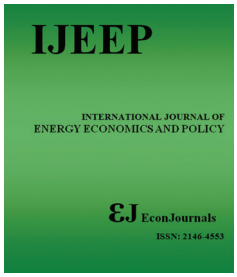

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South African Attitudes About Nuclear Power: The Case of the Nuclear Energy Expansion

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ABSTRACT

Despite the risk associated with nuclear energy, it represents an attractive climate change mitigation option and energy supply security. We examined how South African households perceive nuclear energy in the context of climate change mitigation, risk and avoidance of power outages. The objective of this study is to investigate households' willingness to pay (WTP) for the proposed second nuclear power. Traditional analysis of such data has tended to ignore zero WTP values. A spike model (i.e., "two-part model") which explicitly accounts for zero WTP is employed. We also test for effect of distance on WTP. The Thyspunt dummy is negative and significant in the probit model, which implies that those who are closer to the plant are more likely to state a zero WTP. The second decision, WTP given positive WTP, modelled with a truncated regression model suggests that putting more distance between residences and the nuclear plant would have little effect on WTP. Therefore, distance is not a relevant predictor of WTP for solving the problem of nuclear-related risk. Higher dependence on electricity is most likely to lead people to be more supportive of the planned plant.

Keywords: Climate Change, Distance, Electricity, Nuclear, Willingness to Pay
JEL Classifications: Q42, Q48, Q51, Q54

1. INTRODUCTION

Excessive use of fossil fuels is widely acknowledged as one of the main causes of climate change. The energy sector is one of the sectors that make use of fossil fuels. Greenhouse gasses are released during the combustion of fossil fuels, such as coal, oil, and natural gas, to produce electricity. Generating electricity from nuclear reduces pollution externalities hence it is argued by some to be part of a sustainable low-carbon option. According to Vainio et al. (2017) nuclear energy has been discussed as a possible solution to cut carbon dioxide emissions deriving from energy consumption.

But past accidents as in the recent Fukushima Daiichi accident in Japan have resulted in increased opposition to nuclear power. More and more scrutiny has been paid to the safety issues of nuclear power, despite being a clean and necessary substitution to coal power. Vainio et al. (2017) argue that individuals are increasingly concerned about climate change and, at the same time, they are aware of the risks associated with nuclear power generation. A better comprehension of public risk perceptions is vital because they can greatly influence climate and energy policies, and public support is one of the most vital factors influencing future choices in climate change mitigation. Wu (2017) argues that risk perception and public involvement have become more and more critical in post-Fukushima accident era.

Due to the consideration about the uncertainty of nuclear safety, households may resist the nuclear power expansion in their neighbourhood. In this study, the contingent valuation method

(CVM) is used to estimate WTP for nuclear power expansion in South Africa. There is currently one nuclear power station in South Africa, situated at Koeberg, Cape Town, in the Western Cape province. The government's diversification strategy includes construction of a second nuclear power plant. Households will be expected to contribute towards the capital required to invest in increasing and diversifying the power supply.

Electricity is subject to political considerations. Given this background, the objective of this study is to investigate households' willingness to pay (WTP) for the proposed nuclear power plant in relation to climate change, power outage avoidance and risk. We analyse a survey of the adult population living in South Africa with spike modelling. According to Liao et al. (2010); Ertor-Akyazi et al. (2012), nuclear energy studies eliciting WTP, opinions and preferences have been mostly done in advanced countries, though not in abundance.

Studies evaluating support and WTP for nuclear energy are limited in developing countries, particularly in Africa. This can be attributed to the fact that South Africa is the only country in Africa to have a nuclear power plant. Some other African countries do have plans to build nuclear plants. This study is an attempt to evaluate public perceptions of nuclear power expansion in South Africa.

People's attitudes toward nuclear power and climate change are linked to general environmental concern (Corner et al., 2011; Renn and Marshall, 2016): a positive attitude toward climate change mitigation is associated with a negative attitude toward nuclear power and a belief that nuclear power resolves climate change is associated with a low level of environmental concern. Attitudes toward nuclear power are associated with perceived environmental harm, perceived cost, and perceived risk of nuclear power. However, there is evidence that people's attitudes toward nuclear power become more positive when they consider its benefits in mitigating climate change (Vainio et al., 2017).

2. THE NUCLEAR DILEMMA

Over 400 nuclear reactors are in operation in 31 countries, providing more than 11 percent of total world electricity. There are currently more than 60 reactors under construction worldwide (World Nuclear Association, 2014). Since energy security is a critical element in an economy, nuclear energy can play a role in ensuring smooth supply of electricity; it is reliable, and can provide electricity on a larger scale, like fossil fuels (Ertor-Akyazi et al., 2012). Approximately 7400 megawatts (MW) of nuclear power is under construction around the world (International Energy Agency, 2015). A typical nuclear plant has 1000 MW capacity (Liao et al., 2010). However, such a plant requires a sizeable capital investment. When compared to traditional energy sources such as coal power stations, nuclear power is demonstrably cleaner. Nonetheless, there is mixed support for nuclear, because of the risks associated with it.

There are concerns about its safety. Atrocious accidents have arisen from nuclear power, affecting people's health negatively and even resulting in death. The Chernobyl accident was a catastrophic nuclear accident. As argued by Murakami et al. (2015); Zhu et al. (2016); Danzer and Danzer, (2016) there are also dangers to nuclear waste; it must be stored in a remote location far away from people. Diaz-Maurin and Kovacic (2015) state that for these reasons, there is growing opposition to the expansion of nuclear plants around the world. After the recent Fukushima accident, more safety measures were added, making nuclear power even more expensive.

The recent nuclear accident in Japan has resulted in some countries (such as Germany) abandoning their nuclear plans. Some new nuclear projects have been cancelled, with plans to shut down present plants soon (International Energy Agency, 2015). According to Visschers et al. (2011), people's emotions have an impact on determining whether something is beneficial or destructive.

There is strong opposition to nuclear power around the world. The Fukushima accident influenced public opinion negatively; hence, it is even more important for governments to implement corrective measures and transparency during the process, to regain the public's trust in nuclear power. This was done successfully in France, by educating the public about the benefits and the risks of nuclear power (Sun and Zhu, 2014). In South Africa, a survey of public attitudes to nuclear conducted in 2011 by the Human Sciences Research Council (HSRC) showed that South Africans do not have enough information about nuclear energy. Around 40% of surveyed participants could not state whether they support nuclear power or not (HSRC, 2012).

Nonetheless, the South African government, like those of China, India and France, is in favour of further investment in nuclear power stations. It has announced that it plans to build two more, to reduce reliance on coal and reduce carbon emissions. Nuclear power has a large load factor, compared to other power-generating sources. Even though building a nuclear power station is costly, the cost of the electricity generated from it is low. But although nuclear is considered clean, there are concerns about its safety.

3. BACKGROUND

South Africa is presently the only African country with a commercial nuclear power plant. It has two nuclear reactors which generates approximately five percent of the country's electricity. The South African government has plans to build another nuclear power station. According to Eskom (2008) the plans to build the second nuclear plant are at an advanced stage, with the government (together with Eskom) having identified three possible locations (Bantamsklip and Duinefontein both in the Western Cape, next to the existing Koeberg nuclear plant; and Thyspunt in the Eastern Cape province). An environmental impact assessment concluded that Thyspunt was the best location.

It has been revealed that three main criteria were used to assess the three sites, namely system reliability, quality of supply, integration considerations, and future generation potential. The reasons for choosing the Thyspunt location are as follows (Eskom, 2008):

- It will ensure supply security for the Eastern Cape, since there is no base-load generation in the area
- Extensive transmission infrastructure would be necessary for the other sites; it will be easier to transmit power to nearby Port Elizabeth, using a shorter transmission system of 400kV;

There are fears that the presence of the proposed nuclear station may negatively affect the local economy. Thyspunt is famous for fishing, destined for international markets. Chokka squid[1] caught there is rated second best in the world. Having nuclear power in the vicinity might negatively affect market perceptions as some buyers may regard the squid as contaminated, resulting in the loss of foreign revenue and jobs for the local people. Some households fear that property prices in the area will go down. A drop-in house prices depends on several factors.

4. LITERATURE REVIEW

Ertor-Akyazi et al. (2012), state that in the 1970s, public disapproval of nuclear was very low, at about 20%; but it skyrocketed after the Three Mile Island accident in the US, to over 60%, and went up even more after the Ukrainian Chernobyl accident in the late 80s. It got even worse after the Fukushima Daiichi accident in Japan in 2011. According to Park and Ohm, (2014); Sun and Zhu (2014); Kuramochi (2015) past nuclear accidents are one of the main reasons for the growing resistance to nuclear energy.

Studies were conducted after these accidents to determine if public opinion and WTP for nuclear energy had changed. Some backed the closure of the nuclear plants, and some were still in support of nuclear, despite the accident. On the other hand, those in favour of nuclear were concerned about the stable power supply associated with nuclear; they were also of the opinion that if nuclear plants were to be shut down, the electricity price would increase (Abe, 2015). This shows how destructive information can affect the views of people who are initially in favour of nuclear, resulting in an upward trend of nuclear resistance (Ertor-Akyazi et al., 2012).

Many studies support the argument that a large share of nuclear power in the overall energy mix leads to lower electricity prices. However, these studies assume a perfect market. A perfect market does not exist in many countries. Most countries have either electricity oligopoly or monopoly structures. Ignoring the reality of the market, the models used in many studies are likely to produce misleading results (Nestle, 2012). This suggests that an increase in the electricity price is caused by a shutdown damaging information for nuclear.

Murakami et al. (2015) further indicated that the Fukushima accident altered consumers' views about nuclear power, especially in Japan. The Japanese WTP for a 1% decrease in nuclear power is $0.72/month, which is significantly larger than that of the US. In contrast, the American respondent's perceptions about nuclear were not affected substantially by the accident. From the above comparison, location matters: those located within proximity to where the accident occurred have different views about nuclear to those who were never affected.

A study in Turkey found that more than half of the surveyed respondents were not in support of nuclear power. This negative outlook on nuclear can be attributed to insufficient knowledge, since Turkey does not have an operative nuclear power station or may be a spill over effects of the Chernobyl accident (Ertor-Akyazi et al., 2012). Sun and Zhu (2014) found a higher WTP for nuclear plants constructed away from people's residential areas. Knowledgeable people were WTP more for construction of nuclear plants further away from their residences than those with limited information.

Swiss people prefer nuclear power, as it is deemed more reliable. Nuclear power stations produce 40% of total Swiss electricity (Visschers et al., 2011). This result is in line with Kovacs and Gordelier (2009), who concluded that people residing in countries with many nuclear power plants tend to be in favour of them. Liao et al. (2010) found that around 36% of the respondents believed nuclear share of energy in the country should increase, while 33 percent of the sample wanted it to decrease.

The Japanese nuclear energy accident is cited as the main driver for resistance to nuclear energy around the world. Those in favour of nuclear are only in support on condition that more safety precaution measures are put in place. Inadequate knowledge of and lack of familiarity with nuclear power also leads to nuclear opposition. Support for nuclear exists because it generates clean energy, and operating costs are relatively low. However, those further away from nuclear plant locations are more likely to support nuclear plants. It is therefore vital that an assessment of people's perceptions about nuclear power and the factors driving those perceptions are better understood. In this study, the WTP of citizens in general is assessed, as well as whether proximity to a proposed site matter.

5. THE SURVEY

The study was undertaken in the Eastern Cape province, in and around the Thyspunt area proposed for a nuclear power station. Thyspunt is a rocky stretch of coast approximately 70 km to the West of Port Elizabeth. The greater area comprises Cape St Francis, Oyster Bay, Humansdorp, and the popular surfing beach of Jeffrey's Bay. The area's main economic activities include a diverse agricultural offering, which includes dairy and forestry in Humansdorp, fishing and tourism around St Francis Bay, Cape St Francis and Oyster Bay, and surfing in Jeffrey's Bay.

A review of the literature suggests that WTP for protection against nuclear-related risks such as a nuclear accident decreases *ceteris paribus* with distance from the nuclear plant. To test the spatial dimension of responses to the external effects of nuclear power, a survey was also carried out in and around Johannesburg, in Gauteng province, which is 1150 km away from the proposed site. The aim here is to test if there are differences in WTP due to distance. Johannesburg is the country's economic hub. We began

1 The chokka squid (also known as calamari) industry generates around R340 million in foreign revenue per annum (South African Squid Management Industrial Association, 2014).

by testing the survey questionnaire before using it in the field. Pretesting and piloting led to identification of questions that were unclear and could have resulted in biased answers. After pretesting and piloting survey the survey procedure was refined, to ensure that the final survey would be easy to understand and still incorporate most of the essential questions in the analysis.

The sample includes households across all income levels. Although including the wealthiest and poorest people in the sample doesn't per se guarantee its representativeness, combined with the sample of 695 and the high variance in the demographic information that was gathered, representativeness is assumed.

We conducted a door-to-door survey using a multistage stratified randomized sample. In the first stage, the city populations were stratified into two strata: suburban and townships[2]. In the second stage, wards were selected for enumeration. Further stratification was done based on probability proportionate to size method. In the third and final stage, enumeration blocks and households were selected based on simple random sampling and from each enumeration block, individual households were selected using systematic random sampling. The face-to-face surveys were performed between May and June 2015 and yielded a total sample of 695 respondents, of which 365 were in Johannesburg (i.e., the initial sample consisted of 768 responses, but 73 "protest" responses were excluded).

The surveys were conducted using electronic gadgets instead of the orthodox paper method. This new method has gained momentum lately because of its efficiency. It minimises human error, because the coding of the survey into the gadget occurs in advance, to make it easier and less time-consuming for the enumerator when collecting data. This systematic method reduces mistakenly skipped questions that might otherwise occur when rushing to complete the survey, or entering incorrect information when capturing data, since data capturing occurs automatically when the survey is completed.

The survey instrument comprised three parts. The first part consisted of warm-up questions; general information regarding outages. The second part of the questionnaire covered the government plans to build a second nuclear plant. Respondents were informed that to reduce power outages, the government planned to construct a second nuclear power plant in the Eastern Cape. They were then asked if they supported this plan. Those who answered "yes" were asked to indicate reasons for their support. Those who answered "no" were asked to suggest other alternative energy sources. They were informed that their preferred substitution may lead to rises in the price of electricity, and whether they would be WTP higher for alternative energy sources instead.

The respondents who supported were asked to state their WTP (towards construction of a second nuclear power plant in the Eastern Cape province to reduce power outages). The WTP is towards covering the overall construction costs of a new power plant. The new power plant is aimed at improving the country's energy supply security. Protest zero bids were identified by follow-up questions that examine the respondents' motivation for providing zero bids. In the case of this study, reasons cited for zero bids was the belief that the good should be provided by means other than personal payments. The third part of the survey collected socio-demographic information.

6. DESCRIPTIVE STATISTICS

The variables used in the analysis besides the general demographics include monthly electricity bill, availability of back-up, medical equipment, support for nuclear and Thyspunt dummy. Monthly electricity bill measures electricity consumption and is one of the determinants of WTP. Higher electricity consumption may indicate more dependence on electricity, which results in higher WTP for more electricity investments (Guo et al., 2014; Kim et al., 2015). We also have an electricity dummy variable with 1 representing those people with electricity back-up like generators. These households may not be willing to pay for additional investment in electricity. They can rather have their back-up electricity ready for when electricity disruptions occur than pay extra for a service that they cannot control, and which may be unreliable.

We also have a medical equipment dummy, with 1 showing respondents who depend on electricity for their lives may be willing to pay for stable electricity supply. This may include diabetic medication, which requires refrigeration. The nuclear support dummy variable represents those in support of nuclear and zero for the ones that do not support nuclear power. Considering our interest in checking if distance from nuclear plant mattered, we have a Thyspunt dummy where 1 reflects close proximity, while zero shows those far from plant (i.e., Johannesburg respondents). The descriptive statistics of the surveyed households are presented in Table 1. Where respondents were household members other than the household heads, their responses were interpreted as coming from the heads themselves.

Table 1 shows that a similar share of the people in Gauteng and the Eastern Cape support the proposed nuclear power plan. The two main reasons for supporting nuclear power stated by the households in the survey are that it is deemed reliable, and that it can result in lower electricity prices eventually. However, 12% of the Thyspunt sample would rather pay for an alternative energy source than for nuclear power.

A significant proportion of those in support of the plant in the Thyspunt area were supportive because of the job opportunities that would be created. Unemployment in the area is high; for some locals, job opportunities outweigh nuclear risks. On the other hand, some are worried about possible negative social effects during the construction phase, arising from the influx of relatively unskilled workers from neighbouring areas. Some of the workers may remain in the area after the construction, leading to growth in informal housing, affecting the area's sense of place and residents' lifestyles.

In Johannesburg, some respondents referred to the Koeberg power station – particularly, the fact that it has been in operation for

2 (In South Africa) an area of predominantly black occupation, formerly officially designated for black occupation by apartheid legislation.

Table 1: Descriptive statistics for support of proposed second nuclear power plant

Variable	Thyspunt, Eastern Cape	Johannesburg, Gauteng	Total Sample
	Mean	Mean	Mean
Support for nuclear	0.73 (0.45)	0.75 (0.43)	0.74 (0.44)
Monthly electricity bill amount	R640 ($53)	R1 190 ($99)	R920 ($77)
Costly alternative if not supporting nuclear	0.12 (0.33)	0.09 (0.29)	0.11 (0.31)
Available backup	0.13 (0.34)	0.17 (0.38)	0.15 (0.36)
Use of Medical equipment	0.15 (0.36)	0.13 (0.34)	0.14 (0.35)
Males	0.49 (0.50)	0.59 (0.49)	0.54 (0.50)
Age	37 (11)	34 (12)	36 (11)
Household size	4 (2.02)	3.7 (1.76)	3.8 (1.89)
Kids under 18 years	0.61 (0.49)	0.53 (0.50)	0.57 (0.50)
Education years	12.83 (3.34)	14.50 (3.61)	13.71 (3.85)
Annual household income	R143 258 ($11 938)	R282 466 ($23 538)	R217 935 ($18 163)
Employed	0.75 (0.43)	0.62 (0.49)	0.68 (0.47)
Student	0.03 (0.18)	0.07 (0.25)	0.05 (0.22)
Self-employed	0.10 (0.30)	0.20 (0.40)	0.15 (0.36)
Retired	0.02 (0.14)	0.03 (0.16)	0.02 (0.15)

Standard deviation and dollar values (in monthly electricity bill amount and annual household income) in parentheses

years with no problems. They have faith that nothing disastrous will come of the proposed nuclear plant in terms of safety. This is echoed by Visschers et al. (2011); Ertor-Akyazi et al. (2012); and Park and Ohms' (2014) findings, which showed that trusting that authorities can operate the plant safely results in more social acceptance.

In both provinces main reason cited against nuclear plant was the risk inherent in the transportation and disposal of nuclear waste. Zweifel et al., (2005) argue that being located at a great distance from a nuclear plant does not necessarily protect households from that risk. Radioactive waste and spent fuel are produced at nuclear plants, from where they may be transported to any disposal site, nation-wide. This suggests that there is increased exposure to the risk associated with nuclear waste near the plant. According to Hartmann et al. (2013), being aware of nuclear risk results in opposition to nuclear; and that was shown in our survey, since many of those opposing nuclear referred to what has happened in other countries.

The second reason for not supporting nuclear in Gauteng is the fact that constructing a nuclear power plant is costly. In the Eastern Cape, the second most important reason for condemning nuclear was that construction in Thyspunt would change the wave structure in Jeffrey's Bay, which would have a detrimental impact on tourism. Additionally, the fact that most countries are moving away from nuclear is a compelling reason for South Africa to rather consider exploring other options that are cheaper and safer than nuclear, such as renewable energy. A follow-up question was posed to respondents who did not support nuclear – whether they would rather pay for another, preferred alternative.

In Gauteng, nine percent of the 25% that do not support nuclear are willing to pay for an alternative energy source, even if it is more expensive; while in the Eastern Cape, 12% of the 26% that do not support nuclear are willing to pay more for another, safer energy source. More people in the Eastern Cape who do not support nuclear are prepared to pay for an alternative energy source instead than in Gauteng.

Since Eskom has not been reliable regarding information about and frequency of power cuts, a question was posed to ascertain whether households have ever thought of setting up an independent power source in the future, to offset the power supply problem. Approximately 43% of the respondents were planning to invest in their own household energy generation; 35% had never thought about doing it; and 21% said they might consider it. The limiting factor is budget constraints; some respondents reported that if they had enough money to set up an independent power source, they would certainly do so.

7. EMPIRICAL RESULT FOR WILLINGNESS TO PAY FOR NUCLEAR PLANT

A spike model is employed to analyse the determinants of not having a WTP for nuclear power. The first decision is modelled with a binary probit model, where the dependent variable is equal to one if WTP is positive. The second decision, WTP given positive WTP, is modelled with a truncated regression model (i.e., neither the dependent nor the independent variable is known if the threshold criterion is not met) or a regression model on positive WTP.

The open-ended elicitation format is used (rather than one of the bounded dichotomous choice formats). Tisdell et al. (2008) state that an advantage of open-ended questions is that it is free from starting-point bias which could otherwise influence the respondent's answer. Boyle, 2003 argue that open-ended questions do not restrict respondents to only a few options to choose from and cater for possibilities that the interviewer did not anticipate, and which might be beneficial.

As many respondents stated zero WTP for nuclear, it is vital that we analyse the determinants of these zero WTP responses. That is why this analysis is carried out in two parts, using the spike model for the zero WTP responses, and the truncated regression for the positive WTP responses. Most studies have used the probit model to get rid of zero responses and only analyse the positive

responses, but Kriström (1997) proposed a spike model to cater for cases where zero or negative WTP is stated.

Estimation of a two-part proceeds according to the following specification:

$$F_{wtp}(t) = \begin{cases} 0 & if\ t < 0 \\ p & if\ t = 0 \\ G_{wtp}(t) & if\ t > 0 \end{cases} \qquad E[WTP] = \int_0^{\infty} (1 - F_{wtp}(t))\,dt \qquad (1)$$

Where $F_{wtp}(t)$ is a cumulative function of the respondents not willing to pay the t amount, p represents (0,1), $G_{wtp}(t)$ is a continuous and increasing function, such that $G_{wtp}(t)=0$ =t and $\lim_t$ to infinity is $G_{wtp}(t) = 1$. To be clear what WTP we are discussing here, we have the mean WTP for the whole sample and the mean WTP for the restricted sample. Note that E(WTP) = Pr (zero WTP) * 0 + E(WTP|WTP>0) *Pr(WTP>0). The negative WTP values were not allowed in the CV experiment.

The risks associated with nuclear power, such as accidents and waste disposal, are often cited by those who are against nuclear power plants. A significant number of people around the world shun nuclear power for these reasons, and that attitude is evident in this study as well. One might therefore expect people who live in Thyspunt and surrounding areas – who are most likely to be worst affected, should an accident occur – to be less supportive of the proposed plant. This implies that we expect the distance dummy (i.e., 1 for Thyspunt residents, and 0 for distant [Johannesburg] respondents) to be negatively signed and significant. Distance is therefore a proxy for risk. Many respondents supported the nuclear plan but stated zero WTP towards nuclear. In some cases, supporting a good does not necessarily mean the individual would also pay for it; in extreme cases, a negative WTP may be stated, when a good is detrimental to a person's welfare.

In the truncated regression, Thyspunt dummy tests differences between those who reside near the proposed nuclear plant site, and those who reside further away. In Table 2, we assess the determinants of WTP for the proposed second nuclear power plant. It is important to note that no multicollinearity was detected in the model.

By running a two-part model, our analysis allows a proportion of the sample to have zero WTP, which is realistic in many cases. Our strategy is first to analyse the probability of zero WTP using a binary probit model, where the dependent variable is equal to 1 if WTP is zero. The second step entails analysing the WTP for WTP>0 with a truncated regression model.

The Thyspunt dummy is negative and significant in the probit model, which implies that those who are closer to the plant are more unlikely to state a zero WTP. The other variables that are negatively signed and significant are male dummy, availability of backup power, and children under 18 years. This implies that males (relative to females) are most unlikely to state a zero WTP. This means that females are more likely to state zero WTP for nuclear than males, since the male dummy variable is negative and significant. This was expected, because women are usually more sensitive than males and are not expected to take risks where nuclear is concerned.

Table 2: Determinants of WTP for nuclear power plant using a spike model

Independent Variables	Spike regression probit (WTP > 0)	Truncated regression
Monthly electricity bill	0.0007 *** (0.00008)	0.0004 *** (0.00008)
Thyspunt dummy	−1.65 *** (0.10)	−0.15 (0.12)
Available backup	−0.48 ** (0.19)	0.19 (0.15)
Medical equipment dummy	0.20 *** (-3.32)	0.06 (0.16)
Male dummy	−0.43 *** (0.06)	−0.28 ** (0.11)
Age	0.01 * (0.003)	0.005 (0.01)
Household size	0.01 (0.02)	0.04 (0.03)
Children under 18 years	−0.15 ** (0.07)	0.07 (0.13)
Education years	0.0005 (0.01)	0.01 (0.02)
Log income	−0.01 (0.04)	0.06 (0.08)
Employed dummy	0.19 ** (0.10)	0.36 (0.22)
Student dummy	0.08 (0.16)	0.35 (0.31)
Self-employed dummy	0.28 ** (0.13)	0.6 ** (0.27)
Retired dummy	−0.01 (0.24)	0.59 (0.38)
Cons	2.26 *** (0.42)	2.97 *** (0.91)
Log likelihood	−972.012	−535.10
Number of households	695	695
Prob. >Chi-sqaure	0.00	0.00

Standard errors in parentheses. *P < 0.10; **P< 0.05; ***P < 0.01

For example, after the Fukushima accident, pregnant women who had been exposed to the radiation were asked to terminate their pregnancies. Furthermore, 10 years after the accident, women who had been affected by radiation had mental problems, including depression and stress. These suggest that women are exposed to more physical danger than men are (Bromet, 2012). The unlikeliness if stating a zero WTP also applies to households that already have back-up power such as generators, and households with children under 18 years. WTP for nuclear power for households with young children is not likely to be zero.

On the other hand, the higher the amount spent on the electricity bill, the more likely people are to be willing to pay zero, which is logical given the significant amount already spent on the utility bill. This shows that households that rely on electricity may support nuclear power, but state zero WTP for other reasons, which may include affordability. They may think the electricity price is already high and believe they cannot afford to pay more for nuclear power. Households with medical equipment that requires electricity are most likely to be WTP zero. This may be due to budget constraints, as they are already spending a significant proportion of their budgets on medical expenses. One might think that because they depend on electricity, they would be unlikely to state a zero WTP towards nuclear power, but in this case, they are not willing to pay. This also applies to older people, those in formal jobs, and the self-employed.

The coefficient of distance to the nuclear plant in the truncated model is a significant determinant of WTP>0, which is in

Table 3: WTP for Thyspunt nuclear power plant

Sample	Mean WTP	Standard Deviation	Median WTP	Minimum	Maximum	Share of Zero WTP
Thyspunt	R70 ($6)	132	2.00	0.00	1200.00	0.24
Johannesburg	R124 ($10)	260	20.00	0.00	2250.00	0.24
Whole Sample	R99 ($8)	211	10.00	0.00	2250.00	0.48

contradiction to the sample WTP descriptive. Males are more pessimistic about a nuclear plant, which is reflected in their lower WTP compared to their female counterparts. The finding that having a higher electricity bill is likely to predict higher WTP may be due to the higher dependence on electricity of those households. The highest electricity bill paid by households in the survey was R7000 ($583), those households with higher electricity usage can have a WTP to safeguard their own stable electricity supply.

Given that those who are self-employed may run home-based businesses, which are heavily dependent on reliable supply of electricity, it is not surprising that they view the proposed nuclear plant favourably. The marginal effects after running the truncated model show that if the electricity bill increases by one unit, the conditional WTP increases by 0.0001 units. Self-employed and males' conditional WTP figures are 0.60 units higher and 0.28 units lower respectively. Table 3 compares responses concerning WTP for the proposed nuclear power.

Gauteng households are prepared to pay R124 ($10) in support of the proposed nuclear plant, while households in and around the proposed site in the Eastern Cape are willing to pay significantly less (R70/$6). This is in line with the argument in the literature that WTP for coverage against the risks of a nuclear accident decreases with distance from the plant. We therefore conclude that for geographical reasons, households further away from the nuclear power plant are more supportive, as they are not directly exposed to the risk associated with nuclear plants.

8. DISCUSSION

A picture that emerges from the whole sample is that most respondents are in favour of the construction of the country's second nuclear power plant. On average, an overwhelming 74% of the whole sample supports the proposed second nuclear power plant. Overall, South African households are becoming increasingly reliant on electricity; and the fact that the country has never experienced a nuclear accident may perhaps be the reason for the general support for a plan to secure the national grid.

The support emanates from the fact that the new plant will increase the country's electricity generation capacity, which would increase electricity reliability and the possibility of lower electricity prices. Support also stems from the prospects of job creation in the area due to the construction of the plant. The main concern from those not in support concerns nuclear waste (which can be detrimental to people's health), the negative impact nuclear might have on tourism in the area, and the possibility of falling house prices.

The modelling results suggest that putting more distance between residences and the nuclear plant would have little effect on WTP. This implies that distance effect does not matter as far as the WTP for nuclear plant is concerned. This may be because South Africa has had a nuclear plant for a very long time and has not experienced a nuclear accident. Therefore, distance is not a relevant predictor of WTP for solving the problem of nuclear-related risk. Higher dependence on electricity is most likely to lead people to be more supportive of the planned plant. South Africans seem to be less concerned about safety concerns. Instead, they are more concerned about reliable electricity supply.

Pessimistic males are willing to pay significantly less than females. This is in line with the findings of studies such as Zweifel et al., (2005), which stated that females were more concerned with the well-being of future generations than males. In that study, females were found to be willing to pay more than twice as much as males for additional insurance coverage and solving the waste disposal problem.

It is interesting that self-employed people support the plan. According to Kim et al. (2014), this suggests that the most important thing for them is a reliable power supply. They may trust that no accidents will occur, given proper management of the plant.

9. CONCLUSIONS AND POLICY IMPLICATIONS

There is information asymmetry when it comes to nuclear power. More information should be provided to educate households about the pros and cons of nuclear, and about the reasons the government is considering investing in nuclear power to diversify the electricity mix, as well as the reasons of those strongly against nuclear. According to Zhu et al. (2016), when there is no concrete nuclear power knowledge and trust in the government, people can end up believing negative things that they are exposed to, and that can result into nuclear power opposition.

If the Japanese government had been more transparent, the damage from the Fukushima disaster would have been minimised. It is even more shocking that more than 50% of the Hong Kong population do not know about the appropriate safety precautions or exit areas, should a nuclear accident occur (Chung and Yeung, 2013). Given that figure, one would think other countries might have the same shortfalls that would need to be addressed by a government embarking on building nuclear plants – as South Africa is.

Compared to Gauteng residents, Thyspunt residents are far more likely to display zero (probably even negative) WTP, according to the probit part of the estimation. Nonetheless, the higher WTP for those further from the plant suggests they are more supportive of the plant than those in closer proximity.

One of the short comings of this study is in the manner the two locations are compared. Comparing Thyspunt and Gauteng respondents as done in this study is a missed opportunity as in both locations, WTP becomes less negative (more positive, respectively) with distance. The interesting question would have been where the gradient of distance is more marked?

Future researchers should investigate whether risk perceptions are more important in determining how much people are willing to pay to support nuclear plants, despite the risks associated with them. Most interestingly, future research should allow for negative WTP values as they are of considerable interest. The full density distribution of WTP values could be used to estimate whether the "pro camp" would be (in theory at least) can compensate the "con camp."

Moreover, we recommend the use of more complex approaches such as choice modelling, as it would generate much richer data than CVM surveys. For example, effects on squid fishing, tourism, and employment cited point to the fact that the 'product' in question has several attributes that are not held constant between Johannesburg and Thyspunt, calling for a Discrete Choice Experiment rather than CVM. Although we now, that CVM is also stated choice, the point is that it makes respondents exclusively focus on the price attribute, which also invites strategic behaviour.

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