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Measuring public acceptance on renewable energy (RE) development in Malaysia using ordered probit model

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Abstract. In 2009, government of Malaysia has announced a National Renewable Energy Policy and Action Plan as part of their commitment to accelerate the growth in renewable energies (RE). However, an adoption of RE as a main source of energy is still at an early stage due to lack of public awareness and acceptance on RE. Up to date, there are insufficient studies done on the reasons behind this lack of awareness and acceptance. Therefore, this paper is interested to investigate the public acceptance towards development of RE by measuring their willingness to pay slightly more for energy generated from RE sources, denote as *willingness level* and whether the importance for the electricity to be supplied at absolute lowest possible cost regardless of source and environmental impact, denote as *importance level* and other socio-economic factors could improve their *willingness level*. Both qualitative and quantitative research methods are used to achieve the research objectives. A total of 164 respondents from local universities in Malaysia participated in a survey to collect this relevant information. Using Ordered Probit model, the study shows that among the relevant socio-economic factors, age seems to be an important factor to influence the *willingness level* of the respondents. This paper concludes that younger generation are more willing to pay slightly more for energy generated from RE sources as compared to older generation. One of the possible reason may due to better information access by the younger generation on the RE issues and its positive implication to the world. Finding from this paper is useful to help policy maker in designing RE advocacy programs that would be able to secure public participation. These efforts are important to ensure future success of the RE policy.

1. Introduction

Energy has always been a main contributor towards a rapid growth in an economy. The consequences of using fossil fuel energy sources to generate electricity and the impact on climate change due to greenhouse emission has been concerned in enforcing significant changes on how energy and electricity is generated, transmitted and consumed [1]. Malaysia also has abundant RE sources that can be explored. Since Malaysia is progressing towards becoming an industrialized country, its dependence on energy sector increases accordingly [2]. Hence, energy supply infrastructure need to develop continuously in order to ensure a long-term energy security. These could be achieved by escalating energy efficiency initiatives and enhancing development of RE sources such as biogas, hydro, solar and biomass [3]. Although new alternative on RE and efficient technologies are being developed and implemented every year, the tension caused by a rise in energy demand and global consumption overcome the benefits brought by these improvements [4]. This caused slow progress in



the RE development. Thus, the need of assessing social acceptability of RE is fundamental for understanding a social perspective in term using RE technology and climate change issues [5].

In a study done by [6] on the factors that influence RE technology acceptance in Malaysia, they found cost and knowledge are important factors in influencing the intention to use the RE. Parallel with a study by [7] that investigates the relationship between the social acceptance and level of public interest on solar energy, the public seem to be interested in solar energy but they are less incline to pay for installation cost of the solar panel. These findings enhance the understanding of barriers to develop RE particularly on the role of public knowledge in RE acceptance in Malaysia. Differently, other studies would focus on individual intention and behaviour towards the RE technology [8,9] and willingness to pay more for RE was usually evaluated as a reflection of socials' behaviour [10,11]. The results showed that willingness to pay for green electricity increased with a positive attitude towards green electricity and decreased with electricity cost. Therefore, it has been suggested the policy makers should concern on the role of public perception and awareness in determining the success and failures of RE policy and development. Any initiatives to increase the awareness on RE technologies through suitable programs such as workshops, discussions, forums, seminars and public hearing should be supported [12].

In addition, previous study done by [13] on the public acceptance of solar energy in Peninsular Malaysia, they found that there is still a huge lack of awareness and knowledge on solar energy in all levels of society. However, [1] found out that involvement of teenagers in the energy issues would increase the awareness of the potential RE technology. Similarly with findings from [14] and [15] that reported younger person were more willing to consider installation of RE technologies such as solar water heating and wind farm compared older generations. In contrast, [16] examined on the rural social acceptance and adopted the theory of planned behaviour has been found that rural residents are generally supportive the RE development. Thus, public acceptance is an important issue shaping the widespread implementation of RE developments and the achievement of energy policy targets regardless the geographical and topographical aspect.

As been pointed out by [17], it is hard to achieve the goal of RE development with low level of social acceptance. Thus, social acceptance should be taken into consideration during policy making process. However, there are still insufficient studies conducted in regard to lack of awareness and acceptance. Therefore, this paper is interested to investigate the public acceptance towards development of RE by measuring their willingness to pay slightly more for energy generated from RE sources, denote as *willingness level*. Using ordered probit model [18], the study measured whether the importance for the electricity to be supplied at absolute lowest possible cost regardless of source and environmental impact, denote as *importance level* and other socio-economic factors could improve their *willingness level*.

2. The methodology of Ordered Probit model

In this paper, the dependent variable is defined as, *willingness level* and it is denoted as Y_i . While, the set of independent variables are *age*, $x_{1,i}$; *gender*, $x_{2,i}$; *marital status*, $x_{3,i}$; and *importance level*, $x_{4,i}$. Each model follows a cross-sectional ordered probit model and the i th respondent is based on a latent variable Y_i^* which is related to a $(k \times 1)$ vector of explanatory variables $x_{k,i}$ via the following linear relationship

$$Y_i^* = \mu + \gamma_k' x_{k,i} + \varepsilon \quad (1)$$

where μ is a scalar constant, γ_k is a $(k \times 1)$ coefficient vector and ε is assumed to be normally distributed. For ease of notation we subsume the constant into $x_{k,i} = (1 \ x_{k,i})'$ and define $\beta_k = (\mu + \gamma_k)'$ and hence

$$Y_i^* = \beta_k' x_{k,i} + \varepsilon \quad (2)$$

The latent variable Y_i^* and Y_i in turn are related via

$$Y_i = \begin{cases} 4, & \text{if } Y_i^* > \rho_3 \\ 3, & \text{if } \rho_3 \geq Y_i^* > \rho_2 \\ 2, & \text{if } \rho_2 \geq Y_i^* > \rho_1 \\ 1, & \text{if } \rho_1 \geq Y_i^* > \rho_0 \\ 0, & \text{if } \rho_0 \geq Y_i^* \end{cases} \quad (3)$$

with ρ_0, ρ_1, ρ_2 and ρ_3 being threshold parameters, which are collected in $\rho = (\rho_0 \rho_1 \rho_2 \rho_3)'$. Each ordinal values in equation (3) means the respondents could either *not willing at all* ($Y = 0$), *not willing* ($Y_i = 1$), *neutral* ($Y_i = 2$), *willing* ($Y_i = 3$) and *very willing* ($Y = 4$). The set of independent variables also are taking categorical values as defined in table 1 and binary values as defined in table 2. Hence, all these variables are best modelled using ordered probit model.

Table 1. Definition of categorical values for variables in the model.

Variables	Categorical Values				
	0	1	2	3	4
The willingness to pay slightly more for energy generated from RE sources, denote as <i>willingness level</i> , Y	Not willing at all	Not willing	Neutral	Willing	Very Willing
The importance for the electricity to be supplied at absolute lowest possible cost regardless of source and environmental impact, denote as <i>importance level</i> , x_4	Not important at all	Not important	Neutral	Important	Very Important
Age, x_1	18-24	25-30	31-35	36-40	41<

Table 2. Definition of binary values for variables in the model.

Variables	Binary Values	
	0	1
Gender, x_2	Male	Female
Marital Status, $x_{3,i}$	Single	Married

To complete the model, the distribution of the error term ε_i follows a standard normal ($N(0,1)$) distribution and useful to model ordered categorical variables. The specification allows the calculation of conditional category probabilities $P(Y_i = j|x_{i,k})$ and the log-likelihood function is defined as follows:

$$\begin{aligned} ll_{f_{\tau|j}}(\beta_k, \rho) = & I_4 \log[P(Y_i = 4|x_{i,k}; \beta_k, \rho)] \\ & + I_3 \log[P(Y = 3|x_{i,k}; \beta_k, \rho)] \\ & + I_2 \log[P(Y = 2|x_{i,k}; \beta_k, \rho)] \\ & + I_1 \log[P(Y_i = 1|x_{i,k}; \beta_k, \rho)] \\ & + I_0 \log[P(Y = 0|x_{i,k}; \beta_k, \rho)] \end{aligned} \quad (4)$$

Where $I_j = I(Y_i = j)$ is an indicator function which equals one in case $Y_i = j$ is true and 0 otherwise. The model parameters (β_k, ρ) that maximise that log-likelihood function are the Maximum Likelihood (ML) parameter estimates. Hence a category probabilities calculation is necessary to complete the ML function and defined as follows. In the case of respondents *not willing* ($Y_i = 1$) to pay, the category probability of $P(Y_i = 1|x_{i,k}; \beta_k, \rho)$ is calculated as,

$$P(Y = 1|x_{i,k}; \beta_k, \rho) = P(\rho_1 \geq Y_i^* > \rho_0|x_{i,k}; \beta_k, \rho) = \Phi(\rho_1 - \beta_k'x_{i,k}) - \Phi(\rho_0 - \beta_k'x_{i,k}) \quad (5)$$

where Φ represents the standard normal CDF. The log-likelihood function can be optimised by any standard nonlinear optimiser as long as ρ_0 is constrained to be smaller than ρ_1 . Asymptotic standard errors for the estimated ML parameter estimates $(\hat{\beta}_k, \hat{\rho})$ are calculated based on the basis of the expected inverse Hessian Matrix of the variance covariance matrix.

Hence, the mean marginal effect can be considered as the change in category probabilities as $x_{,k}$ changes from j to $j + 1$

$$E\left(\frac{\partial[P(Y_i=j|x_{i,k};\beta_k,\rho)]}{\partial x_{i,k}}\right) = E[P(Y = j|x_{tk} = j + 1) - P(Y = j|x_{tk} = j)] \quad (6)$$

where the category probabilities $P(Y_i = j|x_{tk} = j + 1)$ are used as defined in equation (5).

3. Result

Based on equation (4), the mean marginal effect of the *importance level* and other socio-economic factors on *willingness level* are computed using Stata. They are illustrated in table 3. Age ($x_{1,i}$) seems to be the only independent variable that is statistically significant at 10% significant level. Based on its negative coefficient, as the respondents' age increases, the probability of *not willing at all* to pay slightly more for energy generated from RE sources increase by is at 3.1% which also means probability of *very willing to pay* decrease by is at 5.0%. This means younger generation are more willing to pay slightly more for energy generated from RE sources as compared to older generation. One of the possible reason may due to the better information access by the younger generation on the RE issues and its positive implication to the world. This finding is consistent with a study done by [19] that found those who choose RE over traditional energy are high income, young age, female gender and environmental consciousness. In another study by [20], the study shows that there are three factors that could influence the public acceptance towards RE development. Among these factors are personal factors which relate to socio-demographic characteristics such as age, gender, education and social class, physical factors including the degree of awareness and understanding, political beliefs and environmental concerns. Since the study is based on randomly selected sample from local universities in Malaysia, there is a possibility that age is the only factor that seems to influence on their willingness to pay slightly more for energy generated from RE sources. However, this effect might change depending on the population of demographics.

Table 3. The mean marginal effects for all the independent variables in the model.

Dependent variable	Independent variables	Significant coefficient, β_k	Mean Marginal Effect (%)				
			Not willing at all	Not willing	Neutral	Willing	Very Willing
Y_i	$x_{1,i}$	-0.2229899^a	0.031	0.023	0.034	-0.038	-0.05
	$x_{2,i}$	0.165362	-0.023	-0.017	-0.025	0.028	0.037
	$x_{3,i}$	-0.1492626	0.021	0.015	0.023	-0.025	-0.034
	$x_{4,i}$	-0.1647886	0.023	0.017	0.025	-0.028	-0.037

^athe result is significant at 10% significant level

4. Conclusion

As conclusion, the results showed that the public acceptance level towards RE development in Malaysia is still low, especially on older generation. This is probably because the nature of elderly who are habituated to culture making it difficult for them to break out of their comfort zone. It is also common for elderly to have troubles adapting to new technologies and development. However,

younger generation seem to be more willing to pay for RE development since they can easily adapted to new developments and access better information access on the RE issues. This is a positive implication to the society since it is the younger generation who will lead the country in future and responsible to make the world a better place. Therefore, finding from this paper is useful to help policy maker in designing RE advocacy programs that would be able to secure public participation. These efforts are important to ensure future success of the RE policy in Malaysia.

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