risk and the amount of management effort involved may not have market values. The focus of this study was to examine sugarcane growers' preferences for different attributes of diversification and how they may trade-off these preferences.

3. Methodology

Choice Modelling (CM) is a non-market valuation technique that was used to predict the choices that farmers might make. CM has become popular for eliciting values for environmental goods with multiple attributes (Adamowicz *et al*. 1998; Blamey *et al*. 1999). There is developing interest in adapting non-market valuation techniques to predict agricultural decision making (Lusk and Hudson 2004). This study represents one of those cases, where CM has been applied to predict diversification choices in the sugarcane industry.

A methodological issue is whether a stated preference approach is accurate, or whether a revealed preference application maybe a more appropriate technique. There are three main reasons why the use of stated preferences can be justified. First, it could be argued that growers are not able to make informed choices. It was difficult to collect technical information for the alternative crops presented in the CM survey, indicating that growers have limited information available about diversification options. Given the current downturn in the sugar industry though, diversification choices are of key interest, and a survey would be drawing on the current information set held by growers. Second, because the experience with diversification is limited, there would be a very restricted pool of growers to which a revealed preference technique could be targeted. Third, the main advantage of using a stated preference technique is that it can provide *ex ante* information, so the results of a study can help decision makers better understand how sugarcane farmers are reacting to structural readjustment and how assistance packages may be better targeted.

The CM technique involves respondents in a survey setting being asked to state their preference or choice when presented with a series of options. Each option is described in terms of certain attributes that are consistent across options but with varying amounts (levels). Respondents are required to choose a particular option and in doing so they indicate how they make trade-offs between the different attributes.

The CM study described in this paper involved a survey of sugarcane growers in three regions of the Central Queensland cane growing area – Mackay and Sarina (henceforth referred to as Mackay), Proserpine, and Bundaberg and Childers (henceforth referred

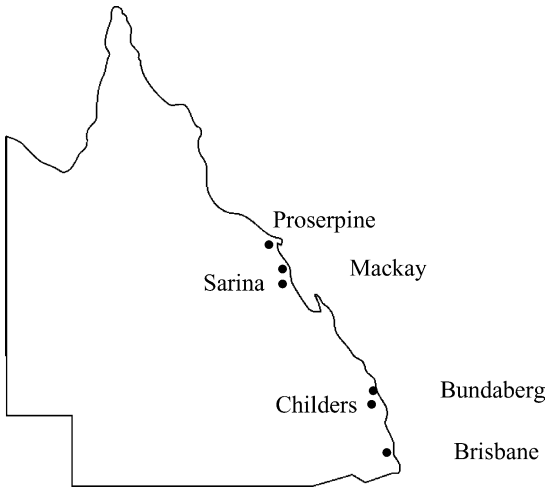

Figure 1 Locations of sugarcane study areas in Queensland

to as Bundaberg) (see Figure 1). Survey respondents were asked to make a series of choices about alternative options for diversification. Each choice set involved a number of options describing the alternatives on offer. The first option was to keep growing sugarcane and not to diversify. This option remained constant between the choice sets. Six other options were presented in each choice set (Table 1).

Each option was labelled and the labels remained the same in each choice set. Each option was described in terms of the same five attributes:

- Start-up costs
- Production costs
- Risk
- Management effort
- Net annual income

These attributes were used to describe a combination of financial and non-financial considerations important in any decision to diversify. While production costs are accounted for in net annual income, it was included as a separate attribute to provide some indication of cash flow and workload requirements.

Table 1 Diversification options presented to growers

	Attribute information based on:	
Diversification options	Mackay/Proserpine	Bundaberg
Beef cattle	Breeding and fattening	Same as Mackay
Tree crops	Lychee and mango	Same as Mackay
Horticulture (annual)	Watermelon and pumpkin	Same as Mackay
Horticulture (nonannual)	Banana and pawpaw	Lady-finger banana and pineapple
Field crops	Maize and mung bean	Sorghum and soya bean
Forestry	Wood-chip and sawlog	Same as Mackay

Table 2 Survey response rates in Mackay, Proserpine and Bundaberg regions

	Mackay	Proserpine	Bundaberg
Callable listings	990	218	735
Contact made	588	145	458
Agreed to participate	458	118	358
Surveys collected	391	99	302
Response rate	67%	68%	66%

The attribute levels associated with each option varied in each choice set and there were three choice sets in the survey (one per page) so that respondents were asked to make a series of similar, but different choices. Full details of attribute levels, an example choice set and other survey details are presented in Windle *et al*. (2003).

The survey design and content was developed in discussion with various experts, and was amended on the advice from grower focus groups held in the Mackay region. All technical details and information presented in the section on crop diversification was based on information provided by relevant experts in the Central Queensland area. Proserpine is only 130 km north of Mackay and as bio-physical conditions are similar in the two regions, the same questionnaire was used in both regions. Bundaberg is 700 km south of Mackay and as conditions were not the same, information provided in two of the options differed in the Mackay and Bundaberg surveys (see Table 1).

The experimental design for the survey generated 81 different choice sets. Each survey had three pages of choice sets and there were 27 different versions of the survey, each with different combinations of attribute levels.

3.1 Survey details

Three surveys were conducted in the Central Queensland area. Sugarcane growers in Mackay were surveyed in December 2002, growers in Proserpine were surveyed in January 2003, and growers in Bundaberg were surveyed in February 2003. The same collection technique was applied in all regions. First, attempts were made to contact all growers by telephone and establish whether or not they were willing to complete a questionnaire survey.[1] Several attempts were made to contact growers at various appropriate times. Surveys were then delivered to the homes of those willing to participate and later collected from them – a drop-off and pick-up collection technique. A high response rate of over 66 per cent was obtained (Table 2).

4. Results

There is little information on the socio-economic characteristics of sugarcane farming systems in Queensland and so important baseline information was collected (Table 3). This information also provides a reference point on which to assess the influence of

[1] Contact information for growers was supplied by CANEGROWERS organisation and related to Cane Production Areas, rather than individual growers. Information was edited for multiple entries and current telephone numbers.

Table 3 Socio-economic characteristics of sugarcane growers in Central Queensland

		Mackay	Proserpine	Bundaberg
Age	Average	53 years	52 years	53 years
Education	Not completed Secondary	72.20%	66.00%	65.70%
Children	Have dependent children	40.8%	46.4%	37.2%
Experience*	Average	30 years	30 years	27 years
Off-farm income*	Have off-farm income	40.5%	49.0%	48.3%
Debt	Have farm debt	60.6%	66.3%	68.2%
Family workers*	1–2 family members working farm	70.1%	64.9%	69.8%
Labour	Employed labour	46.3%	34.4%	44.0%
Farm size*	Median area	128 ha	150 ha	96 ha
Sugar size*	Median area	97 ha	114 ha	66 ha
Other crops grown*	Other crops/cattle currently grown	29.7%	27.6%	52.5%
Tried other crops*	Have tried other crops/cattle	22.9%	21.4%	66.6%

*Statistically significant difference between the regions.

certain characteristics that were found to have a significant influence on choice, as outlined below.

While some characteristics were similar across regions, others were not. Farm enterprises were much more diversified in Bundaberg compared with Mackay and Proserpine. In Mackay and Proserpine, 29 per cent of respondents grew something apart from sugar, but the majority (86%) had cattle (a relatively low skill, low risk enterprise) as another farm enterprise (Windle 2003a). In Bundaberg, over half (52%) of respondents were growing something other than sugarcane, but of these, only 29 per cent had beef as the only other enterprise. The majority (75%) of respondents in Bundaberg had some experience, either current or prior, with growing cattle or crops other than sugarcane (Windle 2003b).

4.1 Choice Modelling results

In all areas, many growers chose the 'Keep growing sugar' option in all three choice sets (64%, 66%, and 41% in the Mackay, Proserpine and Bundaberg regions, respectively). As the purpose of this section of the survey was to examine influences on diversification choices, and these responses provided no such information, they were removed from the data set from which the choice models were developed. As a result, the choice models that were estimated only relate to the subset of growers who indicated some interest in diversification, which meant they may have selected the 'Keep growing sugar' option in some but not all of the choice sets.

The choice data were analysed and modelled using the LIMDEP software program. A two level (nested) choice model was estimated.[2] Respondents were assumed to firstly make a choice about whether they would stay in sugar production or if they

[2] An explanation and example of the use of nested models is given in Blamey *et al*. (2000).

Table 4 Variables used in the Choice Modelling application

Diversification attributes	
Start-up costs	Costs associated with establishing a new enterprise ($/hectare).
Production costs	Costs of producing the crop ($/hectare).
Risk	Years out of 10 income is at or below the cost of production.
Management effort	Management skills required to grow the crop – % change from the standard – that required to grow sugarcane.
Net annual income	Income minus production costs. Estimated over a 30-year period and accounts for delays until first harvest. Approximately the same as gross margins.
Socio-economic variables	
Age	Age of respondent (in years).
Education	Education (ranges from 1 = never went to school to 6 = tertiary degree).
Off-farm income	Household has off farm income, Yes (1) or No (0).
Debt	Household has farm debt, Yes (1) or No (0).
Children	Respondent has children, Yes (1) or No (0).
Constant values	
ASC2 (beef cattle)	Alternate Specific Constant which reflects the influence of all other factors on choice of each option as labelled. (These were not coded).
ASC3 (tree crops)	
ASC4 (horticulture annual)	
ASC5 (horticulture–non-annual)	
ASC6 (field crops)	
ASC7 (forestry)	
IV parameter	Provides a statistical link between the two levels of the nested model.

would consider diversification. This choice was modelled against the socio-economic characteristics of respondents. In the second stage, respondents were assumed to choose between the alternative diversification options presented, according to the levels of each attribute. The nested model was used for the respondents making some diversification choices because it was expected (from focus group results) that this most accurately reflected the choice processes that growers would have followed.

Generating nested models involves two different types of variables. The branch choice equation (explaining the sugar/diversify choice) involves attributes that represent the socio-economic characteristics of the survey respondents. The utility functions that predict choices between different diversification alternatives involve the choice set attributes. In addition, an inclusive value (IV) parameter is included that specifies the link between the two levels of the model. Each of the variables used in the nested model are specified in Table 4.

Model results for the three regions are presented in Table 5. These related the probability of choosing a choice profile to the attributes describing a profile, selected demographic characteristics of respondents, and a constant reflecting the influence of other factors. The IV parameter to diversify is significant in all three models, confirming

Table 5 Nested multinomial logit models for Mackay, Proserpine and Bundaberg

	Mackay		Proserpine		Bundaberg	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Branch choice equations						
Off-farm income	−0.1144	0.2347	−1.1861**	0.5999	−0.0211	0.2344
Debt	0.1957	0.2387	0.7071	0.6399	−0.1279	0.2377
Age	0.02657**	0.0130	0.0608	0.0389	0.0011	0.0128
Children	−0.6405**	0.2726	1.9590*	1.0435	0.1137	0.2723
Education	0.1670	0.1118	−0.4447	0.3488	−0.2106**	0.1057
Utility variables – diversification attributes						
Start-up costs	−0.0000	0.0000	0.0001**	0.0000	0.0000	0.0000
Production costs	−0.0000	0.0000	−0.0000	0.0000	0.0000	0.0000
Risk	−0.0060	0.0046	−0.0217*	0.0117	−0.0140***	0.0054
Management	0.0007	0.0041	0.0073	0.0077	−0.0018	0.0058
Net income	0.0001***	0.0000	0.0001*	0.0000	0.0000**	0.0000
Asc2 – Beef	−0.4429	0.3292	0.1583	0.5966	−1.4655***	0.3376
Asc3 – Tree crops	−1.5881*	0.8310	−3.6499**	1.6718	−1.4795**	0.7080
Asc4 – Hort. annual	−1.0678**	0.5438	−0.4037	1.0419	−0.7689	0.5301
Asc5 – Hort. nonannual	−2.5851***	0.9959	−2.3838	1.8669	−1.6932***	0.5881
Asc6 – Field crops	−1.0815**	0.4875	−1.3876	0.9716	−0.6064	0.5314
Asc7 – Forestry	−1.5429***	0.3926	−1.6952***	0.6559	−2.2480***	0.4160
IV parameter						
Sugar (fixed parameter)	1		1		1	
Diversify	5.6912**	2.7407	7.4570**	3.7015	3.5963*	2.1148
Model statistics						
N (choice sets)	460 (9 skipped)		96 (0 skipped)		525 (0 skipped)	
Log likelihood	−775.173		−148.457		−978.455	
Adj R^2	0.114		0.156		0.122	
χ^2(degrees of freedom)	210.848(17)		65.515		283.140(17)	

***Significant at the 1 per cent level, **significant at the 5 per cent level, *significant at the 10 per cent level.

an appropriate use of the nested model. While the models show broad similarities in the ways that growers make diversification choices, they also reveal a number of differences at the regional level.

5. Discussion

In all of the models there were some alternate specific constants (ASC) that were significant and negative. This meant that factors other than those included in the model were a significant influence on the selection of the option. The negative signs were expected because the alternatives were assessed against the sugarcane option. These results indicate that there are other factors which make sugarcane a preferred crop for growers.[3] While the ASC values varied in their level of significance, the values of the associated coefficients provide an indication of the strength of association.

[3] A significant ASC constant means that other factors were influencing choice of the specific option. In Windle *et al*. (2003) multinomial logit models were developed that identified the socio-economic variables which were significant in the selection of each specific diversification option. In these models the ASC constants were not significant, indicating the models included all factors influencing choice.

In Mackay, the two options that were most preferred are those that complement sugarcane (or allow a switch back to sugarcane production at low cost). Field Crops and Annual Horticulture are both options that can also be combined with sugarcane production. In Proserpine and Bundaberg, fewer of the ASC values were significant, and rankings differed from those in Mackay. In Bundaberg, Beef was the most preferred option. If land is available, it is a low risk, low cost (including management) option. In contrast to the options mentioned above, Forestry and Tree Crops (significant in Proserpine and Bundaberg) are much longer term commitments without immediate returns. This is also true, albeit to a lesser extent, for Non-Annual Horticulture (Bundaberg). They represent a much higher risk diversification strategy and would require higher levels of knowledge and understanding.

There was also some variation across regions in the way that attributes entered the choice models. The only diversification attribute that was significant in all three regions was *Net Annual Income*. This would indicate that, while other factors may be influencing growers' choices, profit maximisation was a key element in decision processes.

Risk was a significant attribute, in Proserpine and more so in Bundaberg, but not in Mackay. The lack of significance in the Mackay model was unexpected, because farmers' attitude to risk has been identified in many other studies as a key element in crop choices (Marshall *et al*. 1997; Marra *et al*. 2003). It is possible that growers in Bundaberg could relate to this attribute to a greater extent than growers in Mackay and Proserpine who had had less experience with other crops (see Table 3). In this case, the non-significance of risk in the Mackay model can be explained by the lack of experience by growers.

Other financial attributes such as *Costs of Production* and *Start-up Costs* did not appear to have been a barrier to diversification and may have been considered as included in an assessment of the gross margins.[4] It is perhaps surprising that start-up costs were not a more significant limiting factor in the regions, considering the relatively high percentage of households with some level of debt and the low incomes being experienced by many growers. The results indicate that access to capital is not a barrier to diversification.

Management Effort was not a significant attribute in the choice models, indicating that additional management effort was not considered by growers as a major cost of diversification. This was unexpected, because many other crops involve greater technical knowledge and management expertise than that required in sugarcane. It does indicate that management effort is not viewed by growers as a barrier to diversification.

The different preferences for diversification alternatives between the regions provide support for the work of Marshall *et al*. (1997) and Murray-Prior and Wright (2001) that growers often make diversification choices based on tactical issues rather than simple assessments of returns, risk, and other factors. In the case of Mackay where risk did not emerge as a significant attribute, the diversification alternatives that growers preferred

[4] To test whether there was an interaction between the diversification attributes, new combined attribute variables were created and new models run. The only combination that proved significant was a combination of production costs and net income in the Bundaberg sample. However, the strength of association was negligible with a coefficient value of 0.00000001.

most after sugarcane were complementary crops, or crops that allowed switching back to sugarcane at lowest cost.

The socio-economic variables that influenced the selection of a diversification option varied in each region. In Mackay, age was not an impediment to change in Mackay as suggested by Fenton *et al*. (2000), but as there was little experience with growing other crops (Table 3), it would seem unlikely that the older and therefore more experienced farmers would be able to apply this experience in their decision to diversify as suggested by Anosike and Coughenour (1990).

In the Bundaberg region, education was the only significant socio-economic variable that influenced the choice of whether or not to diversify. The relationship was negative; that is, those with higher levels were less likely to choose a diversification option. Although this finding is in contrast to many studies (Fenton *et al*. 2000), other studies have been less conclusive and the usefulness of this characteristic as an indicator of change must be questioned when education levels of growers are generally low (Cary *et al*. 2001).

There is contrary evidence to support the influence of off-farm income as an indicator of change. Fenton *et al*. (2000) suggest a negative relationship exists between off-farm income and the ability to experiment with new practices as time becomes a barrier. In contrast, the Productivity Commission (2003) found a positive relation with more sustainable practices, based on the improved affordability of such practices. In this study, off-farm income was the only significant variable in the Proserpine region, but not significant in the other regions. The negative relationship supports the findings of Fenton *et al*. (2000).

The other characteristic with influence in this study was having dependent children. Raising children requires a substantial financial commitment and in times of economic hardship this may make growers with dependent children more risk averse and less likely to choose diversification, as may be the case in Mackay. In Proserpine, the influence of dependent children was positive, and it is possible that in this region children were seen as a resource and would be able to assist in the additional labour and management demands associated with diversification. It is also possible that the ideas of these dependent children, the next generation of growers, were influencing their parents.

The discussion above would suggest any widespread use of social indicators needs to be treated cautiously. The survey results suggest that most sugarcane growers plan to remain in the industry to grow sugarcane, hoping that market conditions will improve. It is likely that sugarcane growers have been largely sheltered from market forces, and increased exposure will inevitably leave some growers more vulnerable and less able to adapt than others. The results of this study suggest that growers in Bundaberg are less vulnerable to industry restructuring than growers in Mackay as they have more experience with a variety of agricultural enterprises and hence more exposure to market forces.

6. Conclusion

The present paper demonstrates use of the Choice Modelling technique to predict the intentions of sugarcane growers to diversify into other crops. This novel example

confirms the potential for non-market valuation techniques to reveal decision making patterns in agribusiness settings, contributing to the literature summarised in Lusk and Hudson (2004).

The results of this study emphasise the importance of regional differences in the sugar industry and confirm Hildebrand's (2002) suggestion that a regional approach is required when addressing current problems in the sugar industry. Significant differences were even found between Proserpine and Mackay, which are only 130 km apart, although such differences are recognised within the industry.

The two diversification attributes that had the most significance were gross margins and risk. The influence of gross margins confirms the importance of profit maximisation as a core goal in growers' decision making. The significance of risk has wider implications. If sugarcane growers are to remain economically viable, farm enterprise diversification may be a realistic option. But if risk is a barrier to change, consideration needs to be given about how to reduce its influence.

The results of the CM study demonstrate that interest by cane farmers in diversification remains relatively low. Approximately two-thirds of growers in the Mackay and Proserpine regions, and 41 per cent of Bundaberg growers did not select any diversification options. The choice models were based on growers that did select a diversification option, and show that sugarcane is still the preferred crop. Diversification alternatives need to have very attractive return and risk attributes to become preferred alternatives. These results suggest that diversification away from sugarcane is unlikely to be substantial in the short term, despite the low market prices currently facing the sugarcane industry.

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