A Nested Logit Model of Green Electricity Consumption in Western Australia

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Abstract

Green electricity products are increasingly made available to consumers in many countries in an effort to address a number of environmental and social concerns. Most of the existing literature on this green electricity market focuses on consumer's characteristics and product attributes that could affect participation. However, the contribution of this environmental consumerism to the overall environmental good does not depend on participation alone. The real impact made relies on market penetration for green consumers (the proportion of green consumers) combined with the level of green consumption intensity – the commitment levels, or proportion of consumption that is green. We design an online interface that closely mimics the real market environment for electricity consumers in Western Australia and use a three-level nested logit model to analyze consumers' choice of green electricity products as well as their commitment levels. Our main conclusions are that the choice of green products is strongly influenced by beliefs in the nature of climate change, and trust in the government and utilities in delivering the product. When green products are selected, the vast majority select the minimum commitment possible, and this is insensitive to the premium being charged on green power, suggesting that we are largely observing a 'warm glow' for carbon mitigation.

Key words: *Green Power; Nested Logit; Warm Glow; Green Electricity*

1. Introduction

The past few decades have witnessed a significant increase in the demand and supply of "environmentally friendly" or "green" products. Market research on consumers behavioural patterns involved in green product choice has shown a very high percentage of consumers willing to buy green products. Another body of research, however, indicates that consumers are only willing to purchase green products with preferred attributes within certain constraints. Research in this field has been primarily conducted by market research companies, the results of which are not in the public domain (Blamey et al., 2001). Academic research in the area only focuses on the factors and attributes that influence consumers' choice of green products. Very little research looks at the level of commitment (defined here as the proportion of an individual use of a product that is 'green') beyond the choice of green products. The environmental impact as a result of green consumption not only depends on consumers' choice of environmentally friendly products, the level of commitment or demand is also crucial. For instance, the contribution of residential rooftop solar panel adoption to a clean energy supply depends on the size (capacity) of each installation as well as the number of installations. However, Andreoni (1989; 1990) argued that consumers not only derive utility from the contribution to the environmental good which is pure altruism and is linked to the level of commitment, utility is also derived from the pro-environmental behavior itself – often termed as a "warm glow" effect which is not necessarily linked to the level of commitment. The amount that consumers are willing to pay has been found to be highly non-linear in the percent of energy that is generated from renewables (Farhar, 1999) and customers are more concerned about the concept of consuming green energy than its actual environmental impact (Goett et al., 2000). One implication is that if a "warm glow" effect is significant, the actual contribution to the environmental good may be limited even if there are a substantial number of green consumers. More importantly, this will also have implications for the actual impact of policies that aim to promote pro-environmental behaviors. It is thus important to study both consumers' choice of green products and their commitment levels. In this paper, we study consumers' participation in green electricity programs in Western Australia. We design a survey that closely mimics the real decision context facing the consumers in Western Australia and use a 3-level nested logit model to investigate both consumers' choices of products and commitment levels. The rest of the paper proceeds as follows. Section 2 provides the background of Australian green electricity programs and reviews relevant literature. Section 3 describes our experimental design. Section 4 introduces our statistical model. We present results in Section 5 and conclusions in the last section.

2. Background and Literature

The option to purchase green electricity products is increasingly available to consumers in many countries. For instance, Kotchen and Moore (2007) identified 29 green electricity suppliers currently competing in eight US states. Mewton and Cacho (2011) also studied 21 green electricity schemes provided by utility retailers in Australia. The willingness of consumers to pay for green electricity or actual participation in the green electricity market has been investigated in a large number of countries including the US (Farhar and Houston, 1996; Wiser, 2007; Bird et al., 2007; Kotchen and Moore, 2007), Australia (Mewton and Cacho, 2011, Ivanova, 2012), Sweden (Ek and Söderholm, 2008), Norway (Navrud and Bråten, 2007), Finland (Salmela and Varho, 2006), UK (Scarpa and Willis, 2010; Diaz-Rainey, 2012), Germany (Menges et al., 2005), Canada (Rowlands et al., 2003) and Japan (Nomura and Akai, 2004). These studies primarily address two questions: 1) what motivates consumers to participate in green electricity programs? 2) how do consumers' characteristics and a product's attributes (eg. energy sources and payment mechanisms) affect participation? Conventional electricity is mostly generated from fossil fuels, which is by far the largest emitter of a number of local as well as global air pollutants such as carbon and fine particulates. Demand for green electricity thus contributes to the mitigation of these pollutants. However, the contribution of this environmental consumerism to the overall environmental good does not depend on participation alone. If a "warm glow" effect is the dominant driver for participation, we would expect a low commitment level overall. As a result, the real impact of this green consumerism and policies promoting it may also be rather limited. It is thus important to investigate both participation and commitment levels.

Under all-or-none schemes, where consumers either choose a conventional electricity product or commit 100% to electricity generated from renewable sources, it is understandable that studies mostly focus on participation. However, this all-or-none approach is increasingly being moderated in real markets, with many green electricity products offering different commitment levels. In Australia, the green electricity market is largely driven by the Australian National Green Power Accreditation Program (NGPAP) which is a market-based program initiated by the NSW government in 1997. The objective of the program is to encourage investment in new renewable energy generation by increasing consumer demand and confidence in accredited "GreenPower" products by letting consumers opt-in to pay a premium and buy more expensive green electricity on a voluntary basis. Currently, a total of 44 "GreenPower" products are provided by 28 NGPAP accredited retailers nationally. In addition, there are other unaccredited green electricity products offered in the market. For instance, Synergy which is the electric utility company that serves the metropolitan Perth area offers residential customers two NGPAP accredited "GreenPower" products – "EasyGreen" and "NaturalPower", and one unaccredited product – "EarthFriendly". Consumers can make a choice between conventional electricity product and these accredited and unaccredited green electricity products. In addition, they can also choose the level of commitment through different payment schemes. For "EasyGreen", consumers can commit a fixed amount (ranging from \$10 - \$80 in \$10 steps) on top of their regular bill. For "NaturalPower" and "Earth Friendly", customers can choose a fixed proportion of their electricity to be generated from renewable sources (25% - 100%) or choose to offset the carbon emission of a fixed proportion of their conventional electricity consumption (25% - 100%). This green electricity market thus provides an excellent setting to study consumers' commitment levels as well as product choices.

3. Choice Experiment Design

The majority of the WA households are served by Western Power's South West Interconnected Systems (SWIS). Synergy is responsible for the retail delivery of electricity in this area. The SWIS covers the entire metropolitan Perth area where we recruit all our respondents. There are currently four electricity products offered by Synergy – the conventional fossil fuel generated electricity, two NGPAP accredited "GreenPower" products – "EasyGreen" and "NaturalPower", and one unaccredited product – "EarthFriendly". Synergy provides an online interface for consumers to compare and make a choice among electricity products and commitment levels. Information on the cost of selecting different products and commitment levels and associated environmental impacts is also provided through the interactive interface. This online interface thus represents the real market environment that households face in metropolitan Perth area. In the hypothetical experimental setting we slightly modify this interface to include extra information regarding the attributes of the electricity products, while trying to closely mimic the real market environment. Figure 1 and Figure 2 present images of Synergy's actual interface and our modified version where we embed our choice experiments[1].

Consumers (respondents in our case) can navigate across products (tabs) to see attribute differences. They can also change commitment levels by moving the slider bar to see the extra cost to their electricity bill and the impact on the level of carbon emissions (shown in panel 2). Once a consumer (respondent) is satisfied with a specific combination of a product and a commitment level, they can make an order (choice in our case). It is reasonable to think that consumers in the real market would need time to get familiar with the structure of the interface before they can make an order. To facilitate this process in our choice experiment, we provide a 5-minute video demonstration to explain how to compare alternative products, adjust commitment levels and make a choice. This video is placed before respondents start with the formal choice questions. Each respondent answers six choice sets. When making the commitment level respondents were restricted to the discrete levels available: \$10-\$80 for EasyGreen (in steps of \$10), or 25, 50, 75, 100% for NaturalPower and EarthFriendly[2]. Thus respondents can be considered to have selected 1 out of 4 products, if the analysis is considered at the product level, or 1 of 17 product/commitment levels, if one considers the full choice process.

1 Although Synergy approved the use of a simile of their web site, they are not responsible for any of the implementation and conclusions drawn from this study.
2 These are also the actual discrete commitment levels marketed by Synergy.

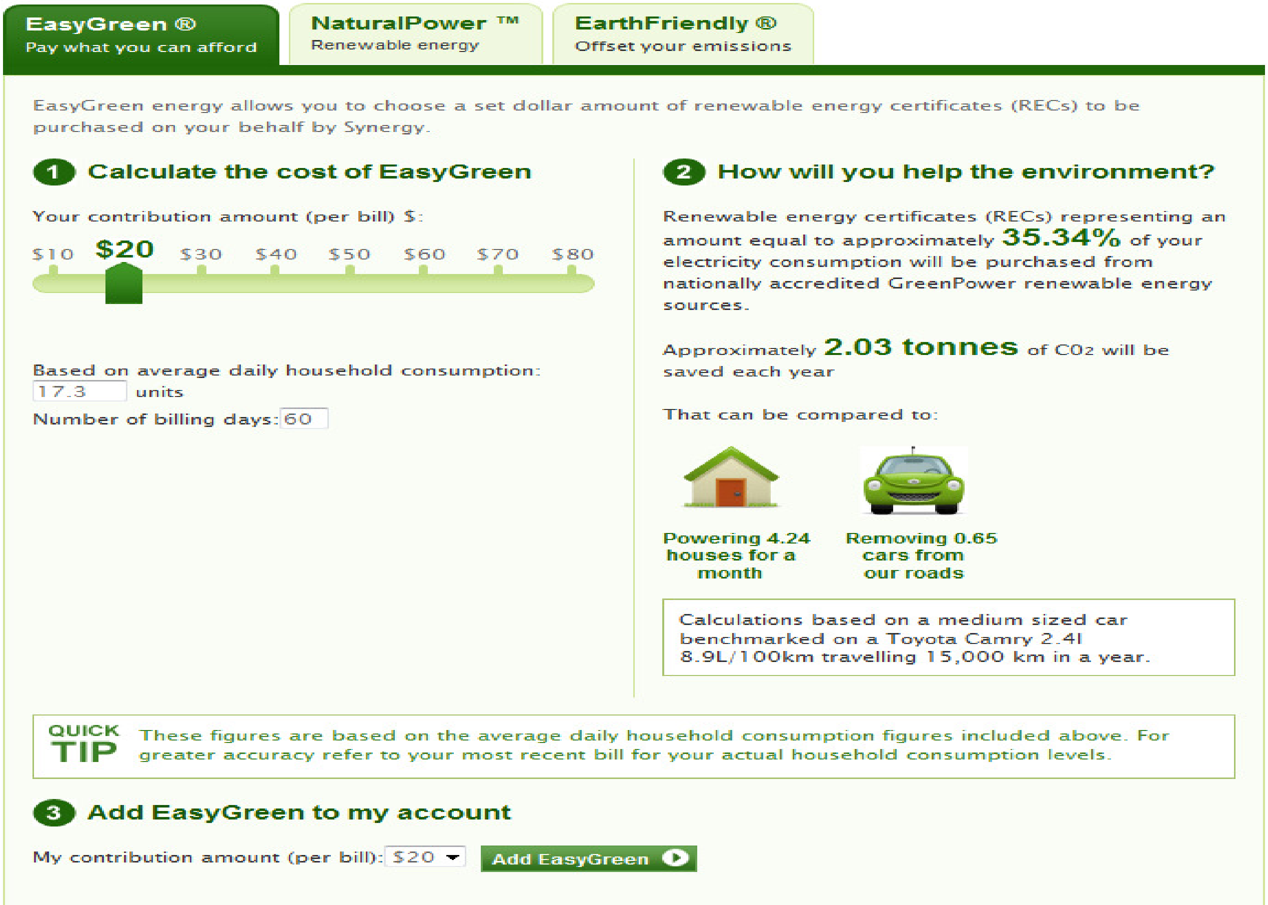

Figure 1: Synergy's Green Power Web Interface

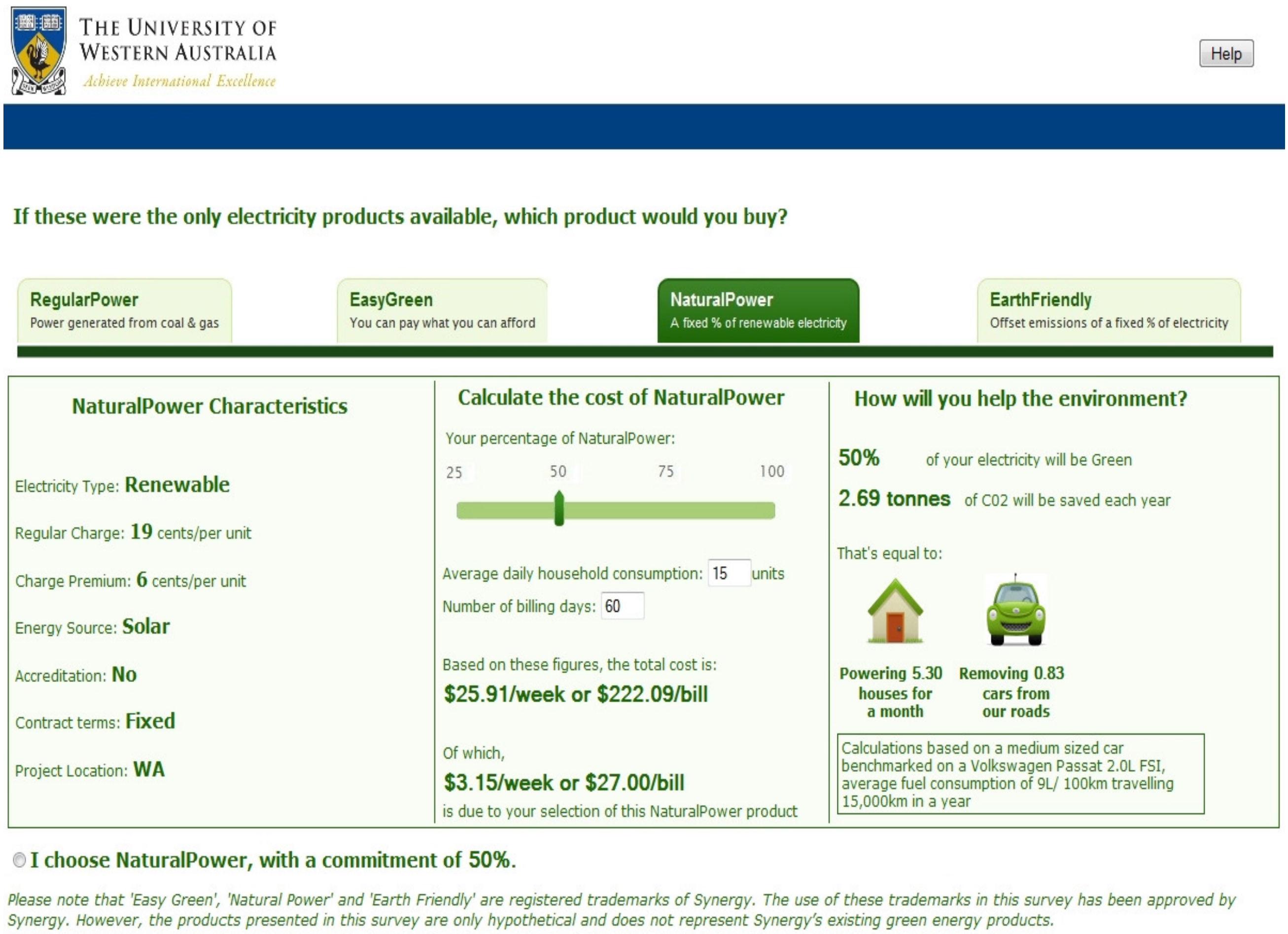

Figure 2: Modified Choice Set Presentation

Table 1 summarizes the attributes and associated values that are used to describe the products. These attributes and values are carefully chosen to capture the differences in existing green electricity products in the Australian market, but it should be noted that the type of source, accreditation, contract terms and location of renewable energy source are not attributes that are described as part of the actual Synergy products. The regular charge (which defines the cost of the conventional electricity, and provides the baseline costs for the green products, to which the elected contribution is added) is fixed within any choice set, but varies across choice sets. The implication is that this cannot be considered as a direct attribute to explain choices across products. However, we anticipate that the level of the regular charge (or more specifically, the expected total utility bill, which will also be influenced by average daily use) may influence the choice between conventional and green products. Thus, if regular charge is high, leading to a high baseline bill, respondents may be less willing to commit to further expenditure. The appropriateness of the attributes and associated value ranges were verified in a pilot study.

The design of the survey used an s-efficiency criteria (using Ngene), with 12 choice sets, blocked into 2 groups of 6. For the 6 choice sets each respondent saw, there was a different regular charge (which was common to all alternatives within the choice set, and hence not used in the design itself). These progressively increased in value (from 19 to 29) through the design for half of the sample, while they declined for the other half (29 through 19). The online survey was conducted in the June of 2012, with 831 completed responses.

Table 1: Product Attributes and Attribute Values

Attributes	Attribute Values
Regular Charge	19,21,23,25,27,29
Charge Premium	0,1,2,4,6
Energy Source	Coal & Gas, Hydro, Bio, Wind, Solar
Accreditation	Yes, No
Contract Terms	Fixed (2-Year), Flexible
Location	WA, Non-WA

4. Modeling Approach

Consumer choice analysis has made extensive use of random utility models where

$$U \text{ (choice } j \text{ for consumer } i\,) = U_{ij} = V_{ij} + \varepsilon_{ji}$$

The utility U_{ij} consists of a systematic component V_{ij} and a random disturbance ε_{ji}. Utility maximization implies that the probability that consumer i will choose alternative j, P_{ij}, is determined by

$$P_{ij} = \Pr\,(U_{ij} > U_{ik}) \qquad \forall\ k \neq j$$

The probability can be empirically estimated once the specification of the deterministic component V_{ij} and the characteristics of the stochastic component ε_{ji} are known. A large number of choice analyses have focused on multinomial or conditional logit models where the stochastic disturbance is assumed to be independently and identically distributed (IID) with a Gumbel distribution. The IID assumption has an important behavioral association with a property known as the Independence of Irrelevant Alternatives (IIA) which states that the ratio of the choice probabilities of any pair of alternatives is independent of the presence or absence of any other alternative in a choice set. An important behavioral implication of IIA is that any pair of alternatives (choices) are equally similar or dissimilar (Hensher et al., 2005). In our choice setting where households need to choose among different electricity products as well as different commitment levels, it is very likely that the IIA/IID assumption is violated if commitment levels for the same product are perceived as closer substitutes. The assumption is also violated if households perceive green electricity products are closer substitutes as compared to the conventional electricity product. If there is unobserved correlation among alternatives, multinomial or conditional logit models will generate inconsistent parameter estimates. When the IIA/IID assumption is thought to be possibly violated, the nested logit model is an appropriate method to accommodate the violations.

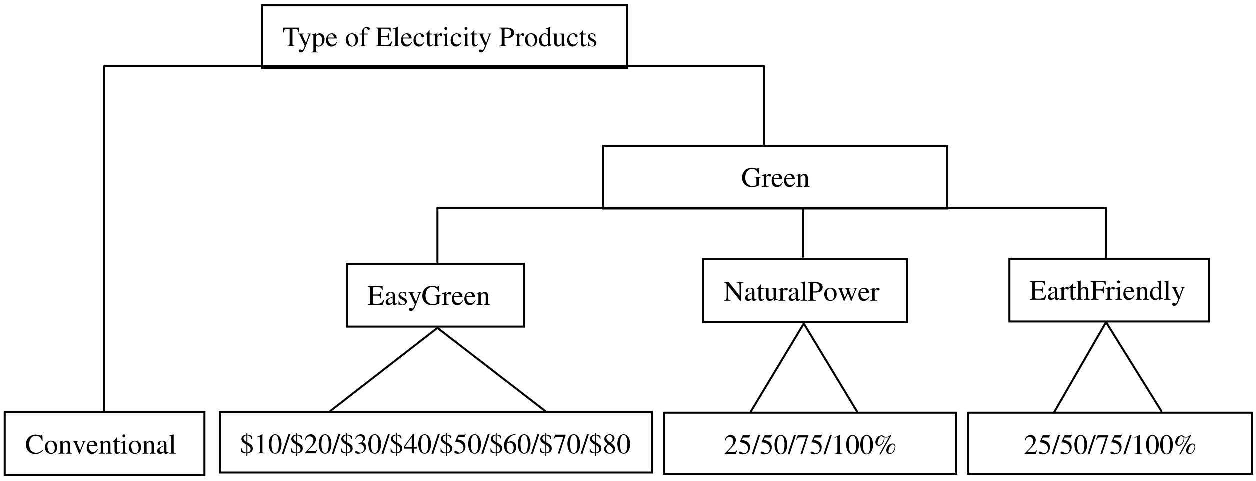

Figure 3: Alternatives Nesting Structure

Figure 3 presents the nesting structure of our model. The structure shown is intended to capture the similarity or dissimilarity of alternatives or products. We assume that a household makes a simultaneous decision rather than a sequential decision regarding the type of electricity products and associated commitment levels. Formally a three-level nested logit model can be specified as

$$\Pr(\text{twig } j, \text{branch } k, \text{limb } l) = P_{jkl} = P_{j|k,l} P_{k|l} P_l$$

where j, k, and l refer to choice of commitment levels, choice of green electricity products and choice of type of electricity products respectively (for convenience, we have suppressed the subscript associated with individuals), and

$$P_{j|k,l} = \exp(\mu_j \boldsymbol{\alpha} \boldsymbol{X}_{\boldsymbol{j|k,l}}) \Big/ \sum_{j=1}^{J_k} \exp(\mu_j \boldsymbol{\alpha} \boldsymbol{X}_{\boldsymbol{j|k,l}})$$

$$P_{k|l} = \exp(\lambda_k \boldsymbol{\beta} \boldsymbol{Y}_{\boldsymbol{k|l}} + \tau_k IB_k) \Big/ \sum_{k=1}^{K_l} \exp(\lambda_k \boldsymbol{\beta} \boldsymbol{Y}_{\boldsymbol{k|l}} + \tau_k IB_k)$$

$$P_l = \exp(\gamma_l \boldsymbol{\varphi} \boldsymbol{Z_l} + \theta_l IL_l) \Big/ \sum_{l=1}^{L} \exp(\gamma_l \boldsymbol{\varphi} \boldsymbol{Z_l} + \theta_l IL_l)$$

where, IB_k and IL_l are known as inclusive values for the k^{th} branch and the l^{th} limb with

$$IB_k = \ln \sum_{j=1}^{J_k} \exp(\mu_j \boldsymbol{\alpha} \boldsymbol{X_{j|k,l}})$$

$$IL_l = \ln \sum_{k=1}^{K_l} \exp(\lambda_k \boldsymbol{\beta} \boldsymbol{Y_{k|l}} + \tau_k IB_k)$$

$\boldsymbol{X}$, $\boldsymbol{Y}$, and $\boldsymbol{Z}$ refer to vectors of attribute variables that enter into utility functions at the twig, branch and limb levels. The terms - μ_j, λ_k, γ_l - are scale parameters of the disturbance term at three levels. τ_k and θ_l are inclusive value (IV) parameters which are measures of the correlation among the random terms due to unobserved attributes of alternatives within the same nest. These inclusive value parameters are sometimes used as a test of utility maximization in nested logit models. Daly and Zachary (1979) and McFadden (1978) have shown that the nested logit model is consistent with random utility maximization under the condition that the IV parameters are constrained within the unity interval (the DZM condition). However, this condition is often violated in many empirical applications. In fact, many researchers choose not to discuss the parameters. Börsch-Supan (1990) argues that the DZM condition is unnecessarily strong given that the NL model should only be viewed as a local approximation. Following the work of Börsch-Supan, Herriges and Kling (1996) provide necessary conditions for local consistency with utility maximization for two-level nested logit models and Gil-Molto´ and Hole (2004) derive the necessary conditions for compliance with utility maximization for three-level nested logit models. The conditions are not sufficient when there are more than three alternatives per nest, but in empirical applications testing the necessary conditions may be considered satisfactory (Herriges and Kling, 1996). We check our model's consistency with utility maximization by applying the conditions derived by Gil-Molto´ and Hole (2004) to estimated IV parameters and predicted marginal and conditional probabilities.

For the model to be identified, we need to impose some normalization restrictions. Hensher and Greene (2002) have shown that normalization from the bottom (RU1) may cause problems for models with generic parameters – that is the same parameters appearing in several nests. To ensure compliance with the necessary conditions for utility maximization, one can implement the RU1 normalization and set the

IV parameters to be equal at the same level in the nest or use the RU2 normalization (from the top) and allow the IV parameters to be free between partitions of a nest. Alternatively, one can estimate a non-normalized nested logit model (NNNL) by either setting the scale parameters to be equal at a level in the nest or allowing the IV parameters to be free but adding an additional level at the bottom of the tree through dummy nodes and links. However, there is no a priori reason for restricting equal IV parameters across nests (as in RU1). Hensher and Greene also show that the application of the RU2 normalization with unrestricted IV parameters in the presence of generic parameters is identical to the results obtained by estimating a NNNL model with dummy nodes and links. The RU2 specification thus avoids the need to introduce dummy nodes and links. In our empirical model, we implement the RU2 normalization. We now turn to our empirical identification.

We define utility at the lowest level, i.e. at the commitment level, but assume that there are some cross utility function parameter restrictions e.g. that the effect of a green product characteristic has the same effect on utility derived from all commitment levels of that product. We assume that utility of conventional depends on the total cost, and individual attributes. The utilities for the commitment levels of each of the green products depends on the attributes of the product, and the total cost and carbon emission savings at each of the commitment levels. As the premium level differs across products, there is not a collinear relationship between costs and emissions within the alternatives of a choice set (the lower the premium, the higher the emissions savings for any particular level of total cost). An alternative specific constant is introduced for each of the green products ($\mathbf{ASC_{EG}}$, $\mathbf{ASC_{NP}}$, $\mathbf{ASC_{EF}}$) as they are effectively labelled alternatives, and an ASC is introduced for each of the minimum contribution levels within the products ($\mathbf{ASC\_WG_{EG}}$, $\mathbf{ASC\_WG_{NP}}$, $\mathbf{ASC\_WG_{EF}}$). Green product attributes are effects coded and other variables are described in Table 2.

$$\boldsymbol{V_{Conventional}} = \boldsymbol{\varphi Z}$$

$$= \varphi_1 \text{TotalCost} + \varphi_2 \text{Female} + \varphi_3 \text{HighSchool} + \varphi_4 \text{TertiaryUndergraduate}$$

$$+ \varphi_5 \text{TertiaryPostgraduate} + \varphi_6 \text{TradeTAFE} + \varphi_7 \text{ClimateBelief2}$$

$$+ \varphi_8 \text{ClimateBelife3} + \varphi_9 \text{GreenParty} + \varphi_{10} \text{Trust1} + \varphi_{11} \text{Trust2}$$

$$V_{EasyGreen,\ Commitment\ level_j} = \boldsymbol{\alpha X}$$

$$= \mathrm{ASC_{EG}} + \mathrm{ASC\_WG_{EG}} + \alpha_1 \mathrm{TotalCost} + \alpha_2 \mathrm{Carbon} + \alpha_3 \mathrm{Accreditation}$$

$$+ \alpha_4 \mathrm{Contract} + \alpha_5 \mathrm{Location} + \alpha_6 \mathrm{Hydro} + \alpha_7 \mathrm{Solar} + \alpha_8 \mathrm{Wind}$$

$$V_{NaturalPower,\ Commitment\ level_j} = \boldsymbol{\alpha X}$$

$$= \mathrm{ASC_{NP}} + \mathrm{ASC\_WG_{NP}} + \alpha_1 \mathrm{TotalCost} + \alpha_2 \mathrm{Carbon} + \alpha_3 \mathrm{Accreditation}$$

$$+ \alpha_4 \mathrm{Contract} + \alpha_5 \mathrm{Location} + \alpha_6 \mathrm{Hydro} + \alpha_7 \mathrm{Solar} + \alpha_8 \mathrm{Wind}$$

$$V_{EarthFriendly,\ Commitment\ level_j} = \boldsymbol{\alpha X}$$

$$= \mathrm{ASC_{EF}} + \mathrm{ASC\_WG_{EF}} + \alpha_1 \mathrm{TotalCost} + \alpha_2 \mathrm{Carbon} + \alpha_3 \mathrm{Accreditation}$$

$$+ \alpha_4 \mathrm{Contract} + \alpha_5 \mathrm{Location} + \alpha_6 \mathrm{Hydro} + \alpha_7 \mathrm{Solar} + \alpha_8 \mathrm{Wind}$$

Table 2 – Variables Definition

Variables	**Definition**
TotalCost	Total cost of an average bill on a 60-day billing cycle ($)
Female	1 for female head of household
HighSchool	1 if the respondent's highest education level attained is high school; the default is primary school
TertiaryUndergraduate	1 if the respondent's highest education level attained is tertiary undergraduate; the default is primary school
TertiaryPostgraduate	1 if the respondent's highest education level attained is tertiary postgraduate; the default is primary school
TradeTAFE	1 if the respondent's highest education level attained is Trade or TAFE; the default is primary school
ClimateBelief2	1 if the respondent answers - "No" - to the question "Do you believe that climate change is occurring"; the default is "Yes"
ClimateBelife3	1 if the respondent answers - "I'm not sure" - to the question "Do you believe that climate change is occurring"; the default is "Yes"
GreenParty	1 if the respondent chooses to vote for the Green Party in the next federal election
Trust1	Likert scale (1-5): "How trustworthy do you think utility companies are?", with 5 associated with the highest level of trust

Trust2	Likert scale (1-5): "How trustworthy do you think the government's accreditation and annual auditing of green electricity products is?", with 5 associated with the highest level of trust
Carbon	Tonnes of carbon saved each year
Accreditation*	1 for products accredited by the National GreenPower Accreditation Program
Contract*	1 if the electricity contract is fixed (2 years)
Location*	1 if renewable or offset projects are located in Western Australia
Hydro*	1 if energy source is hydro; the default is bio-energy
Solar*	1 if energy source is solar; the default is bio-energy
Wind*	1 if energy source is wind; the default is bio-energy

* Green products attributes are effects coded.

Although not reported below, we have also investigated whether there are any effects of the level of the regular charge (beyond the implications for total cost) on choices. Because the regular charge is constant across all alternatives we do this by introducing it as a factor that may affect only the utility of the conventional electricity choice. Our prior hypothesis was that a higher regular charge may crowd out the green products (even if, relatively, costs of all products will be increased/reduced). We did not find any evidence of this effect.

5. Results

Table 2 presents our results from a 3-level nested logit model with the RU2 normalization. Most variables are significant with expected signs. Female customers with higher education levels are more likely to choose green electricity products. Customers who believe that climate change is occurring, those who would like to vote for the Green Party, and those who have higher level of trust in utility companies and government's accreditation and auditing programs are all also more likely to buy green electricity products. Among different green electricity products, people favor products that have been accredited by the NGPAP. Flexible contract terms are preferred. People would like renewable energy projects or carbon offset projects to be located locally in WA. Among all renewable energy sources, only solar is significantly favored, which is possibly a reflection of the high penetration of solar energy in the Australian residential sector. The ASCs for minimum commitment levels are all significant and positive. Controlling for cost and carbon saved, consumers strongly favor the entry level. In fact, for all cases where a green electricity product is chosen, over 60 percent have selected the minimum commitment levels – that is, $10 for EasyGreen, 25% for Natural Power and 25% for EarthFriendly. The utility associated with carbon contribution is out of pure altruism while the utility associated with entry level ASCs can be interpreted as impure altruism or warm glow effect.

The IV parameters at the branch level are all well within the unity interval. The IV parameter for the Green limb is larger than unity. This does not necessarily indicate a violation of utility maximization as nested logit models can be viewed as a local approximation. We thus check our model's local consistency with utility maximization by applying the conditions derived by Gil-Molto´ and Hole (2004) to estimated IV parameters and predicted marginal and conditional probabilities. McFadden (1981) has shown that to ensure consistency with utility maximization, any set of choice probabilities need to satisfy a number of conditions including non-negativity, adding-up to unity, translation invariance, equal cross partial derivatives with respect to utilities, and non-negative even and non-positive odd cross partial derivatives with respect to utilities depending on the number of alternatives within a choice set. In the case of the nested logit model only the final condition is restrictive, which is essential for the implied probability distribution function to be properly behaved, i.e., to have a nonnegative density function. Given our set structure at limb and branch levels, it is necessary to check the first order condition at the limb level and second order condition at the branch level. We find that for 97.6% of all choice occasions, our model passes these conditions. The majority of the small proportion of occasions that fail to pass are associated with respondents who never make a choice of any green products, i.e., always choose the conventional product.

Table 3 - FIML 3-level Nested Multinomial Logit Model (with RU2 normalization)

Attributes	Coefficient	Std. Error	z	Conf. Int. = 95%	
Common to all alternatives					
TotalCost	-.0608***	0.0035	-17.34	-0.0676	-0.0539
Specific to conventional					
Female	-.4703***	0.0623	-7.54	-0.5925	-0.3481
HighSchool	-1.3000***	0.3595	-3.62	-2.0047	-0.5954
TertiaryUndergraduate	-1.6378***	0.3590	-4.56	-2.3413	-0.9342
TertiaryPostgraduate	-1.6411***	0.3625	-4.53	-2.3516	-0.9306
TradeTAFE	-1.4948***	0.3605	-4.15	-2.2013	-0.7883
ClimateBelief2	.8018***	0.1203	6.66	0.5659	1.0374
ClimateBelife3	.6632***	0.0812	8.17	0.5041	0.8223
GreenParty	-1.0890***	0.1211	-8.99	-1.3264	-0.8516
Trust1	-.1984***	0.0365	-5.43	-0.2700	-0.1269
Trust2	-.1826***	0.0357	-5.11	-0.2526	-0.1125
Specific to green products					
Carbon	.0253***	0.0081	3.14	0.0095	0.0410
Accreditation	.1227***	0.0173	7.08	0.0887	0.1567
Contract	-.0905***	0.0192	-4.71	-0.1282	-0.0528
Location	.1380***	0.0182	7.57	0.1023	0.1737
Hydro	-0.0121	0.0299	-0.41	-0.0707	0.0464
Solar	.0674**	0.0305	2.21	0.0076	0.1271
Wind	0.0192	0.0287	0.67	-0.0370	0.0753
ASC's for green products					
ASC_{EG}	-4.6179***	0.4643	-9.95	-5.5279	-3.7078
ASC_{NP}	-5.9997***	0.8375	-7.16	-7.6412	-4.3582
ASC_{EF}	-5.3142***	0.7583	-7.01	-6.8005	-3.8280
ASC's for minimum commitment					
ASC_WG_{EG}	1.3957***	0.2505	5.57	0.9047	1.8866
ASC_WG_{NP}	2.2895***	0.5531	4.14	1.2055	3.3736
ASC_WG_{EF}	1.7591***	0.5130	3.43	0.7537	2.7644
IV parameters, RU2 form = mu(b|l),gamma(l)					
Conventional(BRANCH)	1	.....(Fixed	Parameter).....		
EasyGreen(BRANCH)	.9019***	0.0981	9.19	0.7096	1.0942
NaturalPower(BRANCH)	.5236***	0.1038	5.04	0.3201	0.7271
EarthFriendly(BRANCH)	.7468***	0.1764	4.23	0.4012	1.0925
Conventional(LIMB)	1	.....(Fixed	Parameter).....		
Green(LIMB)	1.2935***	0.0230	56.17	1.2484	1.3386
Restricted log likelihood	-10998.68245				
Maximized log likelihood	-8961.9545				
Chi squared [28 d.f.]	4073.4559				
Significance level	.0000				
Number of obs.= 4986					

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.

Table 4 – Direct and Cross Marginal Effects of a Change in a Product Attribute and Individual Characteristics on the Probability of Choice at Product[$] Level

Attributes	Unconditional Marginal Effects of Attributes of Green Electricity[†]		
	Change in **EasyGreen** ***on*** **C EG NP EF**	***Change in*** **Natural Power** ***on*** **C EG NP EF**	***Change in*** **Earth Friendly** ***on*** **C EG NP EF**
Accreditation	-0.0161, **0.0393**, -0.0132, -0.0101	-0.0212, -0.0134, **0.0477**, -0.0131	-0.0163, -0.0099, -0.0132, **0.0394**
Contract	0.0112, **-0.0290**, 0.0097, 0.0074	0.0156, 0.0098, **-0.0352**, 0.0099	0.0120, 0.0073, 0.0097, **-0.0290**
Location	-0.0180, **0.0442**, -0.0151, -0.0111	-0.0239, -0.0151, **0.0539**, -0.0149	-0.0183, -0.0113, -0.0148, **0.0443**
Solar	-0.0091, **0.0221**, -0.0074, -0.0056	-0.0119, -0.0074, **0.0266**, -0.0074	-0.0095, -0.0057, -0.0075, **0.0227**
Premium	0.0058, **-0.0096**, 0.0021, 0.0016	0.0054, 0.0032, **-0.0104**, 0.0018	0.0089, 0.0047, 0.0022, **-0.0159**
Unconditional Marginal Effects of Personal Characteristics [†]			
Variable	***on*** **C EG NP EF**	**Variable**	***on*** **C EG NP EF**
Female	**-0.1045**, 0.0314, 0.0411, 0.0320	ClimateBelief3	**0.1506**, -0.0451, -0.0594, -0.0461
HighSchool	**-0.2692**, 0.0790, 0.1082, 0.0820	GreenParty	**-0.2194**, 0.0668, 0.0851, 0.0675
TertiaryUndergraduate	**-0.3441**, 0.1015, 0.1376, 0.1050	Trust1 (1-3) [††]	**-0.0891**, 0.0267, 0.0351, 0.0273
TertiaryPostgraduate	**-0.3448**, 0.1017, 0.1379, 0.1052	Trust1 (1-5) [†††]	**-0.1734**, 0.0523, 0.0680, 0.0532
TradeTAFE	**-0.3127**, 0.0920, 0.1253, 0.0954	Trust2 (1-3) [††]	**-0.0821**, 0.0246, 0.0323, 0.0251
ClimateBelief2	**0.1819**, -0.0543, -0.0719, -0.0557	Trust3 (1-5) [†††]	**-0.1600**, 0.0482, 0.0627, 0.0491

[$] C, EG, NP, EF indicate Conventional, Easy Green, Natural Power and Earth Friendly respectively

[†] Unconditional direct marginal effects at the product level are marked in bold and unbolded numbers are cross marginal effects

[††] Marginal effects for a change from the lowest level of trust to the medium level of trust

[†††] Marginal effects for a change from the lowest level of trust to the highest level of trust

Table 5 – Unconditional Marginal Effects of a Simultaneous Change in Green Product Attribute Values across all Products on Probability of Selecting Green Products

Attribute Values	**Unconditional Marginal Effects**			
	Green Total†	**EasyGreen**	**NaturalPower**	**EarthFriendly**
Accredited	0.0538	0.0160	0.0214	0.0164
Flexible Contract	0.0397	0.0122	0.0157	0.0119
Local Projects	0.0605	0.0180	0.0241	0.0184
Solar (vs. Hydro)	0.0348	0.0103	0.0135	0.0109
††Total	0.1871	0.0552	0.0748	0.0571

† "Green Total" provides marginal effects on the Green nest of a generic value change
†† "Total" gives marginal effects of simultaneous changes for all four green attributes from the baseline value i.e. of shifting from least preferred to most preferred level

Table 6 – Conditional Marginal Effects of Premium on Commitment Levels

EasyGreen		**NaturalPower**	
Commitment Levels	**Marginal Effects**	**Commitment Levels**	**Marginal Effects**
		25%	0.0089
$10	0.0156	50%	-0.0024
$20	-0.0001	75%	-0.0031
$30	-0.0023	100%	-0.0034
$40	-0.0030	**EarthFriendly**	
$50	-0.0031	**Commitment Levels**	**Marginal Effects**
$60	-0.0028	25%	0.0252
$70	-0.0024	50%	-0.0056
$80	-0.0019	75%	-0.0090
		100%	-0.0107

Table 4 provides unconditional direct and cross marginal effects of attributes of interest. Unconditional direct marginal effects represent the change in the unconditional choice probability for an alternative given a 1-unit change in an attribute of interest for the same alternative, *ceteris paribus*. Unconditional cross marginal effects represent the impact that a 1-unit change in an attribute of interest to one alternative has upon the unconditional choice probabilities of competing alternatives, *ceteris paribus*. Direct and cross marginal effects for the each product and each attribute should sum to unity with possible rounding errors. As suggested by Louviere et al. (2000) we use the probability weighted sample enumeration (PWSE) rather than sample average or "naïve pooling" to simulate these marginal effects. As shown in the table, individual characteristics have large impacts on unconditional probabilities of product choice. The impacts of product attributes on choice probabilities are relatively smaller. This is also confirmed in Table 5 where we provide marginal effects for generic changes to all three green products in the value of a single green attribute as well as changes to all green attributes. This is to simulate the situation where a supplier changes the attributes of all the products in their portfolio simultaneously. Even with all green attributes changing from the most unfavorable values to the most favorable values generically, the probability of selecting the Green nest increases by only 18.71%. The decomposition of this change across the three green products is 5.52%, 7.48% and 5.71% for EasyGreen, NaturalPower and EarthFriendly respectively.

Table 6 reports the conditional (on the product being selected) marginal effect of a change in the premium on the level of commitment selected. Similarly, conditional marginal effects for each product should also sum to unity with only rounding errors. Increasing the premium makes the minimum commitment level more attractive (positive conditional marginal effect) compared to higher commitment levels (negative conditional marginal effect). However, this effect is very small if one considers that the maximum difference in premium in our experimental design is 6 cents: the probability of selecting the minimum commitment increases by only 7.5%, 5% and 10% for the green products for this change in premium, reflecting the lack of price sensitivity of commitment. This suggests that the (conditional) price elasticity of demand for green electricity within each product category is very low.

6. Conclusion

This paper has made a number of contributions to understanding consumer preferences for green electricity products. The design has allowed us to evaluate not just the choice of product, but also the level of commitment (i.e. the quantity of green power) that consumers purchase. We do that within a nested logit model that exploits the fact that commitment level in the real market is discrete, and hence there are limited numbers of levels that are open to consumers.

We find that the decision to opt into the green market is strongly influenced by characteristics of the individual, with greater participation driven by higher education, and being female. One's belief in whether climate change is occurring is also important, which is consistent with a prior expectations: those who do not see carbon emissions as an issue are not willing to mitigate them. In addition, voting for the Greens party (which may indicate an additional level of environmental commitment, and belief in the need for change), increases choice of green power. Increased trust in the utility companies and in government to deliver effective accreditation also increases uptake. This is potentially an area where more progress can be made, as, on a 5 point 'trust' scale, over 85% of respondents rate both utility companies and government at 3 or below. The nature of the green products themselves seems to have relatively little impact on demand, although there are preferences for 'local' generation and solar power as the source of the renewable. Comparing Easy Green and Natural Power (where the only substantive difference in the products offered by Synergy is in the method of making the commitment: fixed contribution or % of bill), then Natural Power is the preferred product. At the level of commitment, respondents had a strong preference for the minimum commitment level available, and this is insensitive to the level of premium. Respondents appear to be willing to pay $2.50 per tonne of carbon emissions reduced. This is relatively low, and much lower than the current price ($23/t) operating at the national level. This is consistent with our interpretation of the commitment being made as largely 'warm glow', given the high proportion who are selecting the minimum contribution.

This raises an interesting issue which we can address here: what would the consequences for choices be if the minimum levels were increased (e.g. from $10 to $40, or from 25% to 50%)? Would adoption of the green products remain at the current levels?

Our results are also consistent with the market data. The NGPAP releases quarterly report on each utility company's aggregated customer numbers and sales for accredited GreenPower products. As Synergy only has two accredited products – EasyGreen and NaturalPower, the reported statistics covers these two products only. Assuming a representative household with 15-unit consumption per day, the latest quarterly statistics translates to a mere 32% average commitment level.

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