

(計畫名稱)

氣候變遷趨勢下國人對核能的態度及願付價值分析—
考量多重外部性

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Title: Analysis of the attitude toward nuclear energy and willingness to pay under climate changes trend: multiple externalities considered

ABSTRACT

Since both the supporters of nuclear power generation and those against have much influence politically, this study therefore uses willingness to pay (WTP) to show how strong the opinions are on both sides in order to help with the decision making. Those interviewed are first asked about their attitudes to nuclear power, and then both those in favor and those against nuclear power generation are asked double-bounded willingness-to-pay questions. The data for these two types are then combined in a modified model to increase the estimation efficiency. The empirical results confirm that global warming-related variables are important factors associated with WTP. About 2% more of those opposed to nuclear power generation are willing to pay than the supporters. Meanwhile, the median WTP of those supporters who are willing to pay is US\$146.31 per year, while the median WTP of those opponents who are willing to pay is US\$164.85 per year.

Key Words: Nuclear power, Contingent valuation method, Double-bounded model, Negative willingness to pay, Climate change

中文摘要

核能發電的支持者和反對者在政治上都非常有影響力，因此本研究使用願付價值(WTP)來顯示雙方面意見的強度，以幫助決策。受訪者首先被詢問他們對於核能的態度，然後贊成者和反對者分別被詢問雙界二元選擇願付價值的問題。接著本研究修改模型來結合這兩種類型的數據以增加估計效率。實證結果確認，有關全球暖化的變數是影響願付價值的重要因素。此外，願意支付金錢的核能發電的反對者，大約比支持者多2%。同時，願意支付金錢的核能發電的支持者的WTP中位數是每年146.31美元，而願意支付金錢的核能發電的反對者的WTP中位數是每年164.85美元時。

關鍵字： 核能; 條件評估法; 雙界二元選擇模型; 負的願付價值; 氣候變遷

報告內容:

前言

The first wave of the world trend toward nuclear energy began in the mid-1950s, reached a peak in the 1960s, and was followed by the rise of the environmental protection movement in the 1970s. However, the 1979 Three Mile Island accident and the 1986 Chernobyl nuclear catastrophe [57] brought this first wave of the trend toward nuclear energy to an abrupt end. After more than 20 years of relatively little in terms of new developments, there has been a rejuvenation of the industry in recent years. For example, although the U.S. has not built new nuclear power plants since 1979 for a period of about 30 years, there have recently been some 26 applications for nuclear reactor stoves [14], with at least another 7 expected [46]. The main factors underlying this rejuvenation have been global warming and the increases in oil prices. The implementation of a carbon tax has also made the price of fossil fuel to go up even further [8, 18, 25]. Nuclear power is an important form of energy that is cheap, can be steadily supplied, and has low carbon emissions, thus having lower external costs [47]. However, it does give rise to nuclear waste [45, 47] and accident risks [36, 47, 50]. In many countries as well as in Taiwan where fossil fuel stocks are low, more domestically produced nuclear energy implies less dependence on foreign energy sources and a relatively sustainable supply, thereby ensuring future energy security.

文獻探討

The electricity generated by nuclear energy accounts for about 20% of all electricity currently generated in Taiwan. A key question that needs to be asked is whether Taiwan's energy policy will rely on nuclear energy even more in the future. The decision regarding nuclear energy has two dimensions. First, it especially relies on the professionalism of specialists because nuclear energy requires various kinds of

advanced knowledge. Second, people's opinions and preferences are also important [34, 73]. Yet, relatively little is known about these social valuations [26]. The contingent valuation method (CVM) that popular in non-market studies (for example, [1, 2, 33, 37, 40, 41, 51, 58, 65, 71, 74, 77]) is a method designed to reveal preference. While there are some WTP studies that are concerned with energy (such as [66]), much of the focus of WTP is on renewable energy (such as [4, 5, 7, 9, 11, 47, 54, 61, 62, 63, 64, 67, 72]). In relation to this line of the literature, there are also many studies that estimate the WTP in relation to climate change (such as [20, 21, 28, 39]).

However, few studies have estimated WTP that is closely related to nuclear power. One of the focuses of these studies is on nuclear risks [43, 48]. Riddel and Shaw [48] found that the per household cost associated with the health and safety risks of storing high-level nuclear waste was \$17,128 annually, while Itaoka et al. [43] focused on the WTP related to reducing the mortality risk. A WTP study closely related to nuclear energy is that of Li et al. [26], who estimated the WTP for energy research and development (R&D) to reduce US reliance on fossil fuels. One of their five major tests was that the inclusion of nuclear energy would reduce WTP. Besides an emphasis on R&D based on crop-based and renewable resources, nuclear power was tested by means of a split-sample treatment. Li et al. [26] found that the estimated parameter of nuclear power was not statistically significant across all the maximum likelihood estimations, or across all the Bayesian estimations using different coding for the answers in order to handle the uncertainty associated with the responses. They concluded that there was no evidence that supported the view that the inclusion of nuclear power in the R&D energy alternatives had a "poison pill" effect.

There are a number of papers that have touched on the issue of nuclear power. For example, Koundouri et al. [54] asked consumers to rank energies including nuclear but WTP for wind power was the purpose of the estimation. Similarly, Longo et al.

asked respondents to state whether or not other energies were environmentally friendly and whether or not nuclear power was not so environmentally friendly. However, the WTP for renewable energy, especially CO₂ reduction was the target estimate in Longo et al. [47] . In addition, MacMillan et al. [17] estimated the WTP for wind to replace fossil fuels and nuclear energy.

研究目的

It is our intention to estimate the WTP for an increase in the nuclear power ratio and the WTP for a decrease in the nuclear power ratio. To achieve this goal, we formulate a methodological objective.

研究方法

The typical CVM methodology evaluates goods or environmental changes with non-negative values only (for example, [26, 28, 51, 52, 65, 74, 77]). There are other models, such as spike models, that allow for negative WTP as well as positive WTP [10, 52]. The opinions regarding nuclear power are controversial on both sides, and thus negative WTP is substantial. As Bohara et al. [6] pointed out, it is important to make efforts *ex ante* to identify whether the negative WTP is substantial. A new model is thus needed. For this reason, we appropriately handle negative WTP through an *ex ante* survey design and build a model that allows for ‘negative WTP’. This model is a modification of the typical double-bounded CVM model. To this end, we identify the supporters and those who are against first. We then use maximum likelihood estimation on the combined observations of nuclear-supporters and the observations of those opposed to nuclear power by using dummy variables to increase the estimation efficiency. Finally we estimate the WTPs of both the supporters and opponents, respectively. In this way, the negative WTP issue in this study is well managed.

結果與討論（含結論與建議）

Since carbon emissions from using fossil fuels are increasing, it is becoming increasingly clear that a migration to non-greenhouse gas emitting fuels is necessary. As one of the major non-fossil fuels but with many positive externalities and negative environmental and health effects, nuclear power is a controversial choice. In Taiwan, both sides that support or oppose nuclear power are strong and are comparable in size. However, there has not been a nationwide study performed to examine people's preferences regarding this issue. Thus it is important to understand whether and how strongly the Taiwan public supports or opposes nuclear power.

This study confirms that both supporters of and those opposed to nuclear power are comparable. In terms of opinions, about 3% more people thought that the ratio of nuclear power should increase than those who thought that it should decrease. However, in terms of the number of respondents who were willing to pay, 2% more were willing to pay to decrease nuclear power. Finally, in terms of the willingness to pay, the number of those who believed that nuclear power should decrease surpassed the number of those who thought that it should increase by 12.67%. These findings echo Kim [69] who observed that the fossil fuels and nuclear power have the highest external costs, and renewable resources [4, 5, 7, 9, 11, 20, 21, 28, 39, 47, 54, 61, 62, 63, 64, 67, 72] need to be emphasized in the future. The results are of some importance when an energy policy and greenhouse gas decrement policy is drafted. In spite of the careful design and conduct of this study, more exquisite studies are expected due to the relevance of this hotly-debated issue. However, this paper does provide a new way to evaluate public attitudes regarding nuclear energy in relation to climate change.

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計畫成果自評

研究內容大致與原計畫頗為相符，問卷方式因新流感之故，改用無風險的電腦輔助電訪而非原計畫所列的面訪，也開發新的模型而非原計畫所列模型，整體而言研究結果有達成當初預期目標。研究成果具學術價值，也已經投稿國外學術期刊(JEEM)。

可供推廣之研發成果資料表: 本計畫無可供推廣之研發成果。

附錄: 本精簡報告無附錄。