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Residential willingness to pay for deep decarbonization of electricity supply: Contingent valuation evidence from Hong Kong

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ABSTRACT

Motivated by the government's proposed target of reducing CO_2 emissions by 30% of the 2005 level in the year 2020, we estimate the residential willingness-to-pay (WTP) for deep decarbonization of Hong Kong's electricity supply, which is heavily dependent on coal-fired generation. Our contingent valuation survey conducted in 2016 of 1460 households yields dichotomous choice data based on the respondents' answers to a series of closed-ended questions. Such data are less susceptible to the strategic bias that often plagues self-stated WTP data obtained by direct elicitation via open-ended questions. Using binary choice models, we find that average WTP is 48–51%, relative to current bills, if the decarbonization target is achieved via natural gas generation and renewable energy. However, estimated WTP declines to 32–42% when decarbonization entails additional nuclear imports from China. As the projected bill increase caused by the target's implementation is 40%, our WTP estimates support the government's fuel mix policy of using natural gas and renewable energy to displace Hong Kong's coal generation.

1. Introduction

Growing concerns about global warming caused by the world's CO_2 emissions led to international commitments to deep decarbonization made at the 2015 Paris summit on climate change. These were reinforced by the China – United States agreement at the 2016 G20 summit in Hangzhou, China,[1] although the U.S. commitments are unclear under the new Trump Administration.

Electricity plays a pivotal role in the technological pathways to deep decarbonization (Williams et al., 2012). The first pathway involves decarbonization of the electricity sector itself through increased reliance on non-carbon sources (such as wind, solar, hydro and nuclear) as well as by shifting from coal to natural gas, which has a much lower carbon footprint. The use of more efficient and therefore less carbon-intensive technologies, such as combined cycle gas turbines and combined heat and power generation, are part of the present menu of choices. Underscoring this point is Hong Kong's total generation capacity of 12,625 MW (MW) of electricity that is dominated by coal generation (52.3%), followed by natural gas generation (25.2%), nuclear imports from China (10.9%), and other sources (11.6% consisting primarily of pumped hydro storage and diesel generation) (Woo et al., 2014a, 2014b, 2015). The fuel mix of Hong Kong's electricity generated in 2012 was 53% coal, 23% nuclear, 22% natural gas, and 2% other sources.[2]

The second, and much more challenging pathway, is electrification of the transportation sector. In Hong Kong, this sector accounts for 17% of total CO_2 emissions (Woo et al., 2014a, Table 1). While electric taxis and buses are presently rare in Hong Kong, private electric cars have become increasingly popular, thanks to the partial exemption of the 'First Registration Tax' of over 100% of a car's purchase price.[3] The net effect of electric vehicles on Hong Kong's CO_2 emissions, however, critically depends on the carbon content of the city's electricity supply. As much of the incremental generation due to transportation electrification comes from Hong Kong's aging coal units, the contribution to decarbonization that can come from electric vehicles is diminished.[4] A switch from a gasoline-powered to an electric car may even increase carbon emissions, given the low efficiency of coal-fired plants and the lower carbon footprint of gasoline relative to coal.

Electricity generation contributes 66% of Hong Kong's total CO_2 emissions (Woo et al., 2014a, Table 2). In two separate public consultations, the Hong Kong government proposed a CO_2 emissions reduction target of 30% relative to the 2005 level by the year 2020. This is projected to cause an electricity bill increase of about 40% (HKSAR, 2014, 2015).[5] The government's electricity decarbonization policy mirrors the worldwide trend exemplified by European efforts to retire aging coal-fired generation plants, the price-driven shift from

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coal to natural gas in the U.S. and the elimination of coal-fired generation in Ontario, Canada, to name a few initiatives.

This paper estimates the willingness-to-pay (WTP) of Hong Kong households for using natural-gas-fired generation, nuclear energy and renewable sources to displace coal-fired generation.[6] Our WTP estimation is made possible by the data collected from 1460 Hong Kong households that participated in a telephone survey in April 2016. The survey follows the contingent valuation (CV) method commonly used to value environmental protection, a non-market good (Mitchell and Carson, 1989; Bateman and Willis, 2001; Champ et al., 2003; Carson and Hanemann, 2005; Hoyos, 2010; Carson et al., 2014; Stigka et al., 2014). It yields dichotomous choice (DC) data based on the respondents' answers to a set of closed-ended questions. These DC data are less susceptible to the strategic bias that often plagues the self-stated WTP data obtained by direct elicitation (DE) through open-ended questions (Hoyos, 2010; Carson et al., 2014).[7]

Our key finding is that Hong Kong households' WTP estimate is 48–51% if the target is achieved through a combination of natural gas and renewable generation. This estimate declines to 32–42% when decarbonization entails additional nuclear importation from China.[8] As the projected bill increase resulting from the target implementation is 40%, our WTP estimates support the government's fuel mix policy of using natural gas generation and renewable energy to displace Hong Kong's coal generation.

This paper makes three contributions. First, it demonstrates the usefulness of our WTP modeling in informing the policy debate on Hong Kong's decarbonization of electricity. Second, it reports new WTP evidence based on a carefully documented CV data file. Finally, it shows a large disparity between the WTP estimates based on the DE data and those inferred from the DC data, which is likely attributable to the strategic bias known to exist in the DE data.

The paper proceeds as follows. Section 2 motivates our WTP estimation, reviews the extant WTP estimates, describes our CV data, and presents our estimation strategy. Section 3 reports our regression results, which are then discussed in Section 4. Section 5 concludes.

2. Background and methodology

2.1. Motivation

Motivating our study are several issues related to a proposed fuel mix change. Though presented in the Hong Kong context, these issues may also apply to other parts of the world that have committed to deep decarbonization, including China, India and the U.S., the top three countries responsible for over 50% of the global CO_2 emissions in 2016.[9]

The first issue is public acceptance. If the residential WTP estimate is far below the projected bill change, Hong Kong households will likely reject the proposed fuel mix change. Although households only accounted for about 27% of Hong Kong's total electricity consumption in 2015,[10] strong public objection could doom any proposed fuel mix change. While commercial firms account for as much as 66% of Hong Kong electricity consumption, they appear to be insensitive to the projected bill change, perhaps because electricity expenses are a small fraction of their total costs which are dominated by financing, materials, labor and rent. Thus, the government's two public consultations have attracted much less attention from Hong Kong's commercial sector than from households.

The second issue is financial viability. If the residential WTP estimate exceeds the projected bill increase, the change is deemed financially viable. While this condition may not apply to all electricity users in Hong Kong, our residential focus reflects two factors: (a) households are a much stronger driving force in Hong Kong's electricity policy debate than commercial firms; and (b) apparent acquiescence by commercial firms to the projected bill increase.

A third issue, closely related to the first two, is the cost-benefit assessment of the proposed fuel mix change, subject to the condition of public acceptance. Decarbonization has the characteristics of a public good (Laffont, 1988), suggesting the government's presumption that the social benefit (SB) exceeds the abatement cost (AC) measured by the projected bill increase. We postulate SB > WTP because of the free rider problem in the provision of a public good and households' imperfect appreciation of the adverse impacts of climate change.

Under the financial viability condition of WTP > AC, the proposed fuel mix change is publicly acceptable. However, if AC > WTP, the change is unpopular. To be sure, the government may offer a subsidy which exceeds AC – WTP > 0, so as to mitigate objections by households.

In Hong Kong, such a subsidy could be implemented through the government's existing electricity charges subsidy scheme.[11] An alternative consists of tax concessions to the local electricity utilities that can in turn pass the tax savings to their customers under Hong Kong's rate of return regulation detailed in Woo et al. (2015).

The fourth issue is related to the total subsidy size. An estimate of the total subsidy is the gap between the total dollar amount that Hong Kong households are willing to pay and the total abatement cost. Hence, the total subsidy is small when the WTP estimate is close to AC. Even if the total subsidy is large, its funding might be feasible, due to the government's cumulated reserve of over US$100 billion and a budget surplus in 2016 of over US$10 billion.[12] Whether a large subsidy should proceed, however, would be debatable, given the competing possible uses of funds for programs such as economic development, education, environment protection, food safety, health, infrastructure, security, and social welfare (e.g., public housing for low-income households).[13]

The fifth and final issue is related to the distributional effects of a proposed fuel mix change. A household's WTP generally depends on the household's ability to pay. If the change leads to a disproportionally adverse impact on low-income households, a government subsidy scheme could offer relatively larger dollar amounts to low-income households to improve vertical equity.

2.2. Extant WTP estimates

To put our WTP estimation in context, we briefly review a selected sample of recent CV studies which have been chosen for their geographic coverage, data collection methods, estimation approaches, and empirical results. Summarized in Table 1, these studies encompass various regions of the world. The two main types of data collected are: (a) self-stated WTP obtained via direct elicita-

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1 https://www.theguardian.com/environment/2016/sep/03/breakthrough-us-china-agree-ratify-paris-climate-change-deal.

2 http://www.gov.hk/en/residents/government/publication/consultation/docs/2014/FuelMix.pdf.

3 "[T]he concession for first registered environment-friendly petrol private cars will increase from a 30% concession in FRT [First Registration Tax], subject to a cap of $50,000 per car, to a 45% concession in FRT, subject to a cap of $75,000 per car," http://www.td.gov.hk/en/public_services/frequently_asked_questions/vehicle_first_registration_special_arrangement/index.html.

4 http://www.scmp.com/news/hong-kong/health-environment/article/1935817/electric-shock-tesla-cars-hong-kong-more-polluting.

5 The projected bill impact reflects the expected cost increase for the two utilities under rate of return (ROR) regulation. In Hong Kong the regulatory regime enables the utilities to fully recover the allowed returns on investments made with the Hong Kong government's prior approval (Woo et al., 2015). As a result, the utilities have the profit incentive to achieve the government's decarbonization target.

6 Our focus on WTP for decarbonization preempts the need for estimating residential willingness to accept (WTA) for an increase in CO_2 emissions, thus bypassing the thorny issue of WTA/WTP disparity for non-market goods (Horowitz and McConnell, 2002).

7 The use of an in-person interview format does not necessarily remedy the strategic bias, as exemplified by the estimated WTP for a Hong Kong public utilities commission (Woo et al., 2015).

8 Nuclear energy presently meets approximately 23% of Hong Kong's total electricity consumption (MW h) (https://www.hknuclear.com/nuclear/why/hongkong/pages/whynuclearforhongkong.aspx). It is supplied by the 1800-MW Daya Bay Nuclear Power Plant at the Hong Kong – Mainland border. Additional imports may come from the Daya Bay plant or other plants in Guangdong (e.g., the 3500-MW Taishan Plant now under

10 http://www.statistics.gov.hk/pub/B11000022015AN15B0100.pdf.

11 http://www.fstb.gov.hk/tb/en/electricity-charges-subsidy-scheme.htm.

12 The Hong Kong government's history of budget surplus is available at http://www.gov.hk/en/about/abouthk/factsheets/docs/public_finance.pdf; and http://www.scmp.

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Table 1
Contingent valuation (CV) estimates of residential WTP for non-coal resources.

Study	Country	Resource type	CV data type	Number of valid survey respondents (interview method)	Reported estimate (data year)	WTP per household-year in local currency	WTP per household-year in 2015 US$
Carlsson and Johansson-Stenman (2000, Table 2)	Sweden	Air pollution reduction with unspecified non-coal resource	Self-stated WTP data	2120 (phone)	SEK 2000/capita-year for a 50% reduction of harmful substances (1996)	SEK 3980	577.66
Nomura and Akai (2004, p.461)	Japan	Renewable energy (solar and wind)	Choice data	370 (mail)	JPY 2000/household-month (2000)	JPY 24,000	200.07
Bergmann et al. (2006, Table 3)	Scotland	Unspecified renewable energy	Choice data	211 (mail)	GBP 1.178/household-month (2003)	GBP 14.13	28.60
Borchers et al. (2007, Table 4)	US	Renewable energy (wind, solar, farm methane, and biomass)	Choice data	128 (in person)	US$14.77/household-month in a 10% voluntary green energy programs (2000)	US$177.24	243.95
Longo, et al. (2008, Table 9)	UK	Unspecified renewable energy	Choice data	300 (in person)	GBP 29.65/household-year (2005)	GBP 29.65	58.03
Bollino (2009, Table 4)	Italy	Unspecified renewable energy	Choice data	1601 (online)	EUR 6.07–9.11/household-month (2006)	EUR 72.8–109.3	93.22–139.96
Damigos, et al. (2009, Table 7)	Greece	Natural gas	Self-stated WTP data	793 (phone)	EUR 7.6–9.7/household-month (2007)	EUR 91.2–116.4	112.61–143.72
Yoo and Kwak (2009, p.5414)	South Korea	Unspecified renewable energy	Choice data	800 (in person)	KRW 2072/household- month (2006)	KRW 24,864	27.42
Goto and Ariu (2010, p.3)	Japan	Nuclear/ renewable energy (solar)	Self-stated WTP data	3101 (mail)	JPY 0.4/kWh	JPY 2205.2	18.74
					JPY 1.6/kWh (2009)	JPY 8820.8	74.97
Jun, et al., (2010, p.1475)	South Korea	Nuclear power	Choice data	329 (in person)	KRW 548.14/household-month (2007)	KRW 6577.74	7.07
Liao, et al., (2010, p.7062)	Taiwan	Nuclear power	Choice data	1073 (phone)	NT$4828.39/adult-year (2009)	NT$9656.78	322.83
Mozumder, et al., (2011, p.1125)	US	Unspecified renewable energy	Self-stated WTP data	367 (online)	US$10/month for 10% increase of renewable energy	US$120–300	141.09–352.72
					US$ 25/month for 20% share of renewable energy (2006)		
Oliver, et al. (2011, Table 4)	South Africa	Unspecified renewable energy	Self-stated WTP data	380 (phone)	ZAR 101.31/household-month (2006)	ZAR 1215.72	164.65
Carlsson, et al. (2012, Table 4)	China, Sweden and US	CO_2 reduction with unspecified non-coal resources	Self-stated WTP data	China: 1264 (in-person);	CNY 34.09 in China	CNY 409.02	77.31
				Sweden: 1230 (online);	SEK 166.07 in Sweden	SEK 1992.80	247.09
				US: 999 (online)	US$17.27 in US (per household - month) for 30% decarbonizations (2009)	US$207.24	228.96
Zhang and Wu (2012, p.514)	China	Unspecified renewable energy	Choice data	1139 (email and mail)	CNY 7.91–10.30/household-month for green electricity (2010)	CNY 94.92–123.6	17.39–22.64
Zorić and Hrovatin (2012, Table 2)	Slovenia	Unspecified renewable energy	Self-stated WTP data	450 (in-person and online)	EUR 4.18/household-month (2008)	EUR 50.16	60.74
Gracia et al. (2012, Table 4)	Spain	Wind; Solar	Choice data	400 (in person)	Wind: EUR 1.24/household - month (2010);	Wind: EUR 14.88	17.59
					Solar: EUR 2.24/household - month (2010)	Solar: EUR 26.88	31.78
Kotchen et al. (2013, p.623)	US	Greenhouse gas reduction with unspecified resources	Self-stated WTP data	2034 (online))	US$79–89/household-year for domestic reductions in greenhouse gas emissions by 17% by 2020 (2010–2011)	US$79–89	83.24–93.78
Guo et al.	China	Unspecified	Choice	571 (in	CNY 18.5–22.5/household-	CNY	40.67–49.46

Table 1 (*Continued*)

Study	Country	Resource type	CV data type	Number of valid survey respondents (interview method)	Reported estimate (data year)	WTP per household-year in local currency	WTP per household-year in 2015 US$
Lee and Heo (2016, Table 5)	South Korea	Unspecified renewable energy	Choice data	1000 (in person)	KRW 3334–3458/household-month (2014)	KRW 40,008–41,496	37.20–38.52

Note: The last column's estimates are found by (1) converting the original estimates into values of 2015 prices using domestic CPI data from Bloomberg, and (2) converting the results into US$ using the 2015 exchange rates from the Federal Reserve Bank of St. Louis (https://research.stlouisfed.org/fred2/).

tion using the open-ended question format; and (b) discrete choice data via the closed-ended question format.[14]

Recent CV literature suggests that choice data are more reflective of a household's WTP than DE data for two reasons (Hoyos, 2010; Carson et al., 2014). First, when compared to the open-ended question format, the closed-end question format more closely resembles the market environment in which a household makes a purchase decision. Second, choice data are less susceptible to the strategic bias that likely exists in a household's response to an open-ended question.

The WTP estimates reported in Table 1 are diverse, ranging from US$7 to US$577 per household-year. They tend to be higher for the developed countries than the developing countries. The estimates based on choice data tend to exceed those based on DE data.

The Swedish estimates for a 50% CO_2 emissions reduction in Carlsson and Johansson-Stenman (2000, Table 2) are understandably higher than those for a 30% reduction in Carlsson et al. (2012, Table 4). The Japanese choice-based estimate in Nomura and Akai (2004, p.461) is an order of magnitude larger than the DE-based estimate in Goto and Ariu (2010, p.3), thus underscoring the large disparity in the two types of WTP estimates.

2.3. *Data description*

2.3.1. *Selection of fuel mix scenarios*

In order that our WTP estimates reasonably inform the policy debate about Hong Kong's clean electricity future our survey questions encompass the fuel mix scenarios proposed by the government. We include additional scenarios in order to provide the data variations necessary for identifying the empirical relationship between the residential WTP estimates and fuel mix. These scenarios are listed in Table 4. The design reflects a balance of considerations, including comprehensiveness, the need for data variations, and our survey budget (approximately US$18,000 or HK$140 K at the pegged exchange rate of US$1 ≈ HK$7.8).

2.3.2. *In-person vs. telephone interview*

We have relied upon telephone interviews for three reasons. First, in-person interviews are costly. Our limited budget would have implied a much smaller sample size, likely less than 20% of the paper's final sample size of 1460. A sample size of about 300 in-person interviews, even if achievable, would have limited our ability to meaningfully analyze the fuel mix scenarios considered by the government. Second, Hong Kong residents are often reluctant to participate in time-consuming in-person interviews. Third, our survey implementation had two pilot tests. The first used a focus group to collect CV data in an in-person interview format. The responses obtained were found to be comparable with those collected via phone interviews. The second pilot test improved the questionnaire's flow and clarity, thereby reducing the extent of hypothetical bias that may arise. It also allowed us to calibrate interview duration, so as to lessen the possible bias caused by respondent fatigue.

2.3.3. *Questionnaire design*

Our final questionnaire has four parts, requiring about 12 min to complete.[15] Part 1 contains a self-introduction by the interviewer and an explanation of the purpose of the survey, which was administered by the Hong Kong Baptist University's Centre for the Advancement of Social Sciences Research. The self-introduction assures the respondent of strict confidentiality of his/her information provided in the interview. It also informs the respondent that the survey administrator is an independent third party, thereby mitigating any strategic or protesting behavior by the respondent that might arise if the survey is conducted directly by the government or a local electric utility.[16]

Part 2 ascertains that the respondent is over 18 years old and is familiar with the household monthly electricity bill. This aims to reduce any inaccuracy in the CV data caused by the respondent's unfamiliarity with the electricity service.

Section A of Part 3 collects the respondent's electricity views, including service satisfaction, monthly bill, price reasonableness, knowledge of Hong Kong's total carbon emissions due to electricity generation, knowledge of the government's decarbonization target, attitudes towards global warming, and mitigation actions he/she thinks Hong Kong should take. The data on respondents' views and knowledge aid our regression analysis in isolating the hypothetical bias that may exist in CV data (Murphy et al., 2005).

Section B of Part 3 first asks whether the respondent is willing to pay higher electricity rates to reduce CO_2 emissions from Hong Kong's local generation. This helps to identify *status quo* bias that likely leads to low WTP estimates (Hartman et al., 1991; Kahneman et al., 1991).

It then poses three pairs of questions. Each pair corresponds to one of the seven fuel mix scenarios listed in Table 4, which states an emissions reduction target to be achieved by displacing coal generation with ***new*** resources that have a specific fuel mix $\boldsymbol{M}$ = (M_1 = natural gas share, M_2 = nuclear energy share, M_3 = 1 - M_1 - M_2 = renewable energy share).[17]

The pilot test results revealed that respondents had difficulties in understanding a complex fuel mix. To resolve this, each pair of questions focuses on two, rather than three resource types, for example, natural gas and nuclear energy, ***or*** natural gas and renewable energy.

Our focus on natural gas reflects the government's determination that natural gas has more public support than nuclear energy (HKSAR, 2015). Further, we use the CV questions to gauge residential WTP for renewable energy, to assess whether renewable energy development may be viable on a small scale

[14] One of the referees notes that Denmark has an electricity market similar to Hong Kong. Using discrete choice modeling, Yang and Solgaard (2015) and Yang et al. (2016) find that Danish consumers are willing to pay for CO_2 emissions reduction and increasing use of renewable energy.

[15] The Cantonese questionnaire and its English translation are available by email from the first author.

[16] For example, a respondent may strategically understate his/her self-stated WTP responses if he/she suspects that his/her answers may be used to justify a rate increase. Further, a respondent may submit protesting responses due to his/her negative sentiment towards the government or the utility.

[17] We have considered using a full factorial design to develop the possible scenarios formed by the fuel share values of M_1 = 0.5, 0.7, 0.8. 0.9, 1.0; M_2 = 0, 0.2, 0.3, 0.5; and $M_3 = 1 - M_1 - M_2$. The resulting number of 16 fuel mix scenarios for a given emissions reduction target, however, is too large for our budget-constrained survey implementation. Hence, we choose seven scenarios that bookend the government's proposed fuel mixes.

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(e.g., rooftop solar panels on village houses in rural areas).[18] For a given fuel mix, the first question collects the self-stated WTP data and the second the choice data. As a respondent answers the two questions sequentially, the first question preps the respondent for the second question.

The first pair of questions focuses on the use of natural gas as the main solution for decarbonization in Hong Kong:

(a) To achieve an A% (30% or 50%) emissions reduction,[19] how much would you be willing to pay, as a percent increase in your monthly electricity bill, if the coal generation displacement were solely achieved by natural gas generation (i.e., $M_1 = 100\%$)?
(b) Suppose the CO_2 emissions reduction requires a C% (15, 30 or 50) bill increase. Would you support the fuel mix change in (a)?
The second pair of questions considers the combined use of natural gas and nuclear energy:
(c) What would be your self-stated WTP if the A% emissions reduction were accomplished by $M_{1\%}$ natural gas and $(1 - M_1)$ % nuclear energy?
(d) Suppose the CO_2 emissions reduction requires a C% rate increase. Would you support the fuel mix change in (c)?
The third and final pair of questions involves the use of natural gas and renewable energy:
(e) What would be your self-stated WTP if the A% emissions reduction were accomplished by M_1% natural gas and $(1 - M_1)$ % renewable energy?
(f) Suppose the CO_2 emissions reduction requires a C% rate increase. Would you support the fuel mix change in (e)?

The studies cited in Table 1 suggest that residential WTP varies with household demographics. Hence, Part 4 collects the respondent's gender, age, education, income, family size, children and their ages, residence type (e.g., public vs. private housing, and rent vs. own), residence location (within one of Hong Kong's 18 districts), and years of living in Hong Kong.

Part 4 also collects data on a respondent's participation in the 2015 election to capture whether the respondent is politically active; voluntary charity work to capture if the respondent is altruistic; and air purifier ownership to capture the resident's concerns about Hong Kong air quality.

2.3.4. Demographics

Table 2 presents the descriptive statistics of the respondent demographics. Relative to Hong Kong's census data on age, gender, education, family size and income, our 1460 respondents have variable means that are mostly within 10% of the underlying population. We use a two-tailed t-test to determine that the difference between the sample and population means is statistically insignificant (p-value > 0.05) for gender and income, not so for age, education and family size. Given the size of our sample, such differences are not surprising. Furthermore, the inclusion of age, education and family size in our WTP modeling does not result in significant coefficients. Taken together, these findings suggest that our WTP estimates should be informative with respect to the population as a whole.

2.3.5. Views on electricity service

Table 3 presents summary statistics for respondent views collected through Part 3 of the questionnaire. The standard deviations indicate that the respondents have diverse views on (a) whether Hong Kong is a major contributor to global warming, and (b) whether Hong Kong should use more nuclear energy. On average, however, the respondents are satisfied with their electricity service. They agree that the global warming problem is important and that Hong Kong should pay more to reduce its carbon emissions. They do not support increased reliance on nuclear energy, nor do they support continued heavy reliance on coal generation. Finally, 69% of the respondents voted in the 2015 election, 50% do voluntary charity work and 20% own air purifiers.

2.3.6. Majority support for a given fuel mix scenario

Table 4 presents each scenario-specific sample mean and standard deviation of the discrete choice data collected via the closed-ended questions. If 0.5 exceeds the upper bound of the 95% confidence interval for a population proportion, a lack of majority support for a given scenario is said to exist. Non-nuclear fuel mix scenarios tend to have majority support, so long as the projected bill increase is below 50%. The same cannot be said for scenarios that involve additional nuclear imports from China. The raw data suggest household preferences that favor using natural gas and renewable energy.

A comparison of Panels A and B in Table 4 indicates that support for a given fuel mix scenario does not materially vary by decarbonization target. For example, in Panel A, with a decarbonization target of 30%, support for Fuel Mix Scenario 1 ranges from 28% to 63%, depending on bill impacts. The corresponding numbers in Panel B are 21–64%. This, in turn, suggests that respondents' primary focus is on fuel mix and the associated bill change, rather than on the magnitude of emissions reduction. In other words, respondents did not sharply differentiate the two emissions targets when answering the closed-ended questions.

2.3.7. Directly elicited WTP amounts

Table 5 reports scenario-specific means and standard deviations of directly elicited WTP as a percent of bill increase. The WTP amount (HK$) per month is the product of (a) a respondent's self-reported percent of bill increase in response to an open-ended question and (b) the respondent's monthly bill (HK$). When expressed in annual amounts (US$), these WTP amounts are close to the mid-point of the range reported in Table 1.

The amounts shown in Table 5 suggest that Hong Kong households are willing to pay more for a non-nuclear fuel mix than one that contains nuclear energy. A comparison of Panels A and B suggests that Hong Kong households' WTP does not vary substantially with the size of the CO_2 emissions reduction.

2.4. Estimation strategy

While Table 4 presages fuel mix preferences of Hong Kong households, a more refined analysis is required to identify the relationship of WTP to demographics and views on electricity. Here we present an estimation strategy to establish the empirical relationship between WTP and its underlying drivers.

2.4.1. Regression specification

In light of the relative merit of using closed-ended questions in a CV survey, our estimation strategy focuses on the DC data collected via Part 3 Section B of the questionnaire. As is standard in discrete choice modeling, we assume that a survey respondent has an underlying (unobserved) utility:

$$U = \alpha + \beta_1 M_1 + \beta_2 M_2 + \beta_3 M_3 + \beta_E E + \beta_B B + \sum_k \lambda_k X_k + \varepsilon, \quad (1)$$

which is a function of the fuel mix $\boldsymbol{M} = (M_1, M_2, M_3)$, emissions level E, bill level B and a vector $\boldsymbol{X} = (X_1, \ldots, X_K)$ of household attributes and stated preferences. Current emissions and monthly bills are normalized by setting E and B equal to 1.

Under the business-as-usual (BAU) scenario, none of the existing coal generation is being replaced. As a result, the natural gas, nuclear and renewable shares (i.e., the values of M_1, M_2, M_3) are equal to zero. As may be seen in Table 3, only 29% of respondents support the BAU scenario.

We use maximum likelihood to estimate logit and probit versions of Eq. (1).[20] We begin by including all demographics in Table 2 and electricity views in Table 3. We then follow a stepwise model selection procedure to determine

[18] Hong Kong is an 1100-km^2 international metropolis with the highest real estate prices in the world. There is simply insufficient land to develop on-shore solar and wind energy. Offshore wind energy is very costly because of the submarine transmission and associated facilities required to inter-connect remote wind farms located away from Hong Kong's busy

Table 2
Demographics of 1460 survey respondents, showing that (a) the sample means are mostly within 10% of the population means; and (b) the difference between the sample and population means based on a two-tail *t*-test is statistically insignificant (*p*-value ≤ 0.05) for gender and income, not so for age, education and family size.

Demographic variable	Descriptive statistics for the sample				Population mean	Sample mean ÷ Population mean	Sample mean - Population mean
	Mean	Minimum	Maximum	Standard deviation			
Gender = 1 if male, 0 otherwise	0.47	0	1	0.5	0.46	1.02	0.01
Age (years)	52.5	22	70	14.0	48.2	1.09	4.3
Education (years)	13.1	6	17	3.7	11.9	1.10	1.2
Family size	3.3	1	5	1.2	2.9	1.14	0.4
Monthly family income (HK$000)	29.8	0	> 65	20.8	28.8	1.03	1.0
Monthly electricity bill (HK$)	621.4	0	3500	464.2	n.a.	n.a.	n.a.
Years of living in Hong Kong	45.7	1	89	15.5	n.a.	n.a.	n.a.

Note: The population means are based on the 2015 Hong Kong Annual Digest of Statistics (www.statistics.gov.hk/pub/B10100032015AN15B0100.pdf).

Table 3
Respondents' views based on Part 3 of the survey questionnaire.

View	Mean	Standard deviation
(1) Service satisfaction (1 = very unsatisfied, … 5 = very satisfied)	3.77	0.87
(2) Electricity service is price reasonable? (= 1 if yes, 0 otherwise)	0.43	0.50
(3) Global warming is an important problem for the world (1 = strongly disagree, … 5 = strongly agree)	4.41	0.93
(4) Hong Kong is a major contributor to global warming (1 = strongly disagree, … 5 = strongly agree)	2.70	1.16
(5) Hong Kong should solve its own emissions problem (1 = strongly disagree, … 5 = strongly agree)	4.05	1.05
(6) Hong Kong should reduce the use of coal in its local electricity generation (1 = strongly disagree, … 5 = strongly agree)	3.90	1.00
(7) Hong Kong should pay more for cleaner electricity to protect the environment (1 = strongly disagree, … 5 = strongly agree)	4.11	0.96
(8) Hong Kong should use more natural gas in its local electricity generation (1 = strongly disagree, … 5 = strongly agree)	4.07	0.97
(9) Hong Kong should use more nuclear energy (1 = strongly disagree, … 5 = strongly agree)	2.18	1.22
(10) Hong Kong should use more renewable energy (1 = strongly disagree, … 5 = strongly agree)	4.34	0.92
(11) Do you know that Hong Kong aims to reduce by 2020 its greenhouse gas emissions by 30% of the 2005 level? (= 1 if yes, 0 otherwise)	0.20	0.40
(12) Do you support Hong Kong's current fuel mix that is dominated by coal? (= 1 if yes, 0 otherwise)	0.29	0.45
(13) Are you willing to pay more to reduce the use of coal in its local electricity generation? (= 1 if yes, 0 otherwise)	0.71	0.45
(14) Did you vote in the last 2015 District Board election? (= 1 if yes, 0 otherwise)	0.69	0.46
(15) Do you volunteer for charitable work? (= 1 if yes, 0 otherwise)	0.50	0.50
(16) Do you use an air purifier at home? (= 1 if yes, 0 otherwise)	0.20	0.40

which variables should remain in the specification. As the DC data are in the form of a panel, we use heteroskedasticity consistent clustered standard errors to gauge the precision of the variables' coefficient estimates (Wooldridge, 2010).

2.4.2. WTP estimation

Eq. (1) may now be used to estimate the WTP for various decarbonization scenarios. First define V_0 = expected utility level for

$= M_2 = M_3 = 0, E = B = 1,$

$$V_0 = \alpha + \beta_E + \beta_B + \sum_k \lambda_k X_k. \tag{2.a}$$

Next define V_1 = expected utility level for one of the seven fuel mix scenarios in Table 4. In each case, the level of emissions $E < 1$ and there is a positive bill impact so that $B > 1$:

$$V_1 = \alpha + \beta_1 M_1 + \beta_2 M_2 + \beta_3 M_3 + \beta_E E + \beta_B B + \sum_k \lambda_k X_k. \tag{2.b}$$

The change in expected utility is:

$$\Delta V = V_1 - V_0 = \beta_1 M_1 + \beta_2 M_2 + \beta_3 M_3 + \beta_E(E-1) + \beta_B(B-1). \tag{3.a}$$

Setting $\Delta V = 0$ and solving for the corresponding bill impact that leaves the respondent indifferent between business as usual and the given decarbonization scenario, one obtains a measure of willingness to pay:

$$WTP = -[\beta_1 M_1 + \beta_2 M_2 + \beta_3 M_3 + \beta_E(E-1)]/\beta_B. \tag{3.b}$$

Note that if $\beta_j > 0$ (for $j = 1, 2, 3$), $\beta_E < 0$ and $\beta_B < 0$, the resulting WTP > 0.

Using lower case Roman letters to denote the coefficient estimates, our estimated WTP is given by:

$$-[b_1 M_1 + b_2 M_2 + b_3 M_3 + b_E(E-1)]/b_B. \tag{4}$$

Standard errors and confidence intervals for our estimated WTP may be constructed using the delta method.

3. Results

Table 6 summarizes our statistical estimates of the discrete choice model. Non-carbon generation sources are all strongly significant. The β_1 and β_3 estimates corresponding to natural gas and renewables, however, are more than twice as large as the β_2 estimate for nuclear coefficient, indicating a strong preference for the first two over nuclear power. As the probit regression results convey the same story, their discussion is omitted for brevity.

The β_E estimate corresponding to emissions levels is positive and not significant, a subject that we return to below.

The β_B estimate for the effect of bill levels on utility is negative and strongly significant, reflecting a household's negative marginal utility of electricity bill. The precision of this coefficient is important to the calculation and accuracy of our estimated willingness to pay based on Eq. (4).

Household responses to questions about the reasonableness of electricity prices, willingness to pay more for reducing coal generation and … desire … to … in

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Table 4
Sample mean and standard deviation (SD) of the 1460 respondents' "1 = yes" responses based on the discrete choices collected via the closed-ended questions.

Fuel mix scenario	Natural gas share	Nuclear energy share	Renewable energy share	Bill increase	Number of observations	Mean	SD	Majority support?
Panel A. De-carbonization target = 30%								
1	100%	0%	0%	15%	233	0.63	0.48	yes
				30%	245	0.44	0.50	yes
				50%	246	0.28	0.45	no
2	80%	20%	0%	15%	120	0.55	0.50	yes
				30%	122	0.39	0.49	no
				50%	120	0.19	0.40	no
3	50%	50%	0%	15%	113	0.50	0.50	yes
				30%	123	0.28	0.45	no
				50%	126	0.14	0.35	no
4	90%	0%	10%	15%	109	0.75	0.43	yes
				30%	124	0.53	0.50	yes
				50%	118	0.35	0.48	no
5	70%	0%	30%	15%	124	0.56	0.50	yes
				30%	121	0.49	0.50	yes
				50%	128	0.27	0.45	no
Panel B. De-carbonization target = 50%								
1	100%	0%	0%	15%	245	0.64	0.48	yes
				30%	244	0.48	0.50	yes
				50%	247	0.21	0.41	no
6	70%	30%	0%	15%	122	0.52	0.50	yes
				30%	122	0.40	0.49	no
				50%	122	0.11	0.31	no
3	50%	50%	0%	15%	123	0.41	0.49	yes
				30%	122	0.33	0.47	no
				50%	125	0.18	0.39	no
5	70%	0%	30%	15%	121	0.68	0.47	yes
				30%	127	0.53	0.50	yes
				50%	113	0.27	0.45	no
7	50%	0%	50%	15%	124	0.65	0.48	yes
				30%	117	0.50	0.50	yes
				50%	134	0.25	0.44	no

Note: We oversample the 100% natural gas scenario, which is most likely to occur because of Hong Kong's limited availability of renewable resources and public sentiment against nuclear energy. The answer for "majority support?" is "no" if 0.5 ***exceeds*** the upper bound of the 95% confidence interval = sample mean + 1.965* $[SD^2/(N - 1)]^{1/2}$, where N = number of observations in each pair of fuel mix scenario and bill increase. Otherwise, the answer is "yes".

Table 5
Mean and standard deviation (SD) of the 1460 respondents' directly elicited WTP amounts.

Scenario	Natural gas share	Nuclear energy share	Renewable energy share	Number of observations	Percent of bill increase		Monthly amount (HK$)		Annual amount (US$)	
					Mean	SD	Mean	SD	Mean	SD
Panel A: Panel A. De-carbonization target = 30%										
1	100%	0%	0%	724	0.16	0.16	92.60	130.84	142.46	201.29
2	80%	20%	0%	362	0.14	0.15	80.20	127.59	123.39	196.29
3	50%	50%	0%	362	0.12	0.14	63.57	91.25	97.80	140.38
4	90%	0%	10%	351	0.19	0.18	112.32	132.93	172.79	204.51
5	70%	0%	30%	373	0.19	0.23	111.00	153.39	170.77	235.99
Panel B: Panel A. De-carbonization target = 50%										
1	100%	0%	0%	736	0.15	0.14	95.01	132.25	146.17	203.46
3	50%	50%	0%	370	0.12	0.13	77.91	133.03	119.87	204.66
5	70%	0%	30%	361	0.20	0.17	125.11	154.13	192.48	237.12
6	70%	30%	0%	366	0.13	0.13	75.03	105.42	115.44	162.18
7	50%	0%	50%	375	0.19	0.17	118.45	145.15	182.24	223.31

Note: Each respondent's monthly amount (HK$) is the respondent's self-stated WTP (percent of bill increase) × monthly bill. The annual amount (US$) is the monthly amount × 12 months and evaluated at the pegged exchange rate of US$1 = HK$7.8.

crease natural gas generation (as captured by the λ_1, λ_2 and λ_3 estimates), all have statistically significant effects.

We now turn our attention to the average WTP estimates reported in Table 7. These estimates indicate that the logit and probit estimates are positive and statistically significant (p-value < 0.05) and have virtually identical sizes. For the non-nuclear fuel mix scenarios, the WTP estimates vary over a tight range between 48% and 51% of electricity bills. The scenarios with nuclear energy have WTP estimates of 32–42%.

Table 8 contains the annual WTP estimates in $US per year. These DC-based estimates are all positive and statistically significant (p-value < 0.05). They are about thrice the DE-based estimates reported in Table 5. We attribute the large disparity between the DE- and DC-based estimates to the strategic bias known to exist in the directly elicited WTP data.

Table 6
Binary choice regression results based on Eq. (1).

Variable with its coefficient in [ ]	Logit	Probit
Pseudo R^2	0.1129	0.1121
Natural gas share [β_1]	2.4668***	1.4831***
	(0.2407)	(0.1455)
Nuclear energy share [β_2]	0.9155***	0.5537***
	(0.2673)	(0.1624)
Renewable energy share [β_3]	2.7259***	1.6413***
	(0.2851)	(0.1720)
Emissions level [β_E]	0.4596	0.2712
	(0.4900)	(0.2982)
Bill level [β_B]	−4.8338***	−2.9589***
	(0.3492)	(0.2096)
Binary indicator for answering "yes" to question (2) in Table 3 on the price reasonableness of electricity [λ_1]	0.5494***	0.3339***
	(0.0787)	(0.0474)
Binary indicator for answering "yes" to question (13) in Table 3 on the willingness to pay more for reducing Hong Kong's use of coal in electricity generation [λ_2]	0.7736***	0.4485***
	(0.0947)	(0.0544)
Respondent's view on statement (8) that Hong Kong should use more natural gas in its local electricity generation (1 = strongly disagree, … 5 = strongly agree) [λ_3]	0.1521***	0.0877***
	(0.0461)	(0.0268)
Constant [α]	2.0009***	1.2987***
	(0.6385)	(0.3854)

Note: Number of observations = 5840 (= 1460 respondents × (3 closed-ended questions per respondent + 1 status quo situation); clustered-robust standard errors in ( ); ** = "p-value < 0.05", * = "p-value < 0.10".
*** p-value < 0.01.

4. Discussion

Our WTP estimation results inform two substantive questions of academic and policy interest. The first is whether our DC-based estimates are empirically plausible. Our estimates are at the top end of the range in Table 1, even among countries with high per capita incomes. To assess the robustness of our results, we estimated a parsimonious discrete choice model of household support for various fuel scenarios. On the right-hand side, we included only the emissions and billings level variables, E and B. In this case, the coefficients were negative, strongly significant and comparable in magnitude. The resulting willingness to pay was about 50% for a 50% reduction in emissions.

This simplified model serves two important purposes. First, it provides a robustness check on our richer model. Second, it suggests that the insignificance of the emissions variable in the full model (Table 6) most likely results from the difficulty in identifying the emissions effect separately from the effects on utility of alternative decarbonization scenarios. The full model, however, is of central focus here because it allows us to tease out customer preferences over natural gas, nuclear and renewable options, which are central to policy decision-making. The parsimonious model tells us that emissions level reductions are strongly supported; the full model tells us how to achieve these reductions.

We offer three reasons why our estimated willingness to pay is high. First, the 'volunteer' rate in the sample was 50% (Table 3, line 15), suggesting a high degree of public spiritedness and concern for broader societal issues.[21] Second, about 20% of the sampled households use an air purifier at home (Table 3, line 16), suggesting a concern about air quality, which is adversely affected by coal generation. Third, over time, awareness and concerns about climate change have been increasing. Given that this analysis is conducted on 2016 data, it is not surprising that our WTP estimates are higher than those found by preceding analyses.[22]

The second question is whether a proposed fuel mix change would have a disproportionally adverse impact on low-income households. Our tentative answer is "no" for two reasons. First, the inclusion of income as an explanatory variable in our discrete choice models does not result in a statistically significant coefficient, suggesting that even lower-income households support decarbonization programs at rates comparable to higher-income households. Second, Table 9 shows that the dollar amounts that Hong Kong households are willing to pay are a small percentage of their average income levels.

5. Conclusion and policy implications

The Hong Kong government has proposed deep decarbonization targets, and a shift to natural gas and renewable energy to displace the coal consumed by Hong Kong's local generation. Implementation has begun, as evidenced by construction of new combined-cycle gas turbines and long-term procurement of natural gas at the two local electric utilities. There is also continued exploration of developing solar and wind generation in Hong Kong. The statistical analysis of our survey indicates broad support of these initiatives by households. Furthermore, income levels do not appear to have a strong influence on this support.

Thanks to an insightful reviewer's comment, we would be remiss had we ignored the important issue of cost responsibility. This issue arises because Hong Kong households ultimately bear the full cost of the city's deep decarbonization efforts, directly through their electricity bill increases or indirectly through their payments for goods and services produced by electricity-consuming firms. As climate change is a global problem, one may argue that countries not pursuing deep decarbonization should help defray decarbonization costs of countries that are pursuing aggressive (and costly) targets. This argument is, however, tempered by the following considerations.

First, the international commitments of deep decarbonization made in the 2015 Paris summit suggest that many countries are making sincere efforts to reduce their CO_2 emissions. The recently elected Trump Administration's reversals of decarbonization policies have met strong criticism within the U.S. and from abroad. China, the largest emitter of CO_2, has in its latest five-year plan included aggressive measures to reduce emissions as part of its anti-pollution policy.

Second, without an international cap-and-trade program, there is no readily available mechanism to compel one country to help pay for the decarbonization cost of another country. While such a program would improve the economic efficiency of managing CO_2 emissions, its implementation is unlikely to occur any time soon.

To conclude, Hong Kong households appear to be willing to do their part in combating global warming in this highly uncertain environment.

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21 Hong Kong has also made large contributions to disaster aid for example to victims of China's 2008 earthquake and Japan's 2011 nuclear disaster (Weng et al., 2015).

22 There is a plausible explanation for the difference between our DC-based estimates and those reported by Woo et al. (2014a). After the government's first public consultation and the extensive news coverage of the 2015 Paris summit on climate change, Hong Kong households may have gained a better appreciation of the global warming problem. Further, our survey questionnaire contains open-ended questions which are designed to focus the respondent in preparation for the critical closed-ended questions. The same cannot be said about the survey questionnaire used by Woo et al. (2014a).

Table 7
WTP estimates in percent bill increase for the 30% de-carbonization target and their 95% confidence intervals.

Fuel mix scenario				Logit based on Eq. (3.b)			Probit based on Eq. (3.b)		
ID	Natural gas share	Nuclear share	Renewable share	Estimate	Lower bound	Upper bound	Estimate	Lower bound	Upper bound
1	100%	0%	0%	48%	44%	53%	47%	43%	52%
2	80%	20%	0%	42%	38%	46%	41%	37%	45%
3	50%	50%	0%	32%	28%	36%	32%	27%	36%
4	90%	0%	10%	49%	44%	53%	48%	43%	52%
5	70%	0%	30%	50%	45%	55%	49%	44%	54%
6	70%	30%	0%	39%	34%	43%	38%	34%	42%
7	50%	0%	50%	51%	45%	56%	50%	45%	55%

Table 8
Average of the 1460 respondent-specific WTP estimates in US$ per year for the 30% emission reduction target and the average WTP's 95% confidence interval.

Fuel mix scenario				Logit based on Eq. (3.b)			Probit based on Eq. (3.b)		
ID	Natural gas share	Nuclear share	Renewable share	Average	Lower bound	Upper bound	Average	Lower bound	Upper bound
1	100%	0%	0%	460.58	416.03	505.13	452.88	410.18	495.57
2	80%	20%	0%	399.22	359.36	439.08	392.83	354.60	431.05
3	50%	50%	0%	307.19	265.74	348.64	302.75	262.48	343.02
4	90%	0%	10%	465.70	421.10	510.31	457.99	415.29	500.69
5	70%	0%	30%	475.95	429.08	522.83	468.22	423.28	513.15
6	70%	30%	0%	368.54	329.36	407.73	362.80	325.10	400.50
7	50%	0%	50%	486.20	434.55	537.85	478.44	428.67	528.21

Table 9
Average WTP based on the binary logit regression results in US$ per year by annual income category.

Fuel mix scenario				Annual household income category					
ID	Natural gas share	Nuclear share	Renewable share	Under US$38.5 K (HK$300 K); average = US$21.4 K		US$38.5 (HK$300 K) to US$70 K (HK$540 K); average = US$59.8 K		Over US$70 K (HK$540 K); average = US$95.6 K	
				WTP	WTP ÷ Income	WTP	WTP ÷ Income	WTP	WTP ÷ Income
1	100%	0%	0%	392.31	1.84%	500.11	0.84%	599.28	0.63%
2	80%	20%	0%	340.05	1.59%	433.49	0.72%	519.45	0.54%
3	50%	50%	0%	261.66	1.23%	333.56	0.56%	399.70	0.42%
4	90%	0%	10%	396.68	1.86%	505.68	0.85%	605.95	0.63%
5	70%	0%	30%	405.41	1.90%	516.81	0.86%	619.29	0.65%
6	70%	30%	0%	313.92	1.47%	400.18	0.67%	479.53	0.50%
7	50%	0%	50%	414.14	1.94%	527.94	0.88%	632.62	0.66%

Note: The logit- and probit-based WTP estimates are virtually identical, see Table 8.

References

Bateman, I.J., Willis, K.G., 2001. Valuing Environmental Preferences: Theory and Practice of the Contingent Valuation Method in the US, EU, and Developing Countries. Oxford University Press, Oxford.

Bergmann, A., Hanley, N., Wright, R., 2006. Valuing the attributes of renewable energy investments. Energy Policy 34, 1004–1014.

Bollino, C.A., 2009. The willingness to pay for renewable energy sources: the case of Italy with socio-demographic determinants. Energy J. 30 (2), 81–96.

Borchers, A.M., Duke, J.M., Parsons, G.R., 2007. Does willingness to pay for green energy differ by source?. Energy Policy 35, 3327–3334.

Carlsson, F., Johansson-Stenman, O., 2000. Willingness to pay for improved air quality in Sweden. Appl. Econ. 32, 661–669.

Carlsson, F., Kataria, M., Krupnick, A., Lampi, E., Löfgren, , Qin, P., Chung, S., Sterner, T., 2012. Paying for mitigation: a multiple country study. Land Econ. 88, 326–340.

Carson, R., Czajkowski, M., Hess, S., Daly, A., 2014. The Discrete Choice Experiment Approach to Environmental Contingent Valuation. Edward Elgar, Cheltenham Glos.

Carson, R.T., Hanemann, W.M., 2005. Contingent valuation. In: Handbook of Environmental Economics, vol. 2, pp. 821–936.

Champ, P.A., Boyle, K.J., Brown, T.C., 2003. Primer on Nonmarket Valuation. Kluwer, Boston.

Damigos, D., Tourkolias, C., Diakoulaki, D., 2009. Households' willingness to pay for safeguarding security of natural gas supply in electricity generation. Energy Policy 37, 2008–2017.

Goto, H., Ariu, T., 2010. Willingness to Pay For Renewable Energy And Nuclear Power And Their Determinants Factors. Available at: ⟨http://www.infraday.tu-berlin.de/fileadmin/fg280/veranstaltungen/infraday/conference_2010/papers_presentations/paper---goto_ariu.pdf⟩.

Gracia, A., Barreiro-Hurlé, J., Pérez, L.P., 2012. Can renewable energy be financed with higher electricity prices? Evidence from a Spanish region. Energy Policy 50, 784–794.

Guo, X., Liu, H., Mao, X., Jin, J., Chen, D., Cheng, S., 2014. Willingness to pay for renewable electricity: a contingent valuation study in Beijing, China. Energy Policy 68, 340–347.

Hartman, R.S., Doane, M.J., Woo, C.K., 1991. Consumer rationality and the status quo. Q. J. Econ. 106 (1), 141–162.

HKSAR, 2014. Planning Ahead for a Better Fuel Mix. Hong Kong Special Administrative Region. Available at: ⟨http://www.enb.gov.hk/sites/default/files/en/node2605/Consultation%20Document.pdf⟩.

HKSAR, 2015. Public Consultation on the Future Development of the Electricity Market. Hong Kong Special Administrative Region. Available at: ⟨http://www.enb.gov.hk/sites/default/files/en/node3428/EMR_condoc_e.pdf⟩.

Horowitz, J.K., McConnell, K.E., 2002. A review of WTA/WTP studies. J. Environ. Econ. Manag. 44 (3), 426–447.

Hoyos, D., 2010. The state of the art of environmental valuation with discrete choice experiments. Ecol. Econ. 69, 1595–1603.

Jun, E., Kim, J.W., Jeong, H.Y., Chang, H.S., 2010. Measuring the social value of nuclear energy using contingent valuation methodology. Energy Policy 38, 1470–1476.

Kahneman, D., Knetsch, J.L., Thaler, R.H., 1991. Anomalies: the endowment effect, loss aversion, and status quo bias. J. Econ. Perspect. 5 (1), 193–206.

Kotchen, M.J., Boyle, K.J., Leiserowitz, A.A., 2013. Willingness-to-pay and policy-instrument choice for climate-change policy in the United States. Energy Policy 55, 617–625.

Laffont, J.J., 1988. Fundamentals of Public Economics. MIT Press, Cambridge.

Lee, C.Y., Heo, H., 2016. Estimating willingness to pay for renewable energy in South Korea using the contingent valuation method. Energy Policy 94, 150–156.

Liao, S.Y., Tseng, W.C., Chen, C.C., 2010. Eliciting public preference for nuclear energy against the backdrop of global warming. Energy Policy 38, 7054–7069.

Longo, A., Markandya, A., Petrucci, M., 2008. The internalization of externalities in the production of electricity: willingness to pay for the attributes of a policy for renewable energy. Ecol. Econ. 67, 140–152.

Mitchell, R.C., Carson, R.T., 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Resource for the Future, Washington DC.

Mozumder, P., Vásquez, W.F., Marathe, A., 2011. Consumers' preference for renewable energy in the southwest USA. Energy Econ. 33, 1119–1126.

Murphy, J.J., Allen, P.G., Stevens, T.H., Weatherhead, D., 2005. A meta-analysis of hypothetical bias in stated preference valuation. Environ. Resour. Econ. 30 (3), 313–325.

Nomura, N., Akai, M., 2004. Willingness to pay for green electricity in Japan as estimated through contingent valuation method. Appl. Energy 78, 453–463.

Oliver, H., Volschenk, J., Smit, E., 2011. Residential consumers in the Cape Peninsula's willingness to pay for premium priced green electricity. Energy Policy 39, 544–550.

Stigka, E.K., Paravantis, J.A., Mihalakakou, G.K., 2014. Social acceptance of renewable energy sources: a review of contingent valuation applications. Renew. Sustain. Energy Rev. 32, 100–106.

Weng, W.W., Woo, C.K., Cheng, Y.S., Ho, T., Horowitz, I., 2015. Public trust and corruption perception: disaster relief. Appl. Econ. 47 (46), 4967–4981.

Williams, J.H., De Benedictis, A., Ghanadan, R., Mahone, A., Moore, J., Morrow, W.R., Price, S., Torn, M.S., 2012. The technology path to deep greenhouse gas emissions cuts by 2050: the pivotal role of electricity. Science 335, 53–59.

Woo, C.K., Shiu, A., Cheng, Y.S., Li, R., Ho, T., Horowitz, I., Wang, J., 2014. Residential willingness-to-pay for reducing coal-fired generation's emissions in Hong Kong. Electr. J. 27 (3), 50–66.

Woo, C.K., Ho, T., Shiu, A., Cheng, Y.S., Horowitz, I., Wang, J., 2014. Residential outage cost estimation: Hong Kong. Energy Policy 72, 204–210.

Woo, C.K., Cheng, Y.S., Law, A., Zarnikau, J., Ho, S.T., Leung, H.Y., 2015. Consumer support for a public utilities commission in Hong Kong. Energy Policy 76, 87–97.

Wooldridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data. MIT Press, Cambridge.

Yang, Y., Solgaard, H.S., 2015. Exploring residential energy consumers' willingness to accept and pay to offset their CO_2 emission. Int. J. Energy Sect. Manag. 9 (4), 643–662.

Yang, Y., Solgaard, H.S., Haider, W., 2016. Wind, hydro or mixed renewable energy source: preference for electricity products when the share of renewable energy increases. Energy Policy 97, 521–531.

Yoo, S.H., Kwak, S.Y., 2009. Willingness to pay for green electricity in Korea: a contingent valuation study. Energy Policy 37, 5408–5416.

Zhang, L., Wu, Y., 2012. Market segmentation and willingness to pay for green electricity among urban residents in China: the case of Jiangsu Province. Energy Policy 51, 514–523.

Zorić, J., Hrovatin, N., 2012. Household willingness to pay for green electricity in Slovenia. Energy Policy 47, 180–187.