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(Un)sustainable Consumption in Australian Households: An Exploratory Study

ABSTRACT

Unsustainable consumption has been identified as one of the main causes of global environmental deterioration. Particular attention is paid to the role of household consumers and the consequences of their choices. A number of studies show that different socio-economic groups within a nation have diverse consumption profiles leading to different environmental impacts. Thus, policies or programs aimed at regulating unsustainable consumption or promoting sustainability at the household level should be based on a good understanding of the relationship between consumption and the characteristics of households.

The current study aims to assess the consumption or usage patterns of households in NSW, Australia with respect to two main groups of environmentally relevant services namely, energy (electricity and gas) and water. The micro-econometric analysis takes into account the effects of the following variables: household income, household size, age, educational level, main occupation, dwelling type, dwelling ownership and labour force status. The data come from the latest (2003-04) cross-sectional survey of the Australian Bureau of Statistics on household expenditures.

In addition to the empirical results, the paper also presents a review of approaches to model demand, previous empirical studies on the determinants of unsustainable consumption and relevant methodological issues. This study differs from most previous studies on the subject in that the analysis is at the household level and focuses on specific household characteristics as potential determinants of water and energy consumption.

Key words: *sustainable consumption, households, micro-econometric analysis*

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1. Introduction

The relation of sustainability to the area of consumption was first stressed in Agenda 21 (UNCED 1992). Chapter four of Agenda 21 declares that unsustainable consumption and production patterns are the main causes of global environmental deterioration. In the same report, it is also stated that in order to improve environmental quality and to encourage sustainable development, increases in production efficiency and changes in consumption patterns are required. Particular attention was paid to the role of households as consumers and the consequences of the choices they make.

Although the need to change consumption had been discussed in international circles for some time, there has been no consensus as to the definition of (un)sustainable consumption. One of the first and most commonly accepted definitions of sustainable consumption was given by the Norwegian Ministry of Environment at a sustainability conference in Oslo in 1995. In the said conference, sustainable consumption was defined as "the use of goods and service that respond to the basic needs, bringing better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise, the needs of future generation" (Fien, et al. 2008).

There have been many studies attempting to explain the factors that lead to unsustainable consumption (Stern 1997; Norton et al. 1998; Michaelis 2000). Building on these previous studies, this paper aims to determine the demographic factors that affect household water and energy consumption in New South Wales, Australia. Demographic information will enable utility companies to boost their revenue by tailoring services and products to specific groups of people. Likewise, policy makers can use the same information to curb wasteful consumption.

Our study adopts the approach of Ferrer-i-Carbonell and Van Der Bergh's (2004) study of sustainable consumption in The Netherlands. The variables included in their models are supported by findings of several studies. However, unlike these previous studies, the dwelling structure and the type of ownership of households are included in the current model specification. Dwelling structure reflects the lifestyle led by households while ownership reflects how income is used.

There are other differences between this study and that of Ferrer-i-Carbonell and Van Der Bergh's. The focus of the current study is on the consumption made by households, rather than families. In Australia, the structure of families has changed. Due to rising rent, a higher proportion of adult children are staying longer with their parents. The number of single people in shared accommodation and the number of single person households are expected to continue to increase (ABS 2009). Modelling consumption using families as a unit of analysis assumes that a nuclear family is the structure that pervades, which might not be the case.

The rest of the paper is organised as follows. Section 2 presents an overview of the various approaches of demand specification while section 3 elaborates on the micro-econometric model used in the study. A description of the data is presented in section 4 while sections 5 and 6 cover the empirical results and conclusion respectively.

2. Approaches to Model Consumption Demand

Consumption theories explain how individuals (or households) make consumption decisions. A common approach is to statistically estimate particular demand models, usually in the form of a set of demand functions. This approach assumes that preferences are exogenous and that only changes in income and prices modify consumers' demand. The neoclassical perspective requires an explicit specification of the utility function and derives the demand functions by assuming utility maximization subject to a budget constraint. A good example of this is the linear expenditure system (Barten 1993). Another approach is to specify an expenditure function (cost) and derive demand relationships from these, using general results of utility maximization (Shepard's lemma). This general approach does not require a specific utility function but is consistent with a certain class of utility functions. The best known demand system that adopts this approach is the Almost Ideal Demand System (AIDS) by Deaton and Mullbauer (1980).

Similarly, one can define a functional form for a demand system that is flexible enough and with enough parameters to approximate any cost function (or a direct or indirect utility function). The transilog function is a well known example. Another approach is to specify the demand function as double-logarithmic relationships. This modelling approach which implies constant price and income elasticities of demand was commonly used in consumption studies of the 1950s and 1960s. If one does not believe in the maximisation hypothesis or in the neoclassical preferences, a wide range of demand relationships is possible. One might start by specifying a demand function without worrying about the theoretically required functional forms or constraints imposed on the parameters to satisfy demand properties. Accordingly, Alessie and Kapteyn (1991) observed that the analyst can add new assumptions by assuming satiation, bounded rationality, routines and many others.

3. Micro-econometric Model of Household Demand

The approach to model consumption used in this study follows the AIDS cost function specified by Deaton and Muelbaur (1980). Specifically, the consumption decision by the households which proportion of total expenditure *C* is spent on each specific category of consumption is mathematically specified as

$$\log \square,\square = 1 - \square \log \square\square + \square\square\square\square\{\square\square\} \qquad (1)$$

where

$$\square\square\square\square\square = \square 0 + \square\square 0\square\square\square\square\square + 12\square\square\square\square\square\square\square\square\square\square\square\square\square\square\square\square\square \qquad (2)$$

and

$$\square\square\square\square\square = \square\square\square\square\square\square + \square 0\square\square\square\square\square \qquad (3)$$

In the above equations *u* is utility, *p* is the vector of prices $\square\square$ for each good *k*, and the other symbols denote parameter. From equations (1)-(3) , Deaton and Mullebauer (1980) derived the AIDS demand functions by requiring the price of the derivatives to be equal to the quantity demanded and the total expenditures (X) to be equal to C(*u,p*). Both requirements are consistent with the utility maximizing approach. Following these assumptions, the AIDS demand function can now be expressed as

$$\square\square\square = \square\square + \square\square\square\square\square\square\square\square\square\square + \square\square \log(\square\square) \qquad (4)$$

where □□□ represents the share on household expenditure. More specifically it is the expenditure on good *c* as a proportion of total expenditures for household *i*. Equation (4) implies that the share that the share spend on good *c* depends on the prices of all goods *j*, and on total expenditures. As cross-section data is used in this study, prices are excluded in the analysis and equation (4) can now be written as

□□□=□□+□□log(Ci *)* (5)

The coefficient of □□ indicates whether a good is a necessity or a luxury good. Furthermore, total expenditures can be specified by a model that is an extension of Linear Expenditure System (LES) with non-linear terms (Ferrer-i-Carbonell and Van Der Bergh 2004), which when rewritten, gives a dependence on log(income) (*log* (y_i)) and household characteristics x_{ki}.

□□□□□□=□+□2□□□□2□□□+□□□□□□□ (6)

The next step is to substitute equation (6) into (5) and the resulting specification is

□□□=□□+□□□□+□□□□1log□□+□□□□□□□□□ (7)

which can also be expressed as

□□□□=□+□1log□□+□2□□□□2(□□)+□□□□□□□ (8)

Equation (8) was then estimated using OLS, 2SLS and SUR to check for the possibility of endogeneity.

4. Data

The data employed in this study come from the 2003-04 Household Expenditure Survey conducted by the Australian Bureau of Statistics. The survey collected detailed information on sources of household income, assets, liabilities and expenditure as well as demographic information on each household member. The basic version of the data was used to estimate the models in this paper.

Although the ABS survey covered a national sample, this exploratory study focuses only on the NSW sample of 1,745 households. Unlike the Ferrer-i-Carbonell and Van Der Bergh's study, unweighted data was used to avoid the possible effects this might have on the regression results. The variables used in the analysis are summarised in Table 1.

A number of the explanatory variables, as shown in Table 1 are originally categorical or discrete in nature. Prior to model estimation, these variables namely, age, education and main occupation are first transformed into continuous variables assuming a Normal (0, 1) distribution using the method featured in Terza (1987). In this method, it is assumed that the dummy values can be ordered. For example, with the variable for Main Occupation, the assumption is that managers and administrators have a higher status than labourers and related workers. The Terza method has been found to provide substantial gains with respect to bias and efficiency compared to a conventional dummy variable approach (Terza 1987).

Table 1 – Variables used, values of discrete variables and calculated variables

<table>
<tr><th>Water Expenditure Model</th><th>Energy Expenditure Model</th></tr>
<tr><td colspan="2">Age group of the household reference person - The groups formed for this analysis and the corresponding values used were as follows.
1 = 15-24 years old
2 = 25-29 years old
3 = 30-34 years old
4 = 35-39 years old
5 = 40-44 years old
6 = 45-49 years old
7 = 50-54 years old
8 = 55-59 years old
9 = 60-64 years old
10 = 65-69 years old
11 = 70-74 years old
12 = 75-79 years old
13 = 80-100 years old</td></tr>
<tr><td colspan="2">Ln(household income) - Household income – The weekly household income is reported in AUD. This include:
• Gross income less taxes and the Medicare levy
• Social Transfers in Kind which include non-cash benefits and services from the government for education, health, housing, social security and welfare</td></tr>
<tr><td colspan="2">Ln2(household income) - Please see household income above</td></tr>
<tr><td colspan="2">Ln(household size) - Household size - The number of people living in the same dwelling. The persons may or may not be related to one another. A household is defined as a group of people who live in the same home and “make common provision for food and other essentials of living” (Australian Bureau of Statistics, 2008).</td></tr>
<tr><td colspan="2">Number of children under 15 - The number of persons who are younger than 15 years old</td></tr>
<tr><td colspan="2">Number of earners in the household – The number of people in a home who earn a salary, wage or business income. Children under 15 years old and full-time students aged between 15 – 24 years old are not counted.</td></tr>
<tr><td colspan="2">Education degree
The original variable had the dummy values shown below, listed from the lowest to the highest educational attainment.
8 = 'No non-school qualification'
7 = 'Certificate not further defined'
6 = 'Certificate I/II'
5 = 'Certificate III/IV'
4 = 'Advanced Diploma/Diploma'
3 = 'Bachelor Degree'
2 = 'Graduate Diploma/Graduate Certificate'
1 = 'Postgraduate Degree'</td></tr>
<tr><td colspan="2">Looking for work status
0 = “Not Applicable”
1 = “Looked for full time work”
2 = “Looked for part time work”
3 = “Unpaid voluntary worker”
4 = “Did not look for full time work
5 = “Permanently unable to work”</td></tr>
<tr><td colspan="2">Labour force status in main occupation
0 = “Not Applicable”
1 = “Employee full time, paid in cash”
2 = “Employee part time, paid in cash”
3 = “Employer”
4 = “Own account worker, contributing family worker and employee”</td></tr>
<tr><td>Main occupation – transformed into a continuous variable</td><td>Main occupation
0 = “Not Applicable”
1 = “Managers & Administrators”
2 = “Professionals”
3 = “Associate Professionals”
4 = “Tradespersons & Related Workers”
5 = “Advanced Clerical & Service Workers”
6 = “Intermediate Clerical, Sales & Service Workers”
7 = “Intermediate Production & Transport Workers”
8 = “Elementary Clerical, Sales & Service Workers”
9 = “Labourers & Related Workers”</td></tr>
<tr><td colspan="2">Owner/Renter
0 = “Owner”
1 = “Renter”
These values were regrouped from the tenure type of the household, where the original values were:
0 = “Not Applicable”, 1 = “Owner without a mortgage”, 2 = “Owner with a mortgage”, 3 = “Renter”, 4 = “Other”
Those that fell under “Not Applicable” & “Other” were excluded from the model.</td></tr>
<tr><td colspan="2">Dwelling Structure
1 = “Separate house”
2 = “Semi-detached, row or terrace house, townhouse etc. with one”
3 = “Semi-detached, row or terrace house, townhouse etc. with two”
4 = “Flat, unit or apartment in a 1 or 2 storey block”
5 = “Flat, unit or apartment in a 3 storey block”
6 = “Flat, unit or apartment in a 4 or more storey block”
7 = “Flat, unit or apartment attached to a house”
8 = “Caravan, houseboat, improvised home & house or flat attach”</td></tr>
<tr><td>Percentage share of household expenditure on Water
$\left(\frac{\text{Weekly water rates payments (Household)}}{\text{Total weekly goods and services expenditure}}\right)\times 100$</td><td>Percentage share of household expenditure on Energy in selected dwelling
$\left(\frac{\text{Electricity} + \text{Main Gas} + \text{Bott le Gas}}{\text{Total weekly goods and services expenditure}}\right)\times 100$</td></tr>
</table>

When estimating the share of expenditures on energy, the number of employed persons in a household is used to replace the presence of a second earner to correctly measure the sources of income of the household. Similarly, the original categorical values for main occupation are used instead of its continuous transformation.

The dependent variables, weekly water and energy expenditure, are calculated as a percentage share of total weekly household expenditure on goods and services.

5. Empirical Results

5.1 Share of household expenditure on Water

The results of the estimated models for water expenditure are shown in Table 2. Models 1 through 5 were estimated using OLS. Model 5 was then tested for endogeneity using the Durbin-Wu-Hausman procedure. Income was found to be endogenous and thus the 2SLS method was employed to estimate Model 6. The number of earners was not included because of its high collinearity with income.

Table 2 – The share of household expenditures on water

Variables	Model 6^		Model 5		Model 4		Model 3		Model 2		Model 1	
	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value
Intercept	3.982	4.359*	2.845	6.138*	3.721	1.453	2.195	4.340*	2.380	1.361	1.996	6.817*
Age group[1]	0.134	3.689*	0.129	3.523*	0.128	3.485*	0.327	8.763*				
Ln(household income)	-0.389	-3.006*	-0.227	-3.256*	-0.478	-0.658	-0.198	-2.602*	-0.281	-0.542	-0.166	-3.940*
Ln2(household income)					0.018	0.348			0.009	0.223		
Ln(household size)	-0.045	-0.523	0.077	0.832	0.077	0.829	0.267	2.659*				
No of children under 15	0.023	0.592	0.017	0.430	0.017	0.428	-0.008	-0.190				
Education degree[1]	0.004	0.138	-0.003	-0.100	-0.003	-0.118	0.000	0.013				
Looking for work status[2]	0.014	0.123	-0.011	-0.389	-0.012	-0.416	-0.027	-0.845				
Main occupation[1]	-0.045	-1.426	-0.063	-2.23*	-0.065	-2.255*	-0.036	-1.155				
Number of earners in the household			-0.095	-2.088*	-0.096	-2.104*	-0.051	-1.016				
Labour force status in main occupation[2]	-0.026	-0.845	0.013	0.111	0.013	0.113	-0.047	-0.358				
Dwelling structure[2]	-0.015	-0.781	-0.012	-0.625	-0.012	-0.627						
Ownership[2]	-0.919	-14.749*	-0.927	-14.925*	-0.927	-14.923*						
N	1113		1114		1114		1137		1114		1114	
R	0.500		0.507		0.507		0.284		0.094		0.094	
F-value	36.692		34.610		31.711		10.950		7.782		15.522	
R Square	.250		0.257		0.257		0.080		0.009		0.009	
Adjusted R Square	.243		0.249		0.249		0.073		0.008		0.008	

^ Estimated using 2SLS due to endogeneity
* t-values that are significant at p-value=0.05
[1] Transformed into a continuous variable using Terza's method
[2] Discrete variables were not transformed

All six models have a significant R^2 value. Model 1 which has income as the only explanatory variable yields an Adjusted R^2 of 0.008 while the most comprehensive model, Model 6 has an Adjusted R^2 of 0.243. Model 6 which is the final model is discussed below.

The results for Model 6 show that a household's percentage share on water expenditure is significantly affected by household income, the household reference person's age group and whether the dwelling is owned or rented.

The percentage share for water rises by 0.134 when the household reference person belongs to an older age group. The positive relationship between age and share of water consumption is consistent with the findings of Barrett and Wallace (2009) who reported a higher per capita water consumption for an older age group. Other studies (e.g. Billings and Day 1989) have also reported a similar effect with the explanation that older people use more water than children and because they tend to spend more time at home and for gardening. Although Schleich and Hillenbrand (2009) reported a positive relationship between per capita water consumption and age in Germany, they suggest that further studies be undertaken because other researchers have found a negative relationship between per capita water use and retirement age.

As household weekly income rises by 1 dollar, the percentage share spent on water drops by 0.389. This negative relationship indicates that water is a basic commodity. As income rises, the relative expenditure on water tends to decline.

Ownership of the dwelling occupied by a household is significantly associated with share of water expenditures. Relative to owners, renters tend to have a lower percentage share spent on water by 0.919. This could be due to a number of reasons. One is that renters are less likely to have large gardens or swimming pools. It is also likely that as Hoffmann, Worthington and Higgs (2006) reported, landlords pay for water consumption up to a legislated amount causing renters to minimise their water usage to avoid paying for extra water used.

Household size; the household reference person's looking for work status, main occupation and its labour force status; number of children under 15 years old; education degree; household size and dwelling structure are found to have no significant effect on share of household expenditures on water in the final model.

5.2 Share of household expenditure on Energy

The results of the estimated OLS models for share of household expenditure on energy are shown in Table 3. In this study, energy covers electricity, mains and bottled gas. The initial model which has household income as the only explanatory variable yields an adjusted R^2 of 0.05. The additions of other explanatory variables contribute to a minimal increase of only 2 percentage points in the adjusted R^2 value. Model 5 was re-estimated using SUR to check for endogeneity. As there is minimal difference between the estimated coefficients of the SUR and OLS, Model 5 is used as the final model for the discussion below.

The percentage share of household expenditure spent on electricity and gas rises by 0.281 when the household reference person belongs to an older age group. Older people, particularly the elderly tend to live alone and consume more electricity than their younger counterparts (Ironmonger, Aitken and Erbas, 1995). They also tend to spend more time at home than younger people. This is consistent with the finding that young adults aged 18-24 are less likely to take steps in limiting their electricity use compared to the over 25 age group (Australian Bureau of Statistics, 2010).

Table 3 – The share of household expenditures on energy (electricity and gas)

Variables	Model 5		Model 4		Model 3		Model 2		Model 1	
	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value
Intercept	0.957	0.241	0.821	0.207	10.086	1.863	-0.702	-0.179	9.541	14.535*
Age group[1]	0.281	3.476*	0.372	5.049*	0.364	4.958*				
Ln(household income)	1.435	1.209	1.393	1.173	-1.492	-0.969	2.108	1.820	-0.956	-10.136*
Ln2(household income)	-0.159	-1.777	-0.159	-1.774	0.055	0.504	-0.227	-2.655*		
Ln(household size)	-0.036	-0.165	0.220	1.042	0.611	3.106*				
Number of children under 15	0.233	2.476*	0.210	2.238*	0.066	0.792				
Education degree[1]	-0.317	-4.556*	-0.325	-4.690	-0.181	-2.902*				
Looking for work status[2]	0.025	0.318	0.009	0.116	0.056	0.895				
Main occupation[1]					-0.113	-1.844				
Number of earners in the household					-0.194	-1.977*				
Labour force status in main occupation[2]	0.048	0.686	0.027	0.384	0.128	0.500				
Occupation in main job	-0.017	-0.575	-0.006	-0.203						
Number of employed persons in the household	-0.113	-1.031	-0.150	-1.362						
Dwelling structure[2]	-0.146	-3.393*								
Ownership[2]	-0.094	-0.632								
N	1691		1725		1137		1744		1744	
R	0.352		0.339		0.311		0.244		0.236	
F-value	19.748		22.201		12.074		55.070		102.735	
R Square	0.124		0.115		0.097		0.059		0.056	
Adjusted R Square	0.117		0.110		0.089		0.058		0.055	

* t-values that are significant at p-value=0.05
[1] Transformed into a continuous variable using Terza's method
[2] Discrete variables were not transformed

It is not surprising that the number of children under 15 increases the percentage share spent on electricity and gas by 0.233. Based on the findings of the Australian Bureau of Statistics (2010), the more young people there are in a household, the more difficult it is to reduce electricity consumption. This is because younger consumers are less likely to care about how much electricity they consume.

The educational attainment of the household reference person reduces the percentage share of household expenditure spent on electricity and gas by 0.317. The percentage share for a certificate holder will be 0.317 lower than those who have no non-school qualification. This result is supported by the study on environmental awareness conducted by the Australian Bureau of Statistics (2010) which shows that those who do not have a non-school qualification are less concerned about the environment compared to those who have a non-school qualification.

The type of dwelling structure as shown in Table 3 also has a significant effect on percentage share of energy expenditures. A downward change in the type of dwelling could reduce the share spent on energy by 0.146. Those living in caravans would spend a smaller proportion of their weekly household expenditures on energy compared to those residing in flats and separate homes. This relationship could be explained by the lifestyle of flat dwellers. According to Lenzen, Dey and Foran (2004), those who live in flats tend to spend more time outside their home, causing their energy consumption to be transferred elsewhere

Household income, although not significant in the final model, is by itself a significant factor and has the expected negative sign for a necessary good. This result is consistent with those obtained in the Netherlands (Ferrer-i-Carbonnel and Van den Bergh 2004) and in the U.K.

(Baker et al 1989). In all these studies, the negative effect of income on the consumption of gas and electricity is supported. According to Baker et al (1989), rich households that are already consuming high levels of energy are not expected to increase their consumption further. The addition of age, education, occupation and other explanatory variables as shown in Table 3 causes household income to have no significant effect on share of household energy expenditures.

The variables that are found to also contribute to a rise in the share of household energy expenditures but are not significant include the looking for work status, labour force status in the main occupation, main occupation, number of employed persons and tenancy status.

6. Conclusions

The results of the empirical analysis presented in this paper support the idea that a wide range of household characteristics is relevant in explaining household water and energy consumption patterns. While the age group of the household reference person affects the share of expenditures on both water and energy, household income and ownership have a significant effect on the share of water expenditures only. The share of household expenditures on energy on the other hand, is determined by number of children under 15, education, and dwelling structure. As this study is exploratory in scope and limited to a single state only, further analysis needs to be undertaken to include data from the entire national sample. Nonetheless, results of the current study serve to indicate that certain demographic characteristics of households need to be taken into consideration when designing policies and programs for sustainable energy and water consumption.

In order to successfully design policies for sustainable consumption, policy makers need information about the sensitivity of consumption to variables (determinants) that can be influenced or controlled. They also need information on how consumption of specific goods and services impacts on the environment. The results of this study suggest that policies aimed at changing consumption in order to lessen the pressure on the environment could seek to directly affect those characteristics which greatly influence household consumption decisions. Ways to do this may include the use of commutative instruments like education and advertising.

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