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Cost-reflective pricing: empirical insights into irrigators' preferences for water tariffs

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Using prices to improve the efficiency with which water resources are allocated is now widely accepted in principle if somewhat difficult to achieve in practice. Whilst there are some technical difficulties associated with full-cost recovery in irrigation, the lack of political will to tackle reform remains a significant impediment. This article reports the results of an empirical investigation into farmers' preferences for changes to water prices and tariff structures. We conclude that some of the preferences of farmers are conducive to price reform. We also find evidence that public subsidy of infrastructure in irrigation is not always aligned with the preferences of farmers.

Key words: best-worst scaling, cost recovery pricing, water reform.

1. Introduction

Using pricing to improve the efficiency with which water resources are allocated is now a widely accepted principle in many countries (Iglesias and Blanco 2008; Rigby *et al.* 2010). In addition, mounting concern about the environmental ills that attend excessive water abstraction coupled with greater scrutiny of public expenditures in general has added momentum to the policy interest in market-based approaches and the notion of full-cost recovery from water users (see Zuo *et al.* 2015).

Useful theoretical debates about the appropriate structure of water tariffs to achieve both cost recovery and efficiency are available within the literature (e.g. Loehman 2008; Griffin 2009), but the practical dimensions to achieving cost recovery in some sectors remain a challenge. Even in the developed countries that make up the OECD, many irrigators 'benefit from policies that allow them to forego repaying capital expenditures for irrigation infrastructure or to schedule repayment over many years with zero interest' (OECD 2010, p. 139). In the United States, prices vary according to the nature of the water project and the attending institutions, such that cost recovery cannot be assured (Wichelns 2010), and in Australia, where the national reform agenda has placed a high priority on water pricing for almost 30 years, full-cost recovery fails to be achieved in some irrigation areas (Crase *et al.* 2015).

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The political economy of water pricing in irrigation remains problematic and Cornish *et al*. (2004) observe that there is often a lack of political will to impose additional costs on farmers, regardless of their income or wealth relative to others in the community. Easter and Liu (2005) offer an eightfold typology to explain why cost recovery rates are low in irrigation, including the absence of links between fees and services and limited irrigator participation in decision-making, but little is known of the relative importance of these constraints.

The debate about cost recovery and water pricing is also circumscribed by confusion about which prices are relevant to particular decision-makers. To achieve cost recovery, the providers of irrigation services need to generate revenue from end users. This requirement for revenue is sometimes conflated with the prices paid for securing irrigation entitlements and allocations, where water rights are traded (see, Easter and Liu 2005). However, in the context of cost recovery for communal irrigation projects, the key issue is the willingness of irrigators to pay ongoing fees, not their reservations price for water rights. The revenue required by service providers can be collected using different tariffs, and irrigation farmers may have different preferences around these, which ultimately influences their enthusiasm for paying fees.

This article presents the results of an empirical study that focused on irrigators' preferences for changing the way tariffs are structured in a communal irrigation area. The setting for the study is the northern irrigation regions of Victoria. Australia has often been regarded as being at the forefront of market-based water reforms (see, The Economist 2003; National Water Commission 2012), although the controversies associated with full-cost recovery from irrigators are no less pressing in Australia than elsewhere. Irrigators continue to have infrastructure gifted by government, ultimately distorting incentives for water use (Pawsey and Crase 2013) and understanding the perspective of irrigation farmers and the elements of tariffs that are less likely to attract opposition offers some promise in this politically volatile environment.

The remainder of the article is organised into seven additional parts. In Section 2, we provide a brief review of water tariffs whilst a synopsis of the policy and pricing arrangements that circumscribe the study area are presented in Section 3. Section 4 is used to outline the policy context and the best-worst scaling methodology is presented in Section 5. Sections 6 and 7 present the results and discuss the policy implications. Brief concluding remarks are presented in the final section.

2. Water tariffs

Water tariffs often reflect historical precedents and are not always simple to adjust. Griffin (2001, p. 1,335) notes that 'judging from current inertia, both rate-setting policies and governing rules have been dominated by accounting conventions rather than economic ones'. The focus on water tariff design has

also generally centred on urban water users (see, for instance, Sibly and Tooth 2014) rather than agricultural users and lessons are only transferrable to the extent that measurement technologies are similar. From a global perspective, water charges in irrigation are often based on a multiple of the area of land irrigated, or the area that is irrigable. A variation on this approach involves using crop types to determine water charges – this at least takes some account of water usage (Easter and Liu 2005). By world standards volumetric (i.e. metered) water pricing is relatively rare in irrigation, but widely deployed in developed countries, like Australia.

Where water use is measured volumetrically, questions arise about the tariff design that will adequately recover costs without generating rents for service providers, who are usually natural monopolies. In irrigation in Australia, these entities are referred to as Irrigation Infrastructure Operators (IIOs) and generally IIOs might be expected to face decreasing average cost. Thus, setting prices equal to marginal cost would generate losses and the challenge becomes establishing a pricing regime that approximates the social optimum of marginal cost pricing whilst maintaining the long-term viability of the IIO. To deal with this problem, general theories on public utility pricing have long advocated the use of two-part tariffs (e.g. Lewis 1941) where a fixed charge is applied to cover any shortfall in revenue arising from a usage charge set at marginal cost. This general approach is embodied in the National Water Initiative (NWI) which has been the blueprint of reform in Australia for more than 30 years.

Whilst the principles that underpin the two-part tariff are well understood, in practice their application is confounded on several fronts. First, the two-part tariff will only be efficient to the extent that the service provider is obliged to operate at minimum cost. It is for this reason that economic regulation becomes important. Second, it is not always the case that the opportunity costs of all resources will be integrated into the final tariff. If externalities are not priced then the fixed and volumetric components may still fail to signal efficient use. In addition, if water access is 'gifted', there is no accounting basis for including the value of access entitlements in the costs of service providers. This is less problematic where water rights are relatively scarce and traded, as is the case in parts of Australia, but the notion of gifting resources can nonetheless distort prices – a point we take up later.

Griffin (2001) makes progress on some of these issues from a theoretical perspective by considering the effective pricing strategy for a nonprofit municipal water supplier. He further argues that this approach is sufficiently broad and 'the full analysis is equally applicable to irrigation districts supplying metered water' (p. 1,336). In general, he finds that a standard two-part tariff can be efficient when accompanied by a number of adjustments. In particular, where unrenewable groundwater is involved, Griffin (2001) argues for the inclusion of a marginal user cost that relates to 'the future opportunity costs of present water consumption' (p. 1,345). Importantly, Griffin (2001) finds that the marginal capacity cost also needs to be considered to achieve

efficiency and this can be included in the form of a fee levied on new customers connecting to the supply network. Set at the marginal cost of network expansion, this charge recognises the scarcity of nonwater resources, like those related to infrastructure. Although not specifically addressed, presumably any radical improvement in infrastructure should attract charges on a similar basis, even for existing customers.

In the case of most water supply businesses, the cost of provision is dominated by the fixed costs associated with supply infrastructure, implying that an efficient tariff would comprise a relatively large access charge and a small volumetric charge. However, of the few instances where customer preferences have been explored, higher volumetric charges have been sought, primarily reflecting the desire of customers to be 'rewarded' for conservation behaviours (Crase *et al.* 2008). In the context of irrigation, very little published information is on hand about users' preferences for different tariffs. Overwhelmingly, studies that have explored irrigators' preferences have focussed on overall willingness to pay higher charges in response to improved services (see, e.g. Alhassan *et al.* 2013), rather than considering preferences for elements of tariff design.

3. Water tariffs in northern Victoria

The theoretical tidiness of water pricing is seldom matched in real life, as evidenced by the arrangements in northern Victoria. The state-owned water supply business in northern Victoria is Goulburn–Murray Water (G-MW), which is sometimes referred to as the Goulburn–Murray Irrigation District (G-MID). At the time this study was undertaken, there were up to 400 different charges that could potentially be levied by G-MW, often on the basis of historical decisions that have little resemblance to current resource availability or service. Some understanding of the architecture of tariffs in the study region is important for interpreting the results.

Irrigators generally face a set of fixed charges that relate to water and infrastructure access and variable charges that relate to water use. Each irrigator in G-MW holds a water entitlement described in volumetric terms and use cannot exceed the volumetric limit on that entitlement without attracting a penalty. The penalty is in the form of a so-called Casual Use Fee (described in Table 1, below). Water trade is restricted to locations with hydrological connectivity so that G-MW is able to deliver any purchased water.

The fixed charges faced by irrigators are primarily driven by the notion of a deliver 'share'. This is essentially an infrastructure access fee and relates to the right to access the communal irrigation channel. This fee is charged on a megalitre per day basis, irrespective of the volume of water actually owned or used on a farm. In simple terms, the delivery share represents 1 ML of assured water access from the irrigation network in a day. Irrigators can

Table 1 best-worst attributes and levels

Attribute	Level 1	Level 2	Level 3
Service point fees	Leave service point charge at a low fee of $250/service point per year and a high infrastructure access fee. (Service Point Fees *D*)	Increase the service point charge from $250 to $1000/service point per year and lower the infrastructure access fee by reducing the cost of each Delivery Share by $600. (Service Point Fees 2)	
Pricing strategy	Keep charges for Delivery Share (ML/day) set by each irrigation district. (Pricing Strategy *D*)	Move to a single charge for Delivery Share (ML/day) across all irrigation districts. (Pricing Strategy 2)	
Delivery share	Keep current volume at 270 ML per Delivery Share (Delivery Share *D*)	Reduce volume of Delivery Share from 270 ML per Delivery Share to 150 ML per Delivery Share. (Delivery Share 2)	
Control	Keep current ratio of 90% fixed costs and 10% variable costs (Control *D*)	Move to 100% fixed charges (currently 90% fixed costs: 10% variable costs) (Control 2)	Move to 20% variable charges and 80% fixed charges (currently 90% fixed costs: 10% variable costs) (Control 3)
Casual Use Fee	Keep Casual Use Fees as they are. Typically, the fee is $80/ML. (Casual Use Fees *D*)	Increase Casual Use Fees from $80/ML to $100/ML. (Casual Use Fees 2)	
Termination Fee	Keep the termination fee at 10 times the cost of each Delivery Share (Termination Fees *D*)	Reduce the termination fee from 10 to 8 times the cost of each Delivery Share (Termination Fees 2)	
Payment instalment options	Keep the existing payment instalment options (i.e. upfront or with 4 instalments over 5 months) (Payment Instalment Options *D*)	An increase the number of payment instalment options that are available to you, for example the option to pay once a month over 12 months. (Payment Instalment Options 2)	
Break down of charges	Keep the existing break down of charges that appear on your bill (Break Down of Charges *D*)	Reduce the number of charges to simplify the bill (Break Down of Charges 2)	

purchase additional delivery shares to increase access and to gain priority during times of congestion, but this is capped at 270 delivery shares per farm.

The delivery share charges differ within the six irrigation districts that make up G-MW, reflecting historic decisions regarding the levels of investment and density of servicing infrastructure in each district. The charge also plays an important role in influencing decisions to exit irrigation. Under the current arrangements, irrigators can sell their entitlement (i.e. their perpetual access right to water), but to exit irrigation permanently, they must also pay a multiple of the delivery share charge to G-MW. This process is rationalised on the basis that remaining irrigators would be required to meet higher ongoing costs – sometimes called the 'stranded asset' problem. The multiple is set at ten and since delivery share charges range between $2,700 and $4,700 per year, the termination charge substantially weakens incentives to exit irrigation entirely. For example, an irrigator who held 1,000 megalitres and who sold all entitlements to another entity would still be required to pay as much as $4 million to completely exit irrigation.

Other fixed charges relate to the number of service points available, and this cost does not always reflect any 'new' technology used in the infrastructure. Variable charges are driven by water use, but this generally accounts for only 10 per cent of the total cost.

4. The political context for change and the policy conundrum

As noted earlier, an enduring blueprint for water reform exists in Australia in the form of the NWI. The basic tenet of these reforms was that market-based approaches, including cost recovery pricing, would result in a more efficient and sustainable allocation of resources. A substantial weakening of the commitment to full-cost recovery pricing in irrigation occurred in 2007. Faced with one of the longest droughts on record and mounting evidence of the environmental degradation in the Murray–Darling Basin, the Federal government announced a plan to permanently rectify the over-allocation of water in the Basin. This plan included the Commonwealth government wresting control of water from the state governments and the provision of publicly funded 'water-saving' infrastructure to irrigators in return for water for the environment. Although the plan was modified with the election of a new Federal government, the basic idea of subsidising irrigation infrastructure remains part of the policy settings. Government buyback of water entitlements was subsequently put on hold (see, Joyce 2016), and the expenditure on irrigation infrastructure continues to significantly outweigh monies set aside for purchasing water rights.

Under the Water Act 2007, IIOs were to be subject to economic regulation by the Australian Competition and Consumer Commission (ACCC). The earlier reforms in Victoria meant that G-MW was already subject to regulation by the Essential Services Commission of Victoria (ESC) such that, in effect, the ESC continues to regulate G-MW with reference to the rules

developed and by ACCC. In 2016, the ACCC undertook a review of water charging rules that apply to IIOs. The review focussed on three categories of rules pertaining to pricing infrastructure; termination charges; and planning and information management. Overall, the ACCC found that there were opportunities to streamline some pricing rules and make them more consistent and transparent to customers. In addition, the review concluded the maximum permissible termination charge would remain at ten times the fixed delivery charge, although IIOs could apply a lower fee if they wish (ACCC 2016).

The arrangements for economic regulation of irrigation in Victoria have been complicated by the Federal government's attempt to reassign water for environmental purposes and the related ambitions of the state government to shore up urban supplies in Melbourne. The upshot has been that G-MW received almost $2 billion of public monies for irrigation infrastructure in the last 9 years. There is also an inherent conundrum for regulators, IIOs and irrigators created by these arrangements. On the one hand, the earlier purchase of water entitlements by environmental agencies potentially reduces the number of irrigators calling on the irrigation network. On the other hand, subsequent spending on irrigation infrastructure has raised the value of that network but with potentially fewer irrigators to fund cost recovery.

An important but underinvestigated component of public provision of irrigation infrastructure is that the value of gifted infrastructure does not add to the regulator asset base (RAB) upon which regulated water prices are calculated. In simple terms, there is no requirement to meet the cost of capital associated with these investments, nor is there a requirement to pay prices that recover the costs of depreciation on the gifted components.

At the time of this study, the management of G-MW also recognised that the sustainability of irrigation in the region was threatened by poor cost recovery. There is considerable heterogeneity amongst farmers in the G-MW and potentially differing appetites for change. One element of this heterogeneity relates to the proximity of farms to the main irrigation channels – commonly referred to as the backbone. As part of the deployment of improved irrigation infrastructure, G-MW had focussed most efforts on enhancing services closer to the backbone with smaller channels being decommissioned or control assumed by individual irrigators (G-MW 2010). It was against that background that a methodology was required that could guide tariff reform.

5. Best-worst Scaling and water prices

An analytical technique known as best-worst Scaling (BWS) was judged to be useful in this context. BWS is a survey approach centred on an ordering task that requires participants to make a selection from a collection of items by choosing the 'best' (most preferred) and 'worst' (least preferred) items in a series of blocks that contain three or more items. The items may be attributes of a product, options in a decision, or bundles of services and products. The

method allows for numerical ordering of a set of objects or items to identify their 'degree of importance' or 'extent of preference'. By designing a best-worst experiment where the attributes were components of a water tariff, we hoped to identity which parts of the tariff were more (less) highly valued.

BWS was developed by Louviere and Woodworth (1990). Essentially, BWS is a preference elicitation approach that only requires an assumption of ordinality. BWS is underpinned by the same random utility framework that underlies discrete choice experiments (DCEs), and the technique is less cognitively demanding on respondents than other DCEs (Flynn 2010).

Flynn *et al*. (2007, p. 172) highlight the two principle limitation of traditional DCEs that are overcome using BWS. First, the 'pick-one' process that typifies DCEs is a relatively inefficient approach to obtaining preference information. Second, the regression constant term in DCEs results in the attribute impacts being confounded with level scale values.

The BWS approach to determine preferences is particularly effective in creating a numerical ordering in cases with a large number of product attributes or options. Marley and Louviere (2005) highlight the formal statistical and measurement properties for BWS. One of the important characteristics of BWS is that it measures all of the attributes on a common scale (Auger *et al*. 2007). Moreover, the method addresses the scalar inequivalence problem that characterises the way respondents use rating scales (Cohen and Neira 2003).

Three main types of BWS have been identified in the literature and referred to as: (i) case 1, the object case; (ii) case 2, the profile case; and (iii) case 3, the multiprofile case (see, i.e. Flynn 2010; Louviere *et al*. 2015). BWS case 1 permits the researcher to obtain measures for each respondent on a different scale with known properties (Marley and Louviere 2005). BWS case 2 (Flynn *et al*. 2007; Marley *et al*. 2008) and case 3 (Flynn 2010) build on case 1 and allow for items to be represented as multidimensional choice objects (Louviere *et al*. 2013).

A process involving in-depth interviews with irrigators and irrigation officials, focus groups and piloting was used in this study and is described in detail in Cooper and Crase (2013). In total, eight attributes were identified to be included in the best-worst experiment, and these are summarised in Table 1. The criteria used to include these attributes were salience to irrigators and irrigation officials and the extent to which they might be used to progress tariff reform.

Note that in case 2 BWS, each alternative is a single attribute, described by different levels. In choosing an alternative, the respondent is really choosing an attribute. In the current experiment, the design approximates case 2; however, there are four alternatives with eight attributes. The design ostensibly chooses four of the eight attributes (from Table 1), and then, a second design allocates the levels of the selected attribute – this is effectively a hybrid residing between Case 1 and Case 2.

Options	Which option do you **LEAST** prefer? (Select **ONLY ONE**)	Sets of options for you to consider	Which option do you **MOST** prefer? (Select **ONLY ONE**)
1	☑	Reduce volume of Delivery Share from 270 mL per Delivery Share to **150 mL per Delivery Share**	❑
2	❑	Move to **100% fixed charges** (currently 90% fixed costs:10% variable costs)	❑
3	❑	Keep **Casual Use Fees** as they are. Typically, the fee is **$80/mL**.	☑
4	❑	Move to a **Single charge** for **Delivery Share** (mL/day) across all irrigation districts.	❑

Note: Only one box is ticked in each of these columns

In the example above, the selection means a person is saying that out of the four options listed:

- the option they **LEAST** prefer is 'Reduce volume of Delivery Share from 270 mL per Delivery Share to **150 mL per Delivery Share'**
- the option they **MOST** prefer is **'**Keep **Casual Use Fees** as they are'

Figure 1 Example answer of best-worst question.

A balanced incomplete block design (BIBD) was used to determine which of the eight attributes should be shown to respondents (see, e.g., Street and Street 1987; Louviere *et al.* 2015). Table 1 shows that some attributes had three levels whilst others were represented by only two. These levels were selected in consultation with management of G-MW who identified the range over which some attributes could be changed, given their knowledge of the regulatory regime in Victoria.

A total of 56 choice tasks were generated using the BIBD and this comprised thirteen blocks. Put differently, the design resulted in thirteen versions of the survey and each respondent was faced with only four choice tasks. Each choice task comprised four components – each component being a single level and attribute of the bill and the respondent nominating the best and worst of those four components.[1] An example of a best-worst question appears as Figure 1.

[1] The experimental design comprised 56 possible choice sets in total. To limit the cognitive burden placed on respondents, the design was split into 14 different survey blocks where each survey respondent only faced 4 choice sets. Note that each choice set contained 4 items requiring a choice on both the 'Best' and 'Worst' option.

The survey comprised four parts. The first part included questions to capture the socio-demographics of the respondents, their water trading history and intentions, and their attitudes towards the irrigation infrastructure modernisation scheme (i.e. the name given to the publicly subsidised irrigation infrastructure at that time). The second part presented respondents with a range of questions to identify their level of understanding of the pricing process and the current tariff structure. The BWS questions were presented in the third section whilst the final part comprised questions about respondents' attitudes towards the environment, climate change and risk.

As already noted, the attributes and levels emanated partly from discussions with senior managers at G-MW. These were effectively real-world scenarios that managers had been informally exploring with irrigators across the region. The full survey was piloted with three Water Service Committees – these are groups of irrigators that act as sounding boards for the managers of the irrigation district and who are also responsible for disseminating information to others. This piloting phase also allowed for open discussion of tariff reform and ultimately some refinement to terminology in the survey was required, but the attributes and levels remained unaltered.

Feedback from focus sessions suggested that an online survey would be inaccessible, given the access to technology, and phone surveys invariably interrupted farming tasks. A mail-out survey was deemed to be most appropriate, and this was administered following Dillman's total design method, with prepaid envelopes, introductory letters and the establishment of a toll-free help line. In the light of concerns about the privacy of customer information, the mail survey was administered from the offices of G-MW with 2000 surveys circulated.[2]

6. Findings from the best-worst experiment

The data reported here were collected from across the G-MID between November 2012 and January 2013. The main survey was accompanied by press releases to stimulate additional responses, and direct encouragement was also offered by members of the Water Service Committees. The response rate to the survey was approximately 14 per cent. Of the 274 survey responses received, 27 per cent were partially incomplete and results need to be considered in this context. Most respondents were male (82 per cent), and the median age of respondents was between 55 and 64. A little over one-fifth (22 per cent) had completed a tertiary degree or higher, and the median income before tax was in excess of $100,000 although the median after tax profit was −$50,000. Respondents covered all of the irrigation areas across G-MID although most responses (38 per cent) were sourced from the Central Goulburn region. The final data set consisted of 199 respondents generating 6,368 choices on which to formulate empirical models.

[2] A copy of the survey is available from the authors, on request.

Table 2 Sample portion per irrigation district

District	Sample (%)	Proportion of landholder Population in the G-MID (%)*
Central Goulburn	38	26
Loddon Valley	5	18
Murray Valley	14	11
Rochester–Campaspe	13	20
Shepparton	10	1
Torrumbarry	20	24

*Source: G-MW (2013).

The spread of the sample by irrigation districts within G-MW is shown in Table 2 and a chi-square test showed significant differences between the sample and the population – notably, landholders in the Shepparton region were underrepresented. A key influence in this case was likely to be the proximity of the farm to the irrigation 'backbone'. Around 57 per cent of the sample farms were connected to the irrigation backbone which compares with 44 per cent of irrigation farms in the region (G-MW 2013).

6.1 Coding of variables

The potential of nonlinearity in the marginal utilities between levels implies the need for either dummy coding or effects coding. Dummy coding employs a series of 0s and 1s to relate each attribute level of the original variable to the newly created columns, and this was employed here. Table 3 illustrates the dummy coding process for the *Delivery Share* attribute.

The dummy coding used here differs somewhat from that applied elsewhere. This is because of the way the survey questions were presented to respondents. Typically, dummy variables require one level of each attribute to be coded as all zeros, and this level represents 'the base level' for that attribute or variable. The level that is coded 1 is then interpreted as being relative to the base of that attribute. Here, only one base level is constructed for all attributes. As such, the model results are interpreted as being relative to the base level of this single attribute, rather than each attribute having its own reference or base level. More specifically, dummy variables were established for $k - 1$ attributes, and as there were eight attributes in the best-worst experiment, seven dummy variables were created.

Table 3 Example dummy coding

Delivery share attribute levels	Original code	Dummy code	
		Level 1	Level 2
Level 1	0	1	0
Level 2	1	0	1

This is because each choice task was designed with four of the eight attributes; thus, the dummy variables reflect the presence or absence of an attribute in the choice. In this instance, there was no dummy variable created for the break down of charges attribute to create a base attribute. This is simply a parsimonious choice and has no bearing on the results per se.

The utility structure used in the current study is shown in Equations (a–d):

$$U(bw_1) = \beta x D_{bw_1} + \beta x_{bw_1}, \tag{a}$$

$$U(bw_2) = \beta x D_{bw_2} + \beta x_{bw_2}, \tag{b}$$

$$U(bw_3) = \beta x D_{bw_3} + \beta x_{bw_3}, \tag{c}$$

$$U(bw_4) = \beta x D_{bw_4} + \beta x_{bw_4}, \tag{d}$$

where $\beta x D_{bw_j}$ are the parameters associated with the dummy variables, and βx_{bw_j} are the parameters associated with the attribute levels.

6.2 Best-worst Scaling: Latent class model

In this article, we report the results of a latent class (LC) logit model which allows us to directly compare respondents' preferences for the variables included in the BWS experiment (see, i.e., Auger *et al*. 2007). The LC model assumes the existence of C classes or segments within the population of N sampled respondents where C is exogenously defined a priori by the analyst. Allocation of respondents to classes is not observed directly by the analyst and hence is latent, being modelled probabilistically via a class assignment model. As such, each sampled respondent is assigned to each class up to a probability as opposed to being assigned to any one specific class. Within the LC model, each class will have a unique utility function.

The class assignment model is typically specified using a multinomial logit (MNL) model form, where the attributes of the model consist of socio-demographic characteristics or contextual covariates. Given the MNL model specification, the probability that respondent n belongs to class c given covariates Z_n is given as follows:

$$P_{nc} = \frac{\exp(\theta_c' Z_n)}{\sum_{b=1}^{C} \exp(\theta_b' Z_n)}. \tag{1}$$

Given class membership to segment C, the probability that respondent n would choose a particular tariff structure is derived under the random utility theoretical (RUT) framework. Under the RUT framework, an individual

respondent is assumed to select the alternative for which they hold the highest utility. Assuming the error terms of the model are independently and identically distributed (IID) extreme value type 1, the probability that individual n chooses alternative j in choice task t, conditional to belonging to class c is given in Equation (2):

$$P_{njt|c} = \frac{\exp(\beta_c' x_{njt})}{\sum_{i=1}^{J} \exp(\beta_c' x_{nit})}, \tag{2}$$

where x_{njt} represents a vector of attributes associated with alternative j in choice task t and β_c' a vector of estimated coefficients. Given the pseudo panel nature of the data, where each respondent is observed to answer more than one choice task, rather than model the probability that n chooses alternative j in choice task t, we model the probability of observing respondent n make the observed sequence of choices of all T choice tasks presented to them. As such, the conditional choice probability of the model is given as:

$$P_{n|c}^{*} = \prod_{t=1}^{T} (P_{njt|c})^{y_{njt}}, \tag{3}$$

where y_{njt} represents a 0–1 choice index equal to 1 if alternative j was observed to be chosen or 0 otherwise.

Given the above, the unconditional choice probability associated with observing respondent n make a sequence of choices over T choice tasks is calculated as:

$$P_{n}^{*} = \sum_{c=1}^{C} P_{nc} P_{n|c}^{*}. \tag{4}$$

Given data, the aim is to estimate the parameters θ_c' and β_c'. This is achieved using maximum likelihood estimation methods. In the case of the LC model as specified above, the log-likelihood function used to find the parameters is given in Equation (5):

$$\mathrm{LL} = \sum_{n=1}^{N} \ln(P_{n}^{*}). \tag{5}$$

Essentially, the model captures the effect of the attribute and the effect of the attribute levels on different classes of respondents' preferences, whilst also accounting for the pseudo panel nature of the data.

Latent classes with 2, 3, 4 and 5 classes were estimated on the data. Constants only were assumed for the class assignment models in each case. The identification of the number of classes in the population was achieved by

Table 4 Latent class model fit statistics

	2 Classes	3 Classes	4 Classes	5 Classes
AIC	3778.190	3695.879	3610.842	3604.375
BIC	−1612.795	−1429.302	−1244.447	−1098.877
CAIC	3440.214	3206.046	2987.284	2865.224

selecting models with alternative numbers of classes on the basis of the CAIC criteria (see Louviere *et al*. 2000), whilst simultaneously ensuring that each class makes behavioural sense. Table 4 reports the AIC, BIC and CAIC criterion for the different LC models estimated. The final model reported has four preference classes (n.b. whilst providing a better model fit, the parameters in one of the classes exploded when five classes were assumed suggesting a convergence issue).

The final model results are shown in Table 5. The results demonstrate that significant preference heterogeneity exists within the sampled population, whilst it is also noteworthy that every attribute is statistically significant in at least one class.

Given that each variable in the model has been dummy coded (relative to break down of charges), the variables are thus measured using the same metric and hence can be directly compared. It is important to note that the coding of the data as described above results in 16 variables for each class within the model. Each variable corresponds with the attribute and related level, less the status quo for the break down of charges attribute. Care is required, however, in interpreting the results, as the utility obtained from discrete choice models is ordinal, and hence, the marginal utilities represented by the parameter estimates are relative and not absolute. To estimate the model, the parameter for the first level of the break down of charges variable was normalised to zero and hence represents the base level against which all other variables are measured (although it is possible to compare the relative differences between any of the parameters).

For the first class, which has the largest population mass (38.6 per cent of the sample), all the statistically significant parameters are negative, suggesting that the presence of these variables provides disutility relative to the base attribute level of keeping the original break down of charges. For members of this class, reducing the volume of delivery share from 270 to 150 ML provides the greatest disutility of all attribute levels, followed by leaving the service point charge at a low fee of $250/service point per year whilst maintaining a high infrastructure access fee and moving to a single charge for delivery share (ML/day) across all irrigation districts.

For members belonging to class two, comprising nearly 20 per cent of the sample, relative to the base attribute level, there exists a preference to reduce the termination fee from 10 times to 8 times the cost of each delivery share. Further, respondents belonging to this class would prefer a simplified bill

Table 5 Latent class model results

	Class 1		Class 2		Class 3		Class 4	
	Parameters	SE	Parameters	SE	Parameters	SE	Parameters	SE
Service Point Fees (*D*)	−2.701***	0.460	−1.486	0.943	0.186	0.625	6.087***	1.238
Service Point Fees 2	−1.168**	0.459	3.334***	0.789	−4.876***	0.936	−3.081**	1.235
Pricing Strategy (*D*)	−0.235	0.341	−0.293	0.799	0.139	0.441	1.973***	0.622
Pricing Strategy 2	−2.657***	0.341	1.663***	0.527	−0.568	0.467	−0.408	0.594
Delivery Share (*D*)	−0.515	0.336	0.446	0.785	−0.504	0.440	1.892***	0.596
Delivery Share 2	−3.607***	0.476	−1.709**	0.740	1.223***	0.466	1.048	0.710
Control (*D*)	−0.789**	0.355	−0.369	0.751	0.280	0.406	2.083***	0.577
Control 2	−2.065***	0.405	1.510**	0.688	−1.235**	0.509	−2.299***	0.653
Control 3	−1.435***	0.405	0.549	0.699	1.745***	0.575	−1.043	0.949
Casual Use Fee (*D*)	−1.191***	0.341	1.170	0.840	−0.164	0.472	0.348	0.605
Casual Use Fee 2	−1.193***	0.335	0.421	0.533	1.201**	0.530	0.884	0.637
Termination Fee (*D*)	−1.906***	0.325	−2.113***	0.731	−1.229***	0.388	0.709	0.614
Termination Fee 2	−0.469	0.363	4.152***	0.561	2.493***	0.464	1.295*	0.751
Payment Instalment Options (*D*)	0.087	0.401	1.348	1.161	1.616***	0.475	2.926***	0.735
Payment Instalment Options 2	−1.154***	0.414	0.658	0.751	−1.080**	0.541	−3.371***	0.716
Break down of Charges 2	−1.115***	0.411	2.405**	0.944	2.395***	0.519	3.881***	0.766
Class assignment model								
Class probabilities	0.386***	0.043	0.194***	0.034	0.279***	0.041	0.141***	0.030
Model statistics								
Log-likelihood	−1738.421							
Pseudo-R^2 (ρ^2)	0.212							
No. of observations	1,592							
No. of parameters	67							
Chi-square (χ^2)	937.119							

***Significant at the 1% level.
**Significant at the 5% level.
(*D*) Indicates the dummy variables created for seven attributes.

relative to the current bill, whilst increasing the service point charge whilst simultaneously lowering the infrastructure access fee is preferred over keeping the current number of charges. The least preferred variable for this segment is to retain the current service fee.

For class three, comprising nearly 28 per cent of the sampled population, the most preferred action would be to reduce the termination fee, followed by simplifying the number of charges, whilst the least preferred item would involve increasing the service point charge whilst simultaneously lowering the infrastructure access fee. Similar to class three, respondents belonging to class four have a preference for simplifying the number of charges; however, in contrast to class two, their most preferred action would be to keep the service point charge as is but retain a higher infrastructure access fee.

As noted, one of the major advantages of this approach is that variables are measured on the same metric and we can thus interpret them directly. In this model, the parameters are relative to Level 1 of the break down of charges attribute and we can normalise the parameters between 0 and 1 to develop an index to compare the preferred outcomes (i.e. list most to least preferred pricing structure).[3] Table 6 reports the parameters that have been normalised from 0 to 1 for each class. Parameters that are not statistically significant are constrained to 0. The final two columns in the Table report the normalised parameter results by weighing the class-specific normalised parameters by the class assignment probabilities.

As highlighted earlier, the base attribute in this instance is "break down of charges". Accordingly, the normalised parameters are relative to Level 1 for this attribute. This attribute and level were defined as 'keep the existing break down of charges that appear on your bill'. Within each class, the attribute levels that have normalised parameters equal to zero are all equally preferred to Level 1 of the specified break down of charges attribute. For class one, these variables include Pricing Strategy *D*, Delivery Share *D*, Termination Fee 2 and Payment Instalment Options *D*. All other parameters are negative for this class and hence are less preferred than these attribute levels. The results for the three other classes can be similarly interpreted with positive parameters indicating greater preference relative to Level 1 of break down of charges. The class probability weighted results presented in the final two columns represent the population average estimates for the normalised parameter estimates. Overall, for the population, the most preferred attribute level is Payment Instalment Options *D*, whilst Service Point Fee 2 is the least preferred.

It is also useful to scale the parameters to take values between 0 and 1. Such a rescaling of the results is also presented in the final column of Table 6. The rescaling and graphing of the data provides a relative index of attribute level importance by class, as well as for the population on average. The results of this exercise should be consistent with the results presented for the normalised parameter estimates.

[3] Changing the base will simply rescale the results, but preserve the relative differences.

Table 6 Normalised parameters (0–1): betas constrained to zero

	Class 1		Class 2		Class 3		Class 4		Weighted av	
	Normalised parameters	Scaled parameters	Normalised parameters	Scaled parameters	Normalised parameters	Scaled parameters	Normalised parameters	Scaled parameters	Normalised parameters	Scaled parameters
Service Point Fees (*D*)	−2.701	0.34	0.000	0.47	0.000	0.66	6.087	1.00	−0.187	0.64
Service Point Fees 2	−3.869	0.06	1.848	0.88	−4.691	0.00	3.007	0.53	−2.022	0.00
Pricing Strategy (*D*)	0.000	1.00	0.000	0.47	0.000	0.66	1.973	0.37	0.277	0.80
Pricing Strategy 2	−2.893	0.30	1.370	0.77	0.000	0.66	0.000	0.07	−0.850	0.41
Delivery Share (*D*)	0.000	1.00	0.000	0.47	0.000	0.66	1.892	0.36	0.266	0.79
Delivery Share 2	−4.122	0.00	−1.263	0.19	0.720	0.76	0.000	0.07	−1.635	0.13
Control (*D*)	−0.789	0.81	0.000	0.47	0.000	0.66	2.083	0.39	−0.012	0.70
Control 2	−2.855	0.31	1.141	0.72	−0.955	0.53	−0.216	0.03	−1.177	0.29
Control 3	−2.225	0.46	0.000	0.47	2.025	0.95	0.000	0.07	−0.293	0.60
Casual Use Fee (*D*)	−1.191	0.71	0.000	0.47	0.000	0.66	0.000	0.07	−0.460	0.54
Casual Use Fee 2	−2.225	0.46	0.000	0.47	2.025	0.95	0.000	0.07	−0.293	0.60
Termination Fee (*D*)	−1.906	0.54	−2.113	0.00	−1.229	0.49	0.000	0.07	−1.489	0.18
Termination Fee 2	0.000	1.00	2.039	0.92	1.264	0.84	0.000	0.07	0.749	0.96

Table 6 (*Continued*)

	Class 1		Class 2		Class 3		Class 4		Weighted av	
	Normalised parameters	Scaled parameters	Normalised parameters	Scaled parameters	Normalised parameters	Scaled parameters	Normalised parameters	Scaled parameters	Normalised parameters	Scaled parameters
Payment Instalment Options (*D*)	0.000	1.00	0.000	0.47	1.616	0.89	2.926	0.52	0.863	1.00
Payment Instalment Options 2	−1.067	0.74	0.000	0.47	0.536	0.74	−0.445	0.00	−0.325	0.59
Break down of Charges 2	−1.115	0.73	2.405	1.00	2.395	1.00	0.000	0.07	0.706	0.95

7. Interpretation and implications for tariff reform

Whilst acknowledging some limits with these data, there are several insights that arise about tariff reform in this context. The least preferred pricing structures identified by respondents commencing with most egregious were as follows: increasing the service point charge from $250 to $1000/service point per year and lowering the infrastructure access fee (i.e. reducing the cost of each delivery share by $600); reducing the volume of delivery share from 270 to 150 ML; maintaining the termination fee at 10 times the cost of each delivery share; adjusting charges such that they are 100 per cent fixed (currently 90 per cent fixed and 10 per cent variable); adopting a single delivery share charge (based on ML/day) across all irrigation districts; retaining casual use fees as they are – typically the fee is $80 per ML.

The most preferred tariff components include the following: maintaining the current payment instalment options; a reduction in the termination fee from 10 to 8 times the cost of each delivery share; reducing the number of charges to simplify the bill; keeping the charges for delivery share differentiated across the irrigation districts; and retaining the current volume of 270 ML per delivery share.

Recall that our interest was to establish the preferences of irrigators for tariff reform, and in that context, it is worth noting that this information provides some insights for practitioners seeking to progress the debate about cost recovery. Our prior hypothesis was that irrigators are more inclined to engage positively in discussions about cost recovery if the structure of the water tariff better aligns with their preferences. In addition, some elements of the tariff are more likely to reflect changes in underlying and future costs than others. Understanding the most preferred irrigator options offers scope for engaging in a dialogue about full-cost recovery pricing, and in that context, we focus primarily on the three most preferred options.

First, there was support from the modelled data for the option to stay with the existing payment instalment plan. This emphasises the importance of understanding the synergies between revenue management on the part of the government-owned water supply corporation and cash flow of farm businesses that access water. Regardless, this approach is not inconsistent with the notion of full-cost recovery.

Second, irrigators expressed a preference for a reduction in the termination fees. These findings have implications beyond the IIO involved in this project and may have ramifications for governments involved in gifting assets to irrigation entities. One of the major justifications for the current policy approach (i.e. public subsidy of irrigation infrastructure) has been that additional irrigation infrastructure represents an opportunity to increase the financial viability of irrigation (Crase *et al.* 2013). Moreover, both state and federal governments have expressed a preference to gift assets and impose limits on the repurchase of water rights by government (see, Joyce 2016). The support of irrigators for refurbishment of infrastructure has often been

presumed in the public advocacy of this approach, and some lobbyists have also contended that this is the only fair mechanism for reducing abstractions by irrigators (Crase *et al.* 2011). Whilst acknowledging some limits from this survey, the data raise important questions about the potential reluctance on the part of some irrigators to be locked into infrastructure choices. Similar support was evidenced in submissions to the ACCC review, with the Victorian Farmers' Federation noting that termination fees have acted as a barrier to network rationalisation by deterring exit. Had greater exit occurred the progress of the overall infrastructure project may have been improved (ACCC 2016, p. 261).

This raises questions about the efficacy of a policy approach that claims to be supporting irrigation communities in the long run when there is at least some evidence that a cohort of irrigators have very different preferences. In simple terms, irrigators' preferences for lower termination charges are not consistent with governments' commitment to gift additional irrigation infrastructure in the hope of holding people in irrigation. Arguably, this process is also not consistent with the desire to have resource scarcity captured over time.

These data thus shed some light on the potential for policymakers to send mixed messages to irrigators about the need to adjust their demand for water. This is particularly evident when buyback of water rights is undertaken simultaneously with publicly funded infrastructure upgrades in irrigation. On the one hand, governments have sought to use the market to purchase water rights from willing sellers to restore environmental flows in the Murray–Darling Basin. This has had the effect of increasing the price (value) of water rights and encouraged irrigators to move away from some relatively low-value water-intensive activities. On the other hand, governments have simultaneously subsidised irrigation infrastructure for some water users, thereby depressing the charges paid by irrigators to IIOs, like G-MW. In effect those fortunate to be part of the upgrade plans experience an increase in wealth through rising entitlement prices and simultaneously accessing the related infrastructure at lower-than-cost prices.

The response of water supply businesses to possible widespread participation in water buybacks has been to increase the termination fees faced by irrigators, thus creating a perception amongst some irrigators of being penalised for opting to leave the industry. Admittedly, there are other reasons that may explain why irrigators continue to pay their ongoing delivery share costs, like concerns about the value of land for future sale or keeping options open to reactivate irrigation (see, e.g. Wheeler *et al.* 2014). Nonetheless, setting a termination fee at ten times the delivery share is a nontrivial disincentive to reduce the irrigation footprint and material reductions in termination charges could help ensure that mixed messages do not unduly slow irrigation farmer adaptation.

Third, the data suggest that a simplification of the tariff, so that it communicates adequate information about water use, service and the

underlying relationship to cost and water availability, would be well regarded by irrigators. Whilst this approach is also supported on theoretical grounds, the empirical data collected as part of this project arguably offers a more compelling argument for change. In contrast, some economic regulators have been keen to advocate that tariffs explicitly detail the basis of every charge and every adjustment to a charge. However, this detail comes at a cost to those who must interpret complex water bills and clearly there are cognitive limits for those receiving this information. As noted earlier, there are potentially around 400 different charges that could be levied on irrigators in G-MW. The data collected by this project suggests adjustments in favour of a simplified and clear price are long overdue. The more recent findings of ACCC (2016) offer additional support on this front by suggesting streamlining of regulatory processes but the extent to which this is reflected in simpler tariffs is unclear.

Collectively, these data support the view that there is a basis for pursuing tariff reform and this may help deal with the underlying concerns about cost recovery in irrigation. Irrigators sampled in this study had a preference for changing some of the ways they pay for irrigation water and the related services; these preferences are not inconsistent with the market frameworks that align with full-cost recovery. This is not to say that irrigators will acquiesce to change; rather, the data suggest that there is a basis for staging price reform in the study area and that the political costs of changing tariffs may not be so large as to forestall all market-based pricing reforms. As a minimum, this study points to the basis on which a discussion about cost recovery can take place between irrigators, IIOs and regulators.

8. Concluding remarks

Reforming market signals such that users pay the full cost of water and related services remains a significant challenge for policymakers, especially when it comes to agricultural water users. This is particularly apparent in the recovery of costs related to capital, which are frequently absorbed by governments rather than passed on to irrigators. The political will to deal with this issue is mixed and all-too-often governments resort to subsidising capital expenditures in irrigation, even when there has been an agreed trajectory towards full-cost recovery, as has occurred in Australia.

We have argued that one way to better deal with the political costs of price reform in irrigation is to consider the preference of irrigation farmers and identify those elements of reform that are less likely to attract criticism. In addition, we have argued that relatively little empirical evidence is available on this front, making this current study novel. This makes the data assembled for this study relatively unique and provides guidance for further research in this context.

Whilst acknowledging some weaknesses in the data, our results suggest that there is a basis for engaging in a discussion about tariff reform in irrigation that at least partially aligns with the notion of cost recovery. For example,

irrigators had significant preferences for water prices that were clearer, were aligned with their business demands and tariffs that did not limit adaptation or adjustment out of irrigation, should the alternative be more profitable. Clearly, these preferences are not at odds with the notion of full-cost recovery and have the potential to be leveraged to achieve change. In addition, the results highlight some of the gaps in the rationale used by governments to offer subsidies for irrigation infrastructure.

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