The Australian Journal of Agricultural and Resource Economics

Journal of the Australian Agricultural and Resource Economics Society

Australian Journal of Agricultural and Resource Economics, 59, pp. 499–517

Private transaction costs of participation in water quality improvement programs for Australia's Great Barrier Reef: Extent, causes and policy implications*

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The direct private cost to landholders of participating in programs that result in improved farming activities (IFAs) is generally well understood. However, the private indirect or transaction costs, such as the cost of a landholder's time and the expense to learn about IFAs and apply for assistance to implement these changes on-farm, are not so well understood. Where these have been studied, they have been shown to be extensive. We assess the extent and causes of private transaction costs incurred by sugarcane growers participating in the Australian Government's Reef Rescue scheme which pays farmers to adopt environmentally beneficial farm management practices. Utilising a mail-out-mail-back survey of 110 growers, we found that the average total transaction cost per farm of participating in the program was AU$8389. The average total transaction costs per farm as a percentage of the average funding provided was 38 per cent. We also assessed which type of improved farming activity (soil, nutrient, pest or water management) generated the greatest transaction costs and how landholder characteristics such as bounded rationality, opportunism and social connection impacted on the extent of transaction costs.

Key words: Great Barrier Reef, sugarcane, transaction costs, water quality.

1. Introduction

Participating in programs that bring about a change in agricultural practices generates a range of direct production/abatement and indirect transaction costs to a landholder. The production/abatement costs are those directly associated with the change and may include the purchase of equipment and

* The authors would like to thank the sugarcane growers who gave up their time to participate in the survey as well as key staff at the regional bodies NQ Dry Tropics (NQDT), Reef Catchments and Terrain who assisted in survey design and implementation. We would also like to thank the Reef Rescue Integrated Paddock to Reef monitoring, modelling and reporting program and the CSIRO for funding the study. Finally, we thank Dr Rod McCrae for assistance with data analysis and Dr Lisa Brennan McKellar, Dr Stuart Whitten and two anonymous reviewers for their helpful comments on earlier drafts of this manuscript. All errors remain the responsibility of the authors.

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doi: 10.1111/1467-8489.12077

perhaps a reduction in short-term profit. The production/abatement costs of agricultural practice change have been extensively studied and are well understood, particularly in terms of how this impacts on adoption of new practices (Wilson and Hart 2001; Pannell *et al.* 2006; Baumgart-Getz *et al.* 2012). Less well understood are the indirect or transaction costs to landholders (private transaction costs) of participating in programs that require land management practice change. In broad terms, transaction costs are the costs arising, not from the production of the good but from the transfer of a good from one agent to another (Niehans 1971). In the case of adoption of improved farming practices which are funded by government, the transaction is the payment of government funds to the farmer in exchange for the provision of a public good. In the case of analysis presented in this paper, the transaction is the implementation of improved farming activities (IFAs) funded by the Australian Government Reef Rescue program.[1] The private transaction costs of involvement in the Reef Rescue scheme and adoption of IFAs are financial and nonfinancial and include expenses (e.g. purchase of information, cost of travel to collect information) as well as the cost of time to learn about the IFAs. Groupings of private transaction and production/abatement costs associated with involvement in the Reef Rescue scheme are summarised in Table 1.

Previous research suggests that the private transaction costs of on-farm practice change are not small. For example, Mettepenningen *et al.* (2009) report that the average private landholder transaction cost of adopting practice changes under various European agri-environmental schemes was 15 per cent of the total private cost. Rorstad *et al.* (2007) found that private transaction costs ranged from seven to 37 per cent of the total payment received depending on the type of agri-environmental scheme.

Current research suggests that changing farm management on sugarcane properties in Australia's Great Barrier Reef catchments may generate significant public water quality improvements and long-term private financial benefits to the farming community. For example, Roebeling *et al.* (2009) and Van Grieken *et al.* (2013) suggest that the adoption of IFAs that are considered to be 'best practice' has the potential to generate a reduction in direct costs to farmers with a marginal change in yield. Some sugarcane farmers are reluctant to make these seemingly profitable changes which may indicate that, among other factors, there are prohibitive transaction costs to changing land management practice. With improvements in water quality on the Great Barrier Reef an ongoing Federal and State government environmental policy objective (Queensland Government 1994; Australian Government 2003; Australian Government Department of Environment 2013) understanding the extent, distribution and causes of transaction costs to

[1] We use the term improved farming activity (IFA) throughout the paper. We note that best management practice (BMP) is another commonly used term for these practices. We refer to IFAs as this was the preferred term used by the farmers involved in the study.

Table 1 Categories of cost

Improved farming activity transaction steps	Indirect transaction costs to produce change		Other direct production/abatement costs	
	Nonfinancial	Financial	Nonfinancial	Financial
Learning about the program – what is it about? Who can apply? How to apply? What are the potential practice changes? What do these mean to current operations?	Time	Expenses associated with travel to meetings, engagement of consultants etc. (fuel costs, cost of telephone calls, consultant fees). Expenses incurred in any paddock trials of practice	—	—
Applying to be involved	Time	Expenses associated with travel to meetings, engagement of consultants etc. Purchase of infrastructure to enable application	—	—
Reviewing contracts	Time	Expenses associated with travel to meetings, engagement of consultants etc.	—	—
Implementing the change on the property	Additional time to learn about the activities in the context of the property (additional to time invested before the application was lodged). Time to monitor and report on the practice change to funding body	Purchase of resources to fulfil contractual obligations such as monitoring and reporting	Time to implement the change on the property (including time to draft management plans). Ongoing change in time to manage IFA on the ground through time	Purchase of specific equipment. For example, change may be focussed on nutrient reduction which requires the purchase of a stool splitter (this expense is partially funded by the Reef Rescue Program)

sugarcane farmers could contribute to enhancing the adoption of water quality improving agricultural practices over time.

Improving this understanding is the objective of the research presented in this paper.[2] Specifically, we analyse: (i) the extent of transaction costs incurred by private sugarcane farmers when engaging with the Australian Government's Reef Rescue water quality improvement program (referred to as Reef Rescue throughout this paper); (ii) the distribution of private transaction costs across the different types of IFAs; and (iii) the causes of private transaction costs, particularly how the landholder characteristics of bounded rationality, opportunism and social connection affected transaction costs.[3] From this analysis, we provide some policy design suggestions which are specific to Reef Rescue and some broader reflections on the design of agri-environmental schemes to reduce private transaction costs. This information can facilitate policymakers in their decision-making process.

The paper is organised as follows. In Section 2, the theoretical framework for analysis, transaction cost economics is introduced and discussed. In Section 3, the case of analysis – the Reef Rescue program for water quality improvement in Australia's Great Barrier Reef –is introduced. In Section 4, the method for data collection and analysis is introduced with results and discussion of this data analysis provided in Section 5. Conclusions, including a reflection of implications for the Reef Rescue program and the design and implementation of agri-environmental schemes more broadly, are provided in Section 6.

2. Theoretical framework – transaction costs

2.1. What are transaction costs?

There are numerous definitions of transaction costs in the literature. These are well summarised by McCann *et al.* (2005), Allen (1999) and Wang (2007). These definitions range from considering transaction costs as the cost of effecting an exchange (Barzel 1985) to definitions such as Coase's (1960) cost of carrying out market transactions. New Institutional Economists tend to refer to transaction costs as the costs to define, establish, maintain and transfer property rights (McCann *et al.* 2005) as this captures the cost of the creation and change between institutions as well as the cost of exchange within an institution (Marshall 2013). In this paper, we are only considering

[2] This paper is based on research conducted by the authors for the Reef Rescue Paddock to Reef integrated monitoring and modelling program and the CSIRO in 2013. The complete report (Coggan *et al.* 2013b) is available on the Reef Catchments website: www.reefcatchments.com.au.

[3] A complete account of causes of transaction costs to private and public parties should also include an assessment of the characteristics of the transaction and the institutional environment in which a transaction takes place (see Coggan *et al.* (2013a) for a synthesis of the literature on factors that cause transaction costs in environmental policy). We concentrated only on the relationship between transactor characteristics and transaction cost in this study.

transaction costs as the cost of exchange within an institution. Coggan *et al.* (2013a) suggests that for an environmental policy, transaction costs are experienced by the policy maker who designs and administers the policy (creates a new institution) and the private parties who engage with or are affected by the policy (exchange within the institution). For private parties (the focus of this paper), Coggan *et al.* (2013a) suggest that transaction costs are incurred due to the time and effort as well as direct expenses incurred in learning about the policy, lobbying for or against the policy, finding trading partners, preparing applications, negotiating and finalising contacts as well as conducting monitoring and reporting.

There is an expanding international literature assessing the transaction costs of agri-environmental schemes. A large proportion of this literature focuses on the public transaction costs associated with developing and administering such policies. However, there is a growing literature presenting the private transaction costs of such policies. A sample of these studies, categorised as public or private transaction cost studies, are summarised in Table 2.

2.2. What landholder characteristics cause transaction costs?

Transaction cost theory suggests that the key landholder characteristics that impact on transaction costs are bounded rationality (Simon 1957; Libecap 1989; Challen 2000; Ducos and Dupraz 2006; Mettepenningen and Van Huylenbroeck 2009), opportunism (Williamson 1985) which we interpret as trust and confidence in information shared between parties (Ducos and Dupraz 2006; Morrison *et al.* 2008; Ducos *et al.* 2009; Mettepenningen and Van Huylenbroeck 2009) and social connectedness (Morrison *et al.* 2008).

Bounded rationality acknowledges that people are rational but with limits in their ability to foresee all contingencies (Simon 1957). This means that decisions are bounded by the information available to decision makers, the cognitive limits of the decision makers, the cost of new information as well as the time decision makers have to make a decision. Bounded rationality influences transaction costs by affecting the effort invested in information collection. Education and past experience that improves transactor knowledge can improve decision-making ability and influence transaction costs (Libecap 1989; Challen 2000; Ducos *et al.* 2009).

Coggan *et al.* (2013a) state that opportunism generates transaction costs through the time and effort that transactors then invest to develop complete contracts or increase monitoring to manage the risks to transactors from opportunistic behaviours. Ducos and Dupraz (2006), Ducos *et al.* (2009), Mettepenningen and Van Huylenbroeck (2009) and Morrison *et al.* (2008) all highlight that confidence in the information provided by contracting parties as well as relationships formed on trust will reduce transaction costs associated with opportunism. For Reef Rescue contracts, we hypothesise that, whilst all farmers will spend some time validating information provided

Table 2 Sample of studies exploring public and private transaction costs of agri-environmental schemes

Study authors	Transaction cost finding
Studies of public TC	
Howitt (1994)	Transaction costs made up 8% of the water purchase cost for the Californian water bank
Falconer and Whitby (1999)	Administration cost were less than 1% of the payments to farmers for arable area payments in the UK in 1996
McCann and Easter (1999)	Compared the public transaction costs of alternative policies to reduce phosphorous pollution in the Minnesota River
McCann and Easter (2000)	Transaction costs to the public agency made up 38% of the total costs of the United States program of technical assistance for agriculture
Falconer *et al.* (2001)	Public administration costs of agri-environmental schemes across Europe was 102% of payments to landholders initially (1992/93) but declined over time to 18% (1998/99)
Falconer and Saunders (2002)	Transaction cost were more than 110% of the payment to farmers in an English wildlife enhancement scheme in 1996
Studies of private TC	
Falconer (2000)	In general, across a range of empirical studies, private transaction costs amounted to around 5% of the compensation payment received
Falconer and Saunders (2002)	Private transaction costs of English Wildlife Enhancement Scheme agreements were 222 Euros per agreement for negotiation and 148–444 Euros per agreement for the implementation stage (% of transaction cost to payment is not reported)
Rorstad *et al.* (2007)	Farmers transaction cost range from 7% to 37% of payment depending on the type
Mettepenningen *et al.* (2009)	Private transaction cost represent 14.3% of the total cost of being involved

by the government to assess how the information applies to their property, a higher level of trust in government will reduce the extent of validation which will have a downward impact on transaction costs. Social connectedness refers to the connection of a party with other individuals and groups. Social connectivity has the potential to reduce the information–collection costs of the private parties associated with learning about, adopting and adapting to a new policy as individuals are exposed to this information in their day-to-day activities which reduces the need to seek out this information specifically (Morrison *et al.* 2008).

3. The case of analysis: The Australian Government's Reef Rescue program on the Great Barrier Reef

The Great Barrier Reef lagoon situated adjacent to the Queensland coast is the largest reef system in the world with over 3000 reefs covering an area of

approximately 350,000 square kilometres. Since European settlement in the late 1800s, water quality in the Great Barrier Reef lagoon has declined significantly due to a combination of increased pollutant run-off from agricultural and urban activities and removal of the filtering and buffering capacity of the coastal ecosystems (Furnas 2003). Published reports state that sediment loads due to soil erosion have increased three- to sevenfold over the last 140 years (National Land and Water Resources Audit 2001; Furnas 2003; McKergow *et al.* 2005) with Kroon *et al.* (2012) and Kroon (2012) estimating current annual total suspended sediment load exported to the Great Barrier Reef at 17 million tonnes. Total nitrogen and phosphorus exports to the reef have also increased two to fivefold and four- to fivefold, respectively (National Land and Water Resources Audit 2001; Furnas 2003; McKergow *et al.* 2005). This increase is partly due to fertilised land use in coastal floodplains. Improved management of resources in coastal catchments is widely regarded as needed (Smith and Schindler 2009) and has been the focus of the Queensland and Australian Governments' Great Barrier Reef related policies such as the two Reef Plans, Water Quality Improvement Planning and Reef Rescue Program.

In the first Reef Plan (Australian Government 2003), the Queensland and the Australian governments made a 10-year commitment to address diffuse-source pollution from broadscale land use and to halt and reverse the decline in water quality entering the Great Barrier Reef. In 2008, the Australian Government announced an intention to build on the Reef Plan through the release of the Reef Rescue Program (Australian Government Department of Environment 2013). Included within this program is the Water Quality Grants Scheme consisting of AU$146 million over 5 years. This competitive, cost-sharing grants scheme provides land managers with fixed-price payments to implement farming technologies with proved water quality benefits. The funds (usually 50 per cent of the market value of the equipment up to AU$50,000) are administered to the farmers by the six local natural resource management bodies. Industry, technical and community-based extension networks are also enrolled, largely through regional natural resource management bodies, to raise awareness of the program and help with the contracting and reporting in the grants process. In some cases, the natural resource management bodies also provide assistance in the development of proposals. Farmers growing sugarcane may apply to implement activities which improve their soil, nutrient, pesticide, herbicide and water management practices and thereby reduce sediment, fertiliser and pesticide loss and improve water-use efficiency. The water quality benefits of activities are classified according to the 'ABCD' management practice framework for water quality improvement. This framework was developed as part of the water quality improvement plan (WQIP) for Mackay–Whitsundays natural resource management region (Drewry *et al.* 2008) and implemented by the Great Barrier Reef natural resource management regional governance bodies (referred to as the regional bodies from here on).

In this case of analysis, we concentrated on Mackay–Whitsundays (also known as Reef Catchments), Wet Tropics (also known as Terrain) and Burdekin (also known as NQ Dry Tropics) catchments (Figure 1). The 'ABCD' framework is structured to describe suites of IFAs classified as 'Best' (B) practices which currently hold the highest potential for improving water quality, followed by 'Common' (C) and 'Dated' (D) practices. 'Aspirational' (A) management practices may further improve water quality but their potential, as well as their commercial and technical viability, have not yet been proven (Table 3).

Farmers apply for Reef Rescue funding by describing the IFAs they propose to implement, how the implementation of these activities will impact on the environment and what they require in terms of funding and machinery to implement the activities. If successful, farmers buy new equipment from local suppliers or modify their existing machinery such that it can facilitate the adoption of the IFAs.

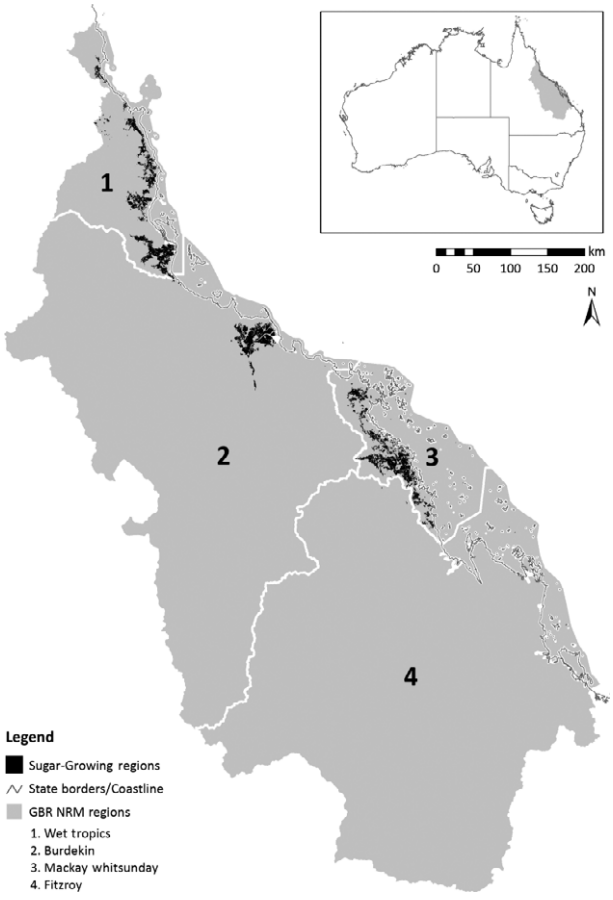

Figure 1 Location of the Great Barrier Reef Catchments, NRM regions and sugarcane grower areas.

Table 3 Queensland State wide ABCD framework definitions

Class	Category	Improved farming activities in this category
A	Aspirational/ cutting edge	Extend best practice, possibly providing society with additional ecosystem services but are yet unproven
B	Best practice	Meet agreed industry and community agreement of best practice
C	Compliant	Meet minimum industry and community standard and regulatory obligations. Meets legislative requirement, code of practice or locally agreed duty of care
D	Degrading/old	Are generally considered unacceptable by industry and community standards

Source: Adopted from Higham *et al.* (2008).

4. Method

4.1 Data collection

Previous studies of transaction costs of environmental policy have employed a mixed method approach to data collection (Howitt 1994; Falconer 2000; Falconer *et al.* 2001; Falconer and Saunders 2002; McCann *et al.* 2005; Rorstad *et al.* 2007; Kuperan *et al.* 2008; Mettepenningen *et al.* 2009; Ofei-Mensah and Bennett 2013). In these cases, the method used was guided by the characteristics of those supplying data, data availability and whether the focus of the research was on measuring transaction costs or generating an understanding of causes of transaction costs. When measuring the public transaction costs of agri-environmental schemes, Falconer and Whitby (1999), McCann and Easter (2000) and Falconer *et al.* (2001) used government databases. Others (McCann and Easter 1999, 2000; Falconer and Saunders 2002; Fang *et al.* 2005; Kuperan *et al.* 2008; Ofei-Mensah and Bennett 2013) have estimated transaction costs based on reports of time taken to develop, implement and use a policy and backed this up with interviews with informants. When collecting data on private transaction costs from farmers, Mettepenningen *et al.* (2009) used face-to-face surveys and Mettepenningen *et al.* (2013) used a mixed approach of online surveys and face-to-face interviews.

Due to time and research budget limitations, we employed a mail-out-mail-back paper-based survey which was sent to 547 landholders who had been successful in the 2010/11 and/or the 2011/12 Reef Rescue rounds.[4] The survey was developed in consultation with representatives from the regional bodies (NQ Dry Tropics (NQDT), Reef Catchments and Terrain) and was pretested with landholders and amended prior to implementation. The survey consisted of 67 questions with key categories of questions being about: (i) the sugar producing property (size, years growing cane, ownership status etc.); (ii) the

[4] NQDT provided details for 150 recipients, Reef Catchments provided details for 200 recipients and Terrain provided details for 197 recipients.

farming activities funded by Reef Rescue (what activities were to be conducted with Reef Rescue funding, reasons for applying, past experience in applying, success of past applications); (iii) the transaction cost generating activities associated with the application (such as the time, effort and expenses incurred when deciding to apply, learning how the IFA would be implemented on the property, learning about new equipment, preparing and submitting the application and signing the contract)[5] ; (iv) perceptions of the Reef Rescue program (Was there enough information about the program and about the IFAs? Was it easy to implement the IFAs? Were the rules fair? Would you apply again? Do you think that IFAs result in water quality improvement?); and (v) the respondent (age, education, off farm income, membership of farm organisations, and feelings of trust in government and others in the community). With the objective to estimate transaction costs, respondents were also asked to estimate the cost of their time working on the property (standard hourly rate) in dollars per hour. Survey respondents were asked to respond based on their first successful application out of the 2010/2011 and 2011/2012 rounds. Each survey form was coded such that it could be matched with de-identified data on respondents available from the regional bodies. From this data, we could access additional detail of the IFAs applied for and implemented as well as the baseline practice (ABCD). A copy of the survey can be supplied by the authors on request.

In order to increase the response rate, the survey was implemented in November 2012 when cane farmers were not likely to be too busy with on-farm work. Following Dillman *et al.* (2009), other methods to increase the response rate included providing survey recipients with the option to fill in the paper-based survey and mail it back using a reply-paid envelope or complete the survey online. One thank you/reminder postcard was sent to all recipients within 3 weeks of the receipt of the original survey. All respondents were entered into the draw to win an iPad. The data collection methodology was approved by the CSIRO Human Ethics Committee. In total, 110 surveys were returned representing a 20 per cent response rate. Whilst we recognise that this response rate is not high, it is consistent with that of previous surveys to this very heavily researched population of sugarcane growers (see for example Emtage and Reghenzani (2008) for other similar surveys in the region and their response rates). We are also confident that our sample is representative of the broader population of sugarcane growers given the similarity in characteristics such as gender, age and education between our respondents and those responding to other surveys conducted in the region (see Boero Rodrigues *et al.* (2006); Emtage and Reghenzani (2008)).

[5] In the Reef Rescue context, transaction costs were considered to be the costs of landholder time and resources expended in learning about the IFAs and the new equipment requirements and how these would apply on-ground as well as the cost of time and effort expended in applying for funding and reviewing and signing contracts.

4.2. Data analysis

Transaction costs were calculated using the formula:

$$\text{TC} = \text{number of hours} * \text{standard hourly rate} + \sum(\text{financial transaction costs})$$

where the number of hours and standard hourly rate is that reported by respondents in the survey. For respondents who did not report their hourly rate, \$39/h was used. This was the average of the reported hourly rates. The financial transaction costs are all the costs associated with the Reef Rescue activity which are not time-related and not the cost of the equipment. Some examples of financial transaction cost are cost of consultants and the cost of fuel and accommodation if travel was required to conduct information–collection activities. The relationship between farm size and transaction costs as well as landholder characteristics (degree of bounded rationality, opportunism and social connection) and transaction costs was assessed through a multiple regression using the data analysis software STATA. The distribution for transactions costs was positively skewed, and so a regression analysis was run predicting the square root of transaction costs to meet the regression assumption of normally distributed residuals. The square-root transformation was used as this was best for achieving the assumption of normally distributed residuals.

5. Results and discussion

5.1. Descriptive statistics

Recalling that respondents were those who had been successful in the 2010/11 and/or the 2011/12 Reef Rescue rounds, the average property size of respondents was 440 ha and the average area dedicated to the production of sugarcane was almost half of this at 217 ha.[6] There were a high proportion of respondents who had been growing sugarcane for a long period of time. For example, 24 per cent of respondents had been growing sugarcane for between 21 and 30 years and 32 per cent had been growing sugarcane for more than 40 years. Most respondents had a very basic level of formal education with 35 per cent not completing high school, 34 per cent noting that high school was their highest level of education, 20 per cent completing a certificate through the community college (trade certificate) and 14 per cent completing tertiary education. Most respondents were male with a fairly even representation of

[6] Our respondents tended to be from larger farms which could mean that our results are biased and reflect more production orientated properties. The average sugarcane property in the Great Barrier Reef tends to be around 110 ha with a sugar production area of around 94 ha (Canegrowers 2013). The average property size for sugar growers in Australia tends to be around 165 ha (see Boero Rodrigues *et al*. (2006)).

growers between the ages of 31 and 50 years old (40 per cent), between the ages of 51 and 60 years old (34 per cent) and greater than 61 years old (27 per cent). These demographic characteristics are comparable to other data collection from the industry such as Boero Rodrigues *et al.* (2006) and Emtage and Reghenzani (2008).

Most respondents understood the link between the quality of water leaving their property and the health of the Great Barrier Reef with 52 per cent and 19 per cent strongly agreeing or agreeing with the statement that the quality of the water leaving the farm is critical to the health of the Great Barrier Reef. Further, most respondents (95 per cent) agreed or strongly agreed that improved farm management results in water quality improvements and that it was easy to relate the IFAs to improvements in water quality. Of all respondents, 66 per cent had a successful Reef Rescue funding application in 2010/2011 and 62 per cent of respondents had a successful Reef Rescue funding application in 2011/2012 (some had successful applications in both years).

5.2. Private transaction costs

The average total transaction cost per farm was AU$8389 (Table 4). This was made up of on average AU$7564 of nonfinancial transaction costs per farm and on average AU$825 of financial transaction costs. The average total transaction costs per farm as a percentage of the average funding provided was 38 per cent. This is consistent with findings from other similar studies (see Rorstad *et al.* (2007)). Along with the total average transaction cost, we investigated what Reef Rescue application and implementation activities were the most time costly for respondents to complete as well as the influence of the financial transaction costs on total transaction costs.

Nonfinancial transaction costs were predominantly generated by the time it takes to conduct activities (see Table 1 for a description of activities that generate nonfinancial transaction costs). To interrogate nonfinancial transaction costs, we assessed the time taken to: (i) decide to apply; (ii) prepare and submit the funding application; (iii) read, sign and return the contract; and (iv) learn how to implement the improved farm management activity or

Table 4 Total average private transaction costs (in Australian dollars) of Reef Rescue engagement

	Sum	Average	Max	Min	Std Dev
Number of hours (h)	20,939	198	560	3.5	143
Standard hourly rate	—	$39	—	—	—
Nonfinancial transaction costs ($)	$801,798	$7564	$21,462	$134	5497
Financial transaction costs ($)	$87,847	$825	$17,420	$0	2430
Total transaction cost ($)	$889,276	$8389	$37,389	$134	6699

activities on ground. Most (45 per cent) respondents reported that they spent 3 days or more collecting information about the IFA and applying for Reef Rescue funding.[7] Most (50 per cent) respondents only spent between one and five hours preparing and submitting the Reef Rescue application and up to half a day reading, signing and returning the contract. Learning how to implement the IFA took most respondents the equivalent of between 1 and 3 days (30 per cent) or the equivalent of 3 days or more to complete (46 per cent). From this result, we conclude that considerable time is invested in activities to learn about the IFA and its implementation and that this predominantly occurs before applications for Reef Rescue funding are made.

On average, financial transaction costs per farm were AU$825. We found that those respondents with the highest perceived hourly rate ($/h) also had the highest financial transaction costs. This indicates that respondents with a low hourly rate tend to be more willing to invest more of their own time researching IFAs, attending meetings and completing training whilst respondents with a higher hourly rate are more likely to outsource activities associated with the IFA through activities such as purchasing advice. Those growers purchasing information tended to be the growers who had been growing sugarcane for more than 20 years (which we refer to as more established).

One objective of this study was to understand whether the average total transaction costs varied according to the type of IFA adopted by the sugarcane farmer. We found that average total transaction costs did vary slightly according to the type of IFA adopted. Irrigation IFAs generated the lowest average transaction cost per farm (AU$5555) whilst soil IFAs generated the highest average transaction costs per farm (AU$9941). This difference may be due to the spillover impact of soil-related IFAs into decision-making in other parts of the farming business which may not have occurred for irrigation-related IFAs (Table 5).

The most popular type of improvement was a move from C level practice to B level practice. Once again, the transaction costs of this level of shift varied depending on the type of program. Shifting from C level practice to B level practice for pesticide generated the lowest transaction costs at AU$7281 whilst shifting from C to B level practice for soil generated the highest transaction costs at AU$9982. The biggest shift in practice was a move from C level practice to A level practice. The smallest shift was from D level practice to C level practice. The average transaction costs for both levels of move was very similar (AU$7914 and AU $7670, respectively) indicating that there is more to the generation of transaction costs than just the extent of the change. We also found that those who had applied Reef Rescue funded IFAs on their properties in the past tended to apply for IFAs closer to A level practice compared with those who were new to the Reef Rescue program.

[7] This result also indicates that in future studies it is necessary to be able to capture a longer length of time for this activity.

Table 5 Average transaction costs for improved farming activity type

Type of improved farming activity	Average total transaction cost per farm (Australian dollars)*	Average total transaction costs per farm (Australian dollars) of a shift from C to B level practice
Nutrient	$8873	$8829
Soil	$9941	$9982
Pesticide	$6581	$7281
Irrigation	$5555	$7949

Note: *Many single Reef Rescue applications addressed more than one type of improved farming activity. For example, the activities may result in improved nutrient and soil management.

Running a multiple regression analysis with STATA, we found farm size (which is also a good proxy for area under cane: Spearman's $r = 0.94$) did not have a significant impact on transaction costs per farm (Table 6). It is therefore concluded that transaction costs are predominantly fixed costs. This may indicate that the larger farms have a greater capacity to absorb the transaction costs. If this is the case, transaction costs may be less of a participation deterrent for large farms compared to small ones. This has been found to be the case by others (see for example McCann (2009). If larger farms have a greater capacity to absorb transaction costs, this could also explain why the average farm size and sugarcane producing area of survey respondents was higher than the general regional averages.

5.3. The relationship between landholder characteristics and transaction costs

One focus of this paper was to assess whether the landholder characteristics of bounded rationality, opportunism and social connection could explain the magnitude of transaction costs. The results of this regression are summarised in Table 6.

To understand the influence of bounded rationality on transaction costs, we explored whether there was a relationship between transaction costs and the highest level of education attained, years growing cane and past experience applying for Reef Rescue funding and implementing Reef Rescue funded IFAs on-farm. The hypothesis behind this was that education and past experience growing cane, seeking assistance with IFAs and implementing IFAs reduces bounded rationality in decision-making and thereby reduces transaction costs.

Education was assessed by analysing the impact of different levels of education on transaction costs, comparing each level of education to the lowest level (not completing high school). It was found that education to bachelor degree or higher was marginally significant, with a university education predicting AU$557[8] less transactions costs compared to not

[8] 557 is the parameter (23.59 squared). Since the dependent variable is the square root of transaction costs, the regression parameters in Table 6 are squared to estimate untransformed transactions costs.

Table 6 Results of regression analysis for transaction costs*

Independent variable	Coefficient on transformed transaction costs*	*P*-value for transformed data	Coefficient on untransformed transaction costs
Farm size	−0.003	0.156	0
Education – high school	3.82	0.65	14.5
Education – trade certificate or equivalent	−5.69	0.56	32.3
Education – Bachelor degree or higher	−23.59	0.069	556.4
Past experience applying	−23.94	0.002	573
Past experience implementing IFAs	10.37	0.173	107.50
Years growing sugar cane	−2.23	0.35	4.9
Trust in government	−1.08	0.85	1.1
Trust in non-government	3.99	0.55	15.9
Social connection	15.13	0.04	228.9
Type of IFA	−0.405	0.85	0.1
Intercept	99.74	0.004	10,245

Note: *n = 100. R squared of 0.24 which indicates that 24% of the variability in transaction costs is accounted for by the variables in this model.

completing high school (the reference point for analysis). Neither earning a trade certificate nor completing high school was significantly different in impacting on transaction costs compared to not completing high school.

The influence of bounded rationality on transaction costs was also assessed by analysing past experience applying for funding and implementing Reef Rescue-funded IFAs. The regression analysis revealed that having past experience applying for Reef Rescue reduced the transaction costs by AU $573 (23.94 squared), and this was significant with a *P*-value of 0.002. Past experience implementing IFAs did not have a significant impact on transaction costs. This result could indicate that repeat applicants are applying for assistance to implement IFAs that are different to those that were funded in previous rounds (as previously stated, those with past experience applying IFAs are more likely to apply for higher-level IFAs in subsequent applications). This result also indicates that it is the transferability of the past experience implementing the IFAs that has an impact on transaction costs not just the existence of past experience.

The number of years growing sugarcane was not found to have a significant relationship with transaction costs. This indicates that the IFAs are completely new practices; once again highlighting that past experience will not influence transaction costs unless knowledge can be transferred between practices.

The impact of opportunism on transaction costs was assessed by analysing the relationship between trust and transaction costs. The relationship was not found to be significant.

Social connection was recorded as a 'yes' or 'no' response with respondents considered to be socially connected if they were active members of organisations other than the grower organisation (CANEGROWERS). Being socially connected was found to have a significant and positive relationship with transaction cost with a *P*-value of 0.04. Being socially connected increased transaction costs by AU$229 or 15.13 squared (Table 6) which is a surprising result that is contrary to theory. Perhaps being a member of many groups beyond just production-related groups, such as the case in this analysis, increases transaction costs due to the time and effort involved in the interaction and information–collection effort when using this type of social connection. Further research could assess the impact of different levels and type of social connection on transaction costs incurred in both the application and implementation of agri-environmental schemes.

6. Conclusions

Overall, we found that most growers who were successful in their application for Reef Rescue funded IFAs in either 2010/11 or 2011/12 have a good understanding about the link between their farm, farm management and the quality of water in the Great Barrier Reef and found the overall experience with the Reef Rescue program to be positive. Despite this, at an average of AU$8389 per farm, private transaction costs of participation were not small and could impact on the uptake of Reef Rescue funded IFAs. That being said, the ratio of average private transaction cost to average payment received is consistent with other similar studies at 38 per cent (see Rorstad *et al*. 2007). The extent of transaction costs varied according to the type of IFA adopted (although not greatly) with irrigation IFAs generating the lowest average transaction cost per farm (AU$5555) whilst soil IFAs generated the highest average transaction costs per farm (AU$9941). With most respondents indicating that they spent 3 days or more deciding if they would apply for Reef Rescue funding, it is clear that respondents conduct information collection about the process as well as implementation procedures and commitments at the initial stages of application and prior to funding as opposed to later in the process. If a government objective is to assist in reducing private transaction costs, and potentially enhancing program adoption, providing information about the application process as well as the implementation and whole farm implications of IFAs at the initial stages of the application process rather than at later points in time may assist. This result is likely to be relevant to agri-environmental schemes more broadly.

Landholder characteristics that had a significant relationship with the level of transaction costs were higher education, having past experience applying for Reef Rescue funding and being socially connected beyond being a member of CANEGROWERS. Having university education and having past experience applying for Reef Rescue funding reduced transaction costs. Being

socially connected was found to significantly increase transaction costs. Further analysis could investigate why this relationship between social connection and transaction costs occurred and if different types of social connection (e.g. social connection that was production-related versus social connection that was not related to agricultural production) generates different impacts on transaction costs and the significance of this relationship.

We hypothesised that past experience implementing IFAs would have a significant and negative relationship to transaction costs but found that this was not the case. The absence of a significant relationship may be because transaction costs are only reduced if the past experience is transferable to the new experience. It was also found that those with past experience implementing a Reef Rescue funded IFA applied for a different type and higher level of IFA in subsequent rounds and that the experience gained from implementing the first IFA is not transferable to implementing subsequent IFAs. This is an important subtlety when considering the practical application of transaction cost theory to the analysis of agri-environmental schemes. More targeted information and assistance about implementing the IFAs rather than how to apply for funding may change the relationship between past implementation experience and transaction costs. This may encourage growers to apply again, which could result in an increase in the uptake of higher-level practices and greater improvements in water quality on the Great Barrier Reef. An improved understanding of the different IFA types and how they affect overall water quality would also contribute to enhancing the efficiency of the Reef Rescue program. The importance of understanding cause-and-effect relationships between land use change and environmental outcomes is relevant to agri-environmental schemes more broadly.

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