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A preference for power: Willingness to pay for energy reliability versus fuel type in Vietnam

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ABSTRACT

Developing countries are projected to experience the greatest increases in per capita energy use, motivating enormous investment in government-led energy projects. As energy fuel choices have large implications for pollution, a critical question surrounds citizens' preferences for renewable energy versus coal. While a robust literature suggests that citizens are willing to pay for renewables, the applicability of these findings to developing countries remains limited as many studies do not benchmark findings against preferences for increased capacity with dirtier fuels. We estimate citizens' willingness to pay for improved electricity reliability from coal versus renewable technologies using a contingent valuation experiment embedded in a nationally-representative survey of 14,000 respondents across Vietnam, the country with the greatest recent increase in coal consumption. We find that while households are willing to pay 95% more in their monthly electricity bill for renewables (USD 7.5 billion per year in aggregate), they are also willing to pay 62% more for coal plants (USD 4 billion per year). Additionally, income and satisfaction with governance drive support both for renewables and coal, suggesting that agenda setting by policymakers is critical. If citizens are not offered alternatives, a majority will support coal even as governance improves or citizens become wealthier.

1. Introduction

Over the next decades, developing countries, particularly those in Asia, are projected to account for almost all increases in global energy demand and associated expansion in fossil fuel consumption (Wolfram et al., 2012; IEA, 2017). This energy demand is spurring an estimated $2 trillion per year global investment in new power generation infrastructure, 70% of which is driven by government-led initiatives (IEA, 2018). While much attention is focused on the energy transition to renewable technologies, especially from a theoretical perspective (Acemoglu et al., 2012; Acemoglu et al., 2016), and the declines in coal usage in North America and Europe, developing countries continue to construct new coal plants. Thus, representing 38% of total global generation (IEA, 2019), coal remains a critical component of the global energy mix. Given implications for the environment, human health, and the economy, the fuels governments choose to use will have profound impacts on the quality of life for local citizens and the world for years to come.

Public support and willingness to pay for energy production remains a key ingredient for successful energy policy, even in non-democratic regimes such as China and Vietnam. While coal has been "falling out of favor" (Editorial, 2019) as shown by protests of new plant construction,[1,2] and wide-scale public support for renewables in both developed (Ma et al., 2015; Sundt and Rehdanz, 2015) and developing countries (Xie and Zhao, 2018; Zhao et al., 2018), access to dependable electricity may be just as important as the fuel choice in developing countries where energy reliability is a concern. Literature has highlighted contexts where citizens may prioritize economic development, even at the near-term expense of health or the environment (Dasgupta et al., 2002; Dinda, 2004). Failure among researchers to account for preferences for improved electrical reliability when examining willingness to pay for renewables could lead to a conflation of the two in a developing country context, where new power plants are often built to expand, rather than replace, existing resources. Put more simply: in developing contexts, citizens might be willing to pay for renewables *or* coal if it improves

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[1] Hoang Phuong. "Long An quyết nói 'không' với nhà máy điện than." *Tuoi Tre Online*. September 29, 2018. https://thanhnien.vn/thoi-su/long-an-quyet-noi-khong-voi-nha-may-nhiet-dien-than-1008430.html. Last accessed June 12, 2019.

[2] *Radio Free Asia*. "Rare Pollution Protest Creates Long Traffic Jam in Vietnam." April 15, 2015; Somini Sengupta. "The World Needs to Quit Coal: Why is it So Hard?" *The New York Times*. November 24, 2018.

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energy reliability. Thus, disentangling how citizens in developing countries value fuel type, reductions in electricity intermittency, and local and global pollution reductions is crucial to identify real levels of public support for different energy choices.

Vietnam is a particularly important setting for these questions as electricity demand among its 95 million citizens has risen by as much as 10% a year during the last decade and is projected to double every nine years through 2035 (U.S. Embassy in Hanoi, 2019; Danish Energy Agency, 2017). To meet the demand, coal consumption grew 75 percent from 2012 to 2017 despite large health effects from pollution (Koplitz et al., 2017), representing the fastest rate of increase in the world over that period (Dapice, 2017). Therefore, understanding how Vietnamese citizens assess the construction of renewable versus coal plants should lead to insights as to the challenges and potential solutions to encouraging similar countries to choose more renewable options.

In this paper, we estimate public support and willingness to pay for improved power reliability from coal versus cleaner technologies using a choice experiment embedded in a nationally-representative survey of more than 14,000 citizens from across Vietnam. We also examine heterogeneous effects of support for renewable plants, particularly based on trust in government, income levels, and education, as these are all factors that could improve over time in developing countries and thus possibly lead to greater support for renewable energy. Finally, using our estimates from a dichotomous choice contingent valuation question, we estimate the aggregate amount Vietnamese citizens would be willing to pay for public investment in renewables.

Our main finding is that citizens strongly desire better power reliability and cleaner technologies, and are willing to pay an average of 91% more in their monthly electricity bill (~$20 USD/month per household) to reduce electricity intermittency through renewable power plants. At the same time, citizens are willing to pay significant amounts for increased power capacity through coal plants, averaging 62% increases in their electricity bills (~$13 USD/month per household), thus highlighting the strong demand for a more reliable grid. Promises of reductions in local, but not global, pollution increase willingness to pay by an average of 25%. This leads to the main implication of our study, which is that developing countries like Vietnam are likely to find strong majorities in favor of renewables *or* coal when each is presented in a vacuum. However, if the regime pushes for renewables, they could generate support for an increased $4 billion in revenue to be invested in renewables.

Our findings also highlight important variation across individuals. Those with higher income and satisfaction with governance are more likely to pay more for renewables and also coal. Only education and knowledge of environmental issues drives willingness to pay for renewables but lowers willingness to pay for coal. Gender also plays a role, with no difference in willingness to pay for coal but men more willing to pay for renewables. This suggests that agenda setting by policymakers is critical (Cox and McCubbins, 2005). If citizens are not offered renewable alternatives, a majority will support coal for better electricity reliability even as development occurs. These findings also suggest a role for international assistance in energy transitions in developing country contexts like Vietnam, as these countries are not likely to face strong sustained domestic opposition to the construction of coal plants except possibly in areas where the plants are constructed.

We contribute to existing literature by estimating preferences for renewable energy and associated environmental attributes in tandem with preferences for dirtier technology and electricity reliability using a large nationally representative sample in a key developing country. As we separately estimate willingness to pay for each component, we are able to have a clear baseline comparison and control for key factors that could potentially confound the valuation analysis. In addition, we estimate key demand shifters for both clean and dirty energy technology, with important implications for the impact of development on pollution levels, that informs several traditions including the Environmental Kuznets Curve hypothesis, public support theory, and agenda setting literature. Lastly, given the insights from these results, we provide key policy implications for the development of cleaner fuels.

2. Are developing country residents willing to pay for renewables?

Dozens of willingness to pay (WTP) surveys have been conducted across a wide range of settings and find a multitude of factors that influence WTP for renewables including income (Ek, 2005; Batley et al., 2001; Komarek et al., 2011; Zhang and Wu, 2012), social status (Batley et al., 2001), education (Sundt and Rehdanz, 2015; Bollino, 2009; Zhang and Wu, 2012), age (Ek, 2005; Hanemann et al., 2011; Kosenius and Ollikainen, 2013; Kotchen et al., 2013), gender (Sundt and Rehdanz, 2015; Bollino, 2009; Kosenius and Ollikainen, 2013), perceived willingness to pay amongst fellow citizens (Wiser, 2007), the frequency of the payments (Solino et al., 2009), political party (Aldy et al., 2012), race (Aldy et al., 2012), views on environmentalism (Sundt and Rehdanz, 2015; Kosenius and Ollikainen, 2013; Ivanova, 2012; Zhao et al., 2018; Kotchen et al., 2013), household size (Zografakis et al., 2010), the type of renewable (Borchers et al., 2007; Cicia et al., 2012; Gracia, Barreiro-Hurle, & Perez y Perez, 2012), and whether or not the survey was conducted face-to-face (Ma et al., 2015).

While most have been conducted in the developed world, such as the US (Komarek et al., 2011; Susaeta et al., 2011; Kotchen et al., 2013; Aldy et al., 2012), Western Europe (Bollino, 2009; Bigerna and Polinori, 2014; Hanemann et al., 2011; Kosenius and Ollikainen, 2013; Zografakis et al., 2010), South Korea (Kim et al., 2013; Yoo and Kwak, 2009), and Japan (Nomura and Akai, 2004), an increasing number have been conducted in other regions such as Latin America (Aravena et al., 2012) and China (Xie and Zhao, 2018; Zhang and Wu, 2012; Zhao et al., 2018).[3] The variation in setting is crucial, as meta-analyses show (Sundt and Rehdanz, 2015; Ma et al., 2015). While citizens in most settings are willing to pay *something* in order to have access to green energy, the number varies considerably. In Finland, for example, citizens were willing to pay more than $20 per household per month compared to less than $2 in South Korea (Sundt and Rehdanz, 2015, p. 3).

Of great relevance to this study is the willingness to pay in developing regions. Existing work shows a strong willingness to pay for renewables in such contexts, particularly China (Xie and Zhao, 2018; Zhao et al., 2018; Guo et al., 2014; Zhang and Wu, 2012). Furthermore, consistent with research from the developed world, this work generally shows that income, education, and government trust impact the willingness to pay for renewables. This is important for its implications for the future. As the Environmental Kuznets Curve theory suggests, if these factors impact willingness to pay and they increase with development, we might expect that electricity consumers will increasingly demand more renewable fuels as the countries develop.

In this paper, we suggest that this explanation neglects several important concerns. First, given the immense fixed costs, the energy decisions made today will have strong impacts on the future. Although citizens ten years from now may have different energy preferences, it will be difficult to close plants that required substantial loans to construct. Therefore, decisions made today will have a long legacy effect on the energy transition that may not be easily modified with development (Meng, 2016). Second, while a rich literature has found widespread public support for renewables in the developing world, few assess support for dirtier technologies as a baseline or account for improved electrical reliability when examining willingness to pay for renewables. Thus, we suggest that environmental concerns and concerns with reliability may be conflated in a typical willingness to pay experiment, especially in developing countries where new plants are used to expand

[3] See also an interesting study on the willingness to pay in remote areas affected by the presence of the renewable energy production facility (Hanley and Nevin 1999).

electricity generation rather than replace existing dirtier technology. Indeed, in developed and developing contexts, a small number of studies show that citizens are willing to pay more to improve reliability through traditional electricity production sources (Hensher et al., 2014; Abdullah and Mariel, 2010).

Related to this, it is important to assess the demographic factors that are distinct between willingness to pay for reliability and green energy. If simple reliability is the goal, it may be that certain citizens may be willing to support coal or renewables as a means to that end, thus rendering the Environmental Kuznets Curve prediction indeterminate. That is, high income citizens or citizens with trust in the government may be willing to support coal or renewables, thus suggesting an ambiguous relationship between development and environmentalism. However, if some citizens are only willing to pay for renewables but not coal, this offers more support for the notion that the future may bring more support for environmentally-friendly energy choices.

3. Context

We conduct our study in Vietnam. Vietnam is a particularly important country to assess the willingness to pay for renewables. By 2035, Vietnam's energy consumption is expected to increase 2.5 times from its 2015 levels, with most projections suggesting an increase reliance on coal (Shem et al., 2019). Part of this is due to Vietnam's economic growth, and part of it is due to the fact that based on Vietnam's economic profile, it is a particularly energy intensive economy (Hien, 2019).

With this in mind, due to concerns in Vietnam over the meeting the Paris Climate Accords and the country's vulnerability to climate change, the government has proposed consumption taxes on coal and petroleum products. Estimates suggest that a 50 percent tax on coal would decrease coal mining 41 percent and the percentage of Vietnam's energy reliance on coal by 14 percent (Nong et al., 2019; Nong, 2018). At the same time, studies show that the tax would entail a loss in private consumption and reduction in GDP (Nong et al., 2019). This raises the question of the degree to which citizens be willing to shoulder part of this burden in order to shift to cleaner fuels.

As mentioned in the previous section, willingness to pay may depend on the existing cost of energy, which is impacted by subsidies for energy. Despite Vietnam's status as a lower-middle income country, electricity is widespread and affordable, in part due to energy subsidies from the Vietnamese government. Most households in 2014 spent less than 6 percent of their monthly income on electricity, though the percentage has increased over time (Ha-Duong and Nguyen, 2017). Part of the reason for these lower prices are subsidies to poorer Vietnamese for energy (Ha-Duong and Nguyen, 2017). While transitioning to renewables through a tax on coal would likely increase this burden, these subsidies are important to consider because it may be that Vietnamese citizens are willing to pay more than citizens in other countries where energy prices for consumers are higher. However, this increased willingness to pay should also impact a willingness to pay for coal, unless citizens are sensitive to the energy source. A crucial question for Vietnam, then, is not simply whether citizens are willing to pay for renewables, but how much more they are willing to pay for renewables than coal.[4]

[4] We leave the very important question of how Vietnam would want to equitably distribute these costs for new power generation for future work. In addition, hydropower is an important component of renewable energy, including for Vietnam (Nguyen-Tien et al., 2018), but we leave analysis of preferences for hydropower for future work.

4. Methods

4.1. Survey design

To conduct our study, we embedded a dichotomous choice contingent valuation experiment (Andor et al., 2018; Mitchell and Carson, 2013; Carson and Hanemann, 2005) in an annual survey conducted by the United Nation Development Programme's Vietnam Provincial Governance and Public Administration Performance Index (PAPI). This 14,304 person survey is conducted on a representative nationwide sample and reaches all 63 provinces. Within those provinces, it then clusters the responses by district, commune, and village. Once villages and urban wards are selected, respondents are randomly chosen for in-person interviews from a list of names of villagers (UNDP, 2019). The tablet-based survey was administered between August and September of 2018 with a response rate of about 80%. Respondents are incentivized to participate with a small gift. The enumerators and interviewees are centrally trained by the Center for Community Support Development Studies, a Vietnamese NGO.

Because the survey is nationally representative at the individual level and is not a household level survey, it uses a Kish Grid at the household level to generate a sample representative of Vietnam by age, gender, ethnicity, income, and education levels of the population over 18 (for the descriptive statistics on the sample see Appendix A1). Critically, this means 47 percent of the sample are not household heads, and therefore likely do not see the electricity bills. While our primary outcome of interest is overall support in the population for renewable energy regardless of whether they are responsible for the bill, it is also important to consider whether experience in paying the bills impacts support for the measures as they might be the most likely to resist any measures to increase prices. Therefore, in our analyses we control for this and in robustness checks consider whether our results vary depending on whether we include only household heads.

In our experiment, we ask each respondent two separate willingness to pay questions. For all respondents, we first ask what they would be willing to pay for a new coal plant. As the text of our question shown in Table 1 illustrates, we describe that Vietnam is considering new coal plants that could reduce power outages by 50 percent in the respondent's province. We then randomly assign one of 14 bid prices ranging from 5000 to 401,000 VDN ($0.21 to $17.20 USD) in increased monthly household electricity bills and ask whether citizens would be willing to pay the additional fee to build the plants or not. Bids were selected based on average monthly electricity bills in Vietnam. In our sample, the average electricity bill is 509,000 VND per month (~$21.90 USD).

We then ask a second question, but this time with a focus on renewables. Given our large sample size, we randomly assign each respondent to one of five potential treatment primes eliciting willingness to pay for renewables to disentangle preferences for clean energy production type (clean coal/renewables), pollution reductions (none/local/global/both), and electricity intermittency (none/reduced). Table 2 presents the text of our contingent valuation question for renewable energy and Table 3 summarizes our treatments by question, type, and frequency. For 20 percent of respondents in this second question, we asked whether the citizen would pay the randomly assigned increased monthly energy bill for a clean coal plant. We then emphasized that the clean coal plant would reduce local air pollution by 50% in their province and reduce power outages by 50% in their province, but consistent

Table 1
Willingness to pay for coal plants question.

Viet Nam is considering building more coal power plants. Would you be willing to pay [randomly selected price] per month in your power bill to construct and maintain additional traditional coal power plants if the coal power plants would reduce power outages in your province by half, with no other effects?

Table 2
Willingness to pay for renewable energy plants question.

Instead of a traditional coal plant, another option is to construct and maintain [clean coal plants/renewable energy plants]. [Clean coal plants/renewable energy plants] would only have the following effects: (i) [decrease/not decrease power outages in your province by half] (ii) [blank/decrease air pollution in your province by half], (iii) [blank/decrease greenhouse gasses emitted by your province by half]. Would you be willing to pay [randomly selected price] per month to your power bill to construct and maintain new [clean coal power plants/renewable power plants] instead of traditional coal plants?

Table 3
Treatment groups for willingness to pay questions.

Percentage Respondents	100% (All receive this prime first)	20%	20%	20%	20%	20%
Power Source	Traditional coal	Clean coal	Renewables	Renewables	Renewables	Renewables
Reduce power outages 50%	Yes	Yes	Yes	Yes	Yes	No
Reduce local Pollution 50%	No	Yes	Yes	No	Yes	Yes
Reduce Greenhouse Gas 50%	No	No	No	Yes	Yes	Yes

with scientific evidence, did not offer that the plant would reduce greenhouse gas emissions.[5,6]

For the remainder of the respondents, we asked whether they would be willing to pay for renewable energy sources, and varied the effects of the plant. To assess whether respondents in Vietnam are also more likely to support renewables when the focus is less on climate change and more on local pollution (Stokes and Warshaw, 2017), we also vary whether the renewable treatment emphasizes the effects of renewables on climate change versus the effects on local pollution. While existing work suggests that partisanship might impact the degree to which citizens support renewables based on climate change (Stokes and Warshaw, 2017), in Vietnam's single-party setting partisanship should not be a concern. However, it may still be the case that citizens are less likely to find global climate change a compelling reason to pay for plants given the small effects any given plant will have on the global issue (Samuelson, 1954; Nordhaus, 1993, 2019).

We also vary whether the proposed renewable plant will impact power cuts. One logic of building renewable plants is to reduce outages and increase the reliability of supply. However, renewables can also be used to shift from dirty energy sources to cleaner energy sources. As such, in the final prime we ask whether citizens would support building renewable plants if they had no effect on reliability, but would decrease local air pollution and greenhouse gas pollution. Similar to the first question but including two additional higher prices to account for the potentially more appealing attributes, we randomly assign one of 16 bid prices ranging from 5000 to 466,000 VDN ($0.21 to $20.15 USD) in increased monthly household electricity bills across all respondents for the second question.

4.2. Willingness to pay estimation

We estimate willingness to pay for our treatments using a standard dichotomous choice contingent valuation method (Carson and Hanemann, 2005; Mitchell and Carson, 2013; Hanemann, 1984). Following existing literature (Bateman et al., 2002; Amponin, Bennagen, Hess and de la Cruz, 2007) we assume an individual (i) receives indirect utility (V) as a function of their income (Y_i), the mix of electricity generation sources (E), price for electricity generation (P_i), a vector of sociodemographic factors (D), a vector of environmental knowledge and quality factors (Q), and a vector of current electricity demand and reliability factors (F). A change in electricity generation mix from E0 to E1 would result in a change in utility of V(Y_i, P_i, D, Q, F, E1) - V(Y_i, P_i, D, Q, F, E0). Assuming individual are utility maximizers, an individual would support a proposed change in the electricity mix from E0 to E1 if the change in indirect utility is greater than zero:

$$V(Y_i - P_i, D, Q, F, E1) - V(Y_i, D, Q, F, E0) > 0$$

Assuming structure on the stochastic element unobserved by the researcher (ε), the log of the odds that respondent i is willing to pay for the change in electricity generation source mix is:

$$Ln\left(\frac{Prob(Yes)}{1 - Prob(Yes)}\right)_i = \beta_0 + \beta_1 P_i + \sum \beta_t D_t + \sum \beta_u Q_u + \sum \beta_v F_v + \varepsilon_i$$

Given this functional form, the β coefficients can be estimated via maximum likelihood using a logistic regression. Willingness to pay can be then calculated by Equation (1):

$$WTP_i = \frac{\beta_0 + \sum \beta_t D_t + \sum \beta_u Q_u + \sum \beta_v F_v}{\beta_1} \quad \text{Eq. 1}$$

Based on this theory, we use our survey results to estimate two logistic regressions using multiway clustering to account for survey design. Additionally, respondents are weighted in order to account for different population sizes at the lowest cluster level. Finally, post-stratification weights on provincial population are included to account for the fact that the survey is conducted in every province regardless of province population.

While our randomization should lead to balance across the various treatment groups, to improve the precision of the estimates and examine the effects of different covariates on the outcomes we include a number of control variables in our main analysis. Some variables are core to our analysis. First, pertaining to the question of whether experience with energy reliability impacts outcomes, we include a measure of experience with power cuts, with the expectation that those with greater experience with power cuts will be more willing to pay for any kind of energy unless that plant does not improve reliability. Average power bill could also play a role, if those paying more for power (controlling for income) are less willing to increase their spending on electricity. Because of the skewed distribution of this variable, we include the natural log of the respondent's monthly electricity bill.

These include the education level of the respondent (by percentile), given that more educated citizens in some contexts are more willing to pay for clean energy (Sundt and Rehdanz, 2015; Bollino, 2009; Zhang and Wu, 2012). Because of our interest in examine a potential environmental Kuznets Curve effect, we also include a measure of income. While PAPI does included a self-reported income measure, we prefer to use an *assets* variable constructed out of the assets ranging from 0 to 18 owned by the respondents (including items such as motorbikes, mobile phones, televisions, air conditions, and others). This variable is normally distributed and is easier for respondents in the Vietnamese context to estimate. Incidentally, it is also highly correlated with the income

[5] We considered varying the percent reductions in power outages, local pollution, and GHG emissions. However, given the randomization of the prices and the different types of renewables, we were concerned about insufficient power for such an analysis. We think estimating the elasticity of WTP across these margins would be very interesting for future research.

[6] New cleaner plants could reduce local and global pollution if they allow dirtier plants to be decommissioned. In addition, individuals may differentially value the term renewables above clean coal, even if the pollution or electricity intermittency impacts are the same (Aldy et al., 2012).

measure.

Other demographic factors may also impact willingness to pay. Gender is also theorized to play a role, with women generally being seen as more environmentally conscious than men (Sundt and Rehdanz, 2015; Bollino, 2009; Kosenius and Ollikainen, 2013). Some also find that age is an important factor, so we include age (Ek, 2005; Hanemann et al., 2011; Kosenius and Ollikainen, 2013; Kotchen et al., 2013). We also include household size (Zografakis et al., 2010).

Another potential important factor is experience with pollution, with experience potentially increasing sensitivity to environmental concerns. We proxy this through a question asking respondents whether the air quality has gotten worse in previous years. To ensure that perceptions of air quality does not measure more general environmentalism, we include the perceptions of local water quality. We include whether or not the respondent works in agriculture or not, given concerns amongst farmers in Vietnam that drought and climate change are impacting their ability to grow rice, particularly in the Mekong Delta. Related, region may also play a role, so we include a rural-urban variable.

We also anticipate that political variables could play a role in driving support for coal and renewable projects. In general, when trust is higher, citizens are more supportive of government proposals, which in our case would include the coal and renewable plants (Marien and Hooghe, 2011). Therefore, we include the PAPI Index of governance quality (a 1–10 ranking of each provincial government). Political party may also matter (Aldy et al., 2012), therefore we include a variable as to whether the respondent is a party member. Environmental knowledge also matters; therefore, we include a dummy variable indicating whether or not citizens were aware of the impact of coal, renewable or other plants based on the prime they received.

After estimating the mean WTP for our sample, we lastly perform an aggregation exercise to understand the total willingness to pay for the country as a whole, being careful to scale up our individual results using our survey weights to ensure a representative aggregation. We contextualize these numbers with recent estimates of expenditures for new plant development and pollution reduction by the national government.

5. Results

5.1. Public support for coal versus renewables

Before getting into the results of the model, as suggestive evidence of preferences, we first assess the maximum price at which citizens would be likely to support construction of a new coal plant and compare this to support for renewables. See Table A2 in the Appendix for the percent support by each bid price. Fig. 1 shows the unconditional linear relationship between the cost, in increased monthly electricity bills for the respondent, of new power plants to reduce electricity outages by 50% in the respondent's province and the probability that a respondent would support the plants. We find that citizens prefer renewables to coal, on average, as long as the cost for renewables is not more than 60% more expensive than coal (about $6.50 per month per household or about a 30% increase in the average monthly energy bill). But whether for renewables or coal, the higher the price the less citizens are willing to support the construction of the plant.

However, as Fig. 1 makes clear, a substantial number of citizens would support a new coal plant. Up to approximately $11 USD per month per household (~50% of an average electricity bill), more than half of citizens would likely support construction of new coal plants. This suggests that a substantial number of citizens would support any type of plant that reduces energy outages if the price is right: if citizens are only presented with the choice of coal, and the changes in the prices charged are modest, most citizens will support the construction of the coal plant.

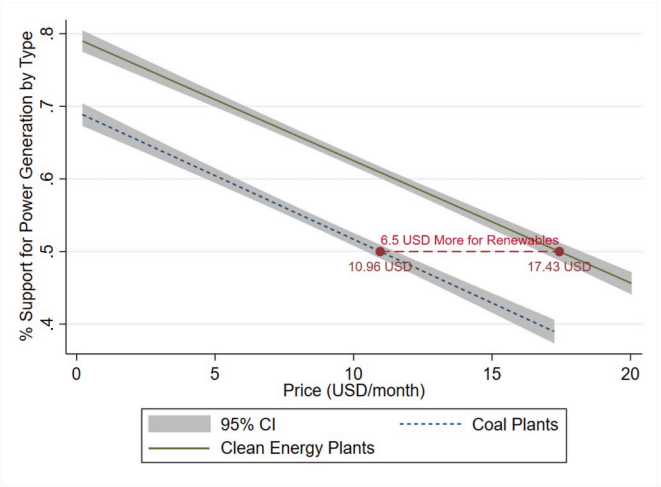

Fig. 1. Public Support for New Coal Versus Renewable Power Plants
Note: This graph displays the linear relationship between support for coal (blue line) or renewable (green line) plants and the monthly surcharge on the electricity bill. The red horizontal dashed line is the average additional amount citizens would pay for renewables, relative to coal, at the point at which the probability of choosing to build either plant is 0.5. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

5.2. Willingness to pay for new plants

We next assess willingness to pay (WTP) from our contingent valuation question using a multivariate logistic regression model. This allows us to analyze which groups are most likely to support coal, renewables, or both. Additionally, it will help explain what elements of alternative power sources are most appealing to citizens. Therefore, in our models we include our key demographic, environmental, and energy use control variables that could shift WTP. Using the model results, we estimate average WTP for new coal versus clean power plants to reduce electricity intermittency as well as our different pollution reduction treatments.

In our first regression model, we estimate willingness to pay for coal, a question answered by all respondents. As explanatory variables, we include the (randomly assigned) price bid, demographic controls (education, assets, male, has children, age, member of Communist Party, employment in the agricultural sector, rural residence, and perceived quality of local governance), environmental controls (perceived local air and water quality, prior knowledge of negative coal effects), and electricity controls (village-level average days without power, the natural log of the respondent's electricity bill). In sensitivity analysis (discussed further in Section 5.3), we also include province-level fixed effects, regional fixed effects, and other control variables to examine additional heterogeneous effects. We then estimate willingness to pay based on Eq. (1) above.

In our second regression model, we estimate willingness to pay (WTP) for cleaner energy by pooling responses across all five treatments. We use a version of the McFadden-Hausman specification test (Hausman

and McFaden, 1984) to assess the validity of pooling our five treatment responses together, finding general support for this approach.[7] In results not shown, we estimated WTP for renewable plants without pooling across treatments and find qualitatively similar results. We include all the same control variables from the coal support regression and also include dummy variables to indicate the qualities of each treatment primes, including for renewables (1 if renewable energy, 0 if clean coal), 50% reduction in local pollution emitted from power generation in the province (1 if reduction included in prime, 0 otherwise), 50% reduction in global pollution emitted from power generation in the province (1 if reduction included in prime, 0 otherwise), and 50% reduction in electricity intermittency (1 if reduction included in prime, 0 otherwise). We lastly interact average days without power with the power intermittency reduction prime to test for a differential effect in WTP based on underlying quality of power availability.

For all respondents who answer "no" to the renewables willingness to pay question, we follow up with a question to check for protest responses (protest zeros) and excluded respondents who may not be expressing their true preferences in the "no" response (Halstead et al., 1992).[8] The same as for coal, we also include province-level fixed effects and other controls in results not shown, as well as include potential protest zero responses, but find no significant impact on the results. We finally estimate WTP based on Eq. (1) above, and also estimate the marginal impact on WTP for each treatment prime.

We find that Vietnamese are willing to pay significant amounts for new power generation facilities to reduce electricity intermittency. On average, respondents were willing to pay $11.26 USD per month (~51% increase in the average monthly electricity bill) for new coal plants that would reduce electricity intermittency by 50% in their province of residence. Desire for coal notwithstanding, citizens greatly prefer renewable technologies and are willing to pay an average of $21.07 per month (~96% increase in average electricity bills). This suggests that agenda setting may play a critical role in deciding new power plant type (Cox and McCubbins, 2005). As shown through our research design sequencing, if citizens are only asked whether they want coal or not, a majority may support the construction of coal plants even if they prefer renewables.

Turning to which elements of alternative fuels Vietnamese citizens find appealing, our randomly assigned treatments in the willingness to pay for renewables question varies the energy production type (clean coal/renewables), pollution reductions (none/local/global/both), and electricity intermittency (none/reduced). As Fig. 2 shows, consistent with previous research in other countries, the primary drivers of support for alternative energy include the positive association with the word "renewables" and sensitivity to the effects on local pollution (Aldy et al., 2012). The impact of including "renewables" rather than "clean coal" in the treatment led to an average increase in willingness to pay by about

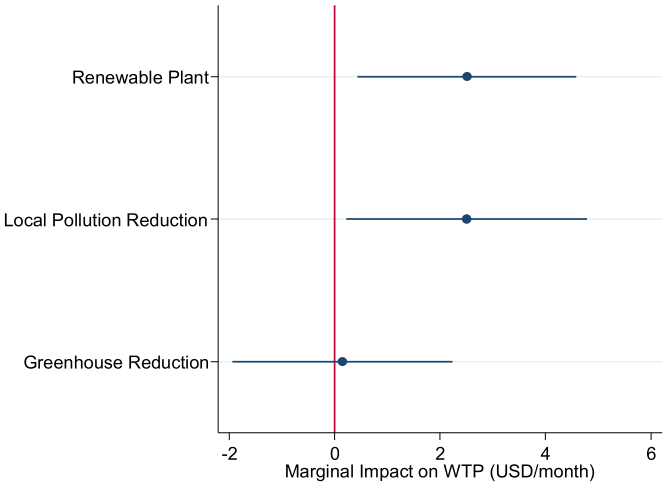

Fig. 2. Impact of Treatment on Willingness to Pay.
Note: These are the marginal effects of each independent prime on WTP for clean energy. The blue dots display the point estimates with 95% confidence intervals indicated by the blue lines. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

$2.50 USD (an 11% increase in electricity bills) per month. Additionally, describing that the proposed plants would decrease local pollution by 50% in the respondents' province led to an increase in average WTP of about $2.49 USD per month. However, including 50% reductions in the amount of province-level greenhouse gas emissions had no statistically significant impact on WTP, as predicted by public goods theory (Samuelson, 1954; Nordhaus, 1993, 2019).[9]

Turning to electricity intermittency, we also include a treatment to either reduce electricity intermittency by 50% in the respondent's province or not reduce electricity intermittency, implying that new plants would simply replace existing infrastructure with cleaner power but with no impact on energy reliability. In villages that experience high electricity intermittency, we find that people have lower WTP for a proposal that does not reduce electricity intermittency. As shown in Fig. 3, for those with reliable power (on the left-hand side of the graph) further reductions in intermittency makes little difference in WTP as citizens are equally willing to pay for new renewable plants. However, those with more intermittency become progressively less willing to pay for plants if they do not improve reliability. At the same time, they remain willing to pay if the plants would improve power generation.

5.3. *Preference heterogeneity and the determinants of willingness to pay*

Another important consideration is who is willing to pay for coal versus alternative energy sources. Fig. 4 shows the marginal effects of a one standard deviation increase in key explanatory variables on willingness to pay for coal versus renewables. Several findings emerge from the results. First, education and knowledge have different impacts on coal versus renewables. More educated citizens and those who are more knowledgeable about coal's harmful pollution impacts are more willing to pay for renewables and less willing to pay for coal, consistent with previous work (Urpelainen and Yoon, 2015).

[7] When we perform the test, we find significant differences in estimated coefficients across the five regressions for education, gender, rural, and water quality, rejecting the null hypothesis that they are all the same value. However, given the number of estimated coefficients included in our model, the null hypothesis would be rejected by chance with some positive frequency. In addition, given our very large survey sample size of 14,000, our estimated coefficients have very high precision even though the magnitudes of the estimated coefficients across regressions are qualitatively similar. Thus, we proceed with the pooled regression as our main result.

[8] Specifically, we ask them the reason they said "no" including: 1) The effects are not worth that much to me, 2) I do not have the money in my budget to pay a higher bill, 3) The effects are important to me, but I should not be required to pay, and 4) Other. We dropped any responses that fell in category 3, totaling 981 responses (6.86% of the sample), as they are likely to be protesting the question itself and therefore may not be signaling their true preferences over energy type. In sensitivity not shown, we included the protest zero responses. As expected, the WTP estimates including protest zeros were slightly lower but not significantly so and the qualitative results remain unchanged.

[9] As found in the US, while more citizens are supportive of reducing pollution, the issue of climate change can either be abstract or polarizing (Stokes and Warshaw, 2017). In Vietnam's single-party context, we do not expect polarization yet still control for membership to the Communist Party. Climate change may be an abstract concern. However, in results not shown, including climate beliefs as a control variable does not change the results as more than 90% of respondents believe the climate is warning.

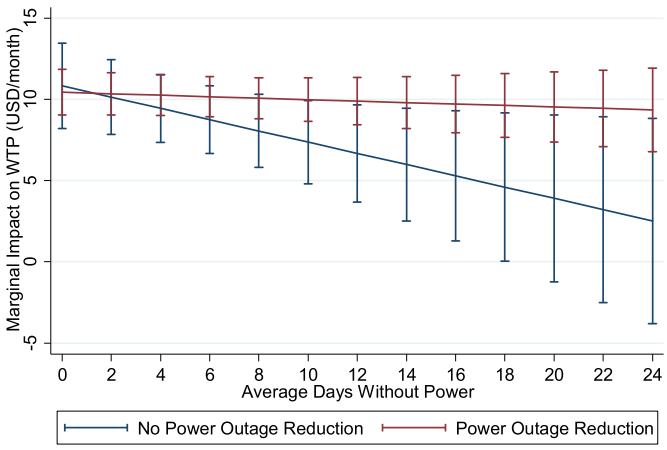

Fig. 3. Marginal Impact of Power Outages on WTP for Plants
Note: Marginal impact of electricity intermittency on willingness to pay for reductions in electricity intermittency (red line) or no reductions (blue line) with 95% confidence intervals. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

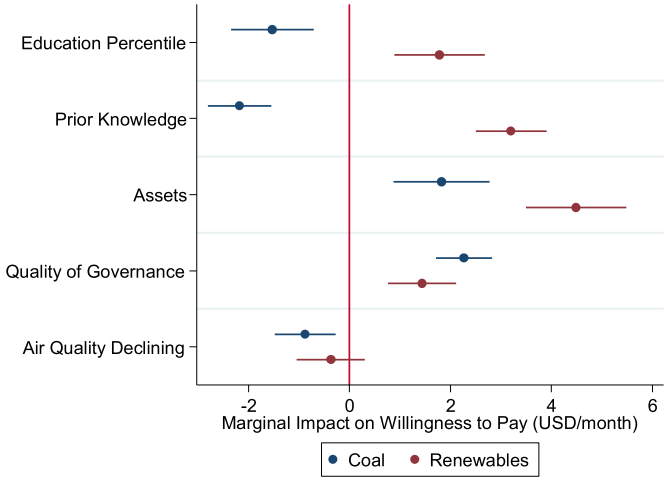

Fig. 4. Impact of Covariates on Willingness to Pay for Coal Versus Renewables.
Note: These are the marginal effects of a one standard deviation increase in the independent variable on the willingness to pay for renewables or coal plants. Lines represent 95% confidence intervals.

Experience with pollution is also somewhat consistent with expectations, though much weaker. Those with poor air quality are less likely to support coal. However, perhaps surprisingly, experience with pollution does not lead to increased support for renewables. From a policy perspective, this implies a dampening effect for traditional energy: support for coal decreases as pollution increases, but as pollution declines, support for renewables does not wane.

Of interest, income and quality of governance increase willingness to pay for renewables but also predict willingness to pay for coal. This suggests that the income does not seem to change citizen priorities (Inglehart and Welzel, 2005), but rather richer citizens are more willing to pay for these goods because they have more disposable income. Additionally, on the question of governance, quality of governance seems to simply give citizens a greater trust in whatever the local government seeks to do. Therefore, if the local government proposes a new plant, they will support it whether it be coal or renewable. This finding is similar to previous research that has found greater trust in the solar companies leads to greater support for solar (Urpelainen, 2016). However, we find this is result is not specific to renewables, but importantly applies to coal as well.

Finally, estimated coefficients in Table 4 also show the impact of additional control variables. Contrary to existing literature suggesting that women are more likely to support renewables than men (Sundt and Rehdanz, 2015; Bollino, 2009; Kosenius and Ollikainen, 2013), in Vietnam men are more willing to pay for renewables than women. There is no difference, however, in their willingness to pay for coal. Older citizens are more willing to pay for coal, but not more willing to pay for renewables. This suggests that the older generations are, on average, more concerned with reliability than the environment. In additional analysis not shown, the addition of regional fixed effects uncovers some interesting regional variation. In general, the northern regions, such as the Northern Uplands, the Red River Delta, and Central Vietnam are more willing to pay for renewables that other regions in the south such as the Mekong Delta, Southeast Vietnam (which includes Ho Chi Minh City), and the Central Highlands (the omitted category).

In our sensitivity analysis, we also included proximity to coal plants by including a dummy variable indicating the presence of existing coal plants by province to assess whether direct experience with dirty plants

Table 4
Logistic model regression results.

Dependent Variable	(1) Coal Support	(2) Renewables Support
Coal Bid (VND)	−0.00325***	0.000809***
	(0.000171)	(0.000227)
Renewable Bid (VND)		−0.00333***
		(0.000180)
Education Percentile	−0.0794***	0.0925***
	(0.0213)	(0.0234)
Assets	0.0435***	0.107***
	(0.0114)	(0.0119)
Male	0.0129	0.393***
	(0.0514)	(0.0563)
Have Children	−0.0129	−0.184***
	(0.0494)	(0.0533)
Age	0.00850***	0.00171
	(0.00219)	(0.00226)
Communist Party	−0.0511	0.285***
	(0.0654)	(0.0896)
Agricultural Sector	0.199***	0.153***
	(0.0601)	(0.0575)
Rural	0.157***	0.0817
	(0.0568)	(0.0618)
Quality of Local Governance	0.0105***	0.00662***
	(0.00129)	(0.00156)
Air Unclean	−0.142***	−0.0603
	(0.0491)	(0.0550)
Water Unclean	−0.306***	−0.132
	(0.101)	(0.129)
Prior Knowledge of Coal Impacts	−0.340***	0.500***
	(0.0492)	(0.0552)
Average Days Without Power	0.00252	−0.0268**
	(0.00519)	(0.0128)
Ln Energy Bill	0.0160	0.0753*
	(0.0402)	(0.0404)
Renewable Prime		0.194**
		(0.0807)
Local Pollution Reduction Prime		0.193**
		(0.0888)
Greenhouse Gas Reduction Prime		0.0111
		(0.0812)
Electricity Intermittency Reduction Prime		−0.0310
		(0.104)
Average Days Without Power X Power Prime		0.0233**
		(0.0109)
Constant	−0.839*	−2.212***
	(0.499)	(0.520)
Observations	12,880	12,729

Note: Standard errors using multiway clustering to account for survey design in parentheses. ***p < 0.01, **p < 0.05, *p < 0.1.

impacted willingness to pay for coal. However, the results showed no significant effect.[10] Also, we were concerned that our effects could be driven primarily by those that do not pay the electricity bills in the household. To capture this, we assumed that household heads would be more likely to pay the bills, and therefore included it as a control variable. Results showed no effect on the willingness to pay for renewables amongst household heads.[11]

5.4. Aggregate implications

Vietnamese citizens are willing to pay significant amounts per month in increased electricity bills to have an improved electricity grid. Aggregating to the national level across the roughly 29.5 million households, these findings translate to WTP among citizens of about $4 billion USD per year (~1.8% of GDP) for new coal development and $7.5 billion per year (~3.3% of GDP) for expanded renewables. This is in line with the $40 billion pledged by the Vietnamese government to be spent on electricity generation and grid development from 2016 to 2020 (U.S. Embassy in Hanoi, 2019). Interestingly, citizen concerns for reducing local pollution from electricity generation, valued at about $0.9 billion USD per year, far outweighs the approximately $0.2 billion USD annual budget in 2017 for the entire Ministry of Natural Resources and the Environment (Chi, 2017). Consistent with public goods theory surrounding climate change where individual actors bear all the cost but only a fraction of benefits from mitigation (Samuelson, 1954; Nordhaus, 1993, 2019), we find no significant WTP for greenhouse gas pollution reductions. Aggregating the (insignificant) point estimate, we find citizens WTP about $0.05 billion per year to combat climate change from the electricity sector, despite the country's high vulnerability to future impacts especially those from sea level rise (Dasgupta et al., 2007).

6. Conclusion and policy implications

A variety of policy instruments could decrease Vietnam's reliance on coal. This paper asks the degree to which citizens would be willing to support different energy transitions. We find that citizens are willing to pay more for renewables. However, there is still significant willingness to pay for coal. Furthermore, those who have intermittent power are more willing to support proposals that increase power reliability. This finding fills an important gap in the voluminous research on willingness to pay for renewables. In particular, it shows that citizens are willing to pay for coal as well as renewables, albeit at lower levels, so agenda setting for renewables is critical.

We also find important heterogeneous effects. In particular, we find that development will not necessarily be a panacea for the environment, as wealthier citizens are willing to support *both* coal and renewables, suggesting there is no clear effect of increasing wealth driving support for renewables vis-à-vis coal. Increased education levels, however, does depress support for coal and increase support for renewables. This provides important context suggesting that the advantage of renewables is not as great as existing studies might suggest unless explicitly compared against willingness to pay for coal. In short, where energy reliability is a concern *and* where government trust is high, citizens may be willing to go along with coal or renewable plant construction.

The findings have important policy implications in an era of changing energy demand, especially in contexts like Vietnam that are poised to potentially have a large effect on global efforts to reduce carbon emissions. First, foreign donors who do not want to encourage additional greenhouse gas emissions are right not to subsidize the production of coal plants. We find that citizens are sensitive to costs and will be willing to pay for coal if the price is right. Therefore, increasing the price will discourage support for coal. However, continuation of international financing of new coal plants, such as through low cost loans, will encourage new coal development.[12]

Second, advocates for green energy must be sensitive to issues of energy reliability, which is a major concern in developing contexts such as Vietnam. This is particularly important as it motivates the need for policy researchers to carefully disentangle preference for renewables (and affiliated impact on local versus global pollution) with preferences for decreased power intermittency.

Finally, and importantly, agenda setting appears to be critical. As a vast literature on agenda setting from political science suggests, the power to decide the alternative can play an important role what is decided (Cox and McCubbins, 2005). If citizens are only asked whether they want coal or not, a majority may support the construction of coal plants even if they prefer renewables. However, if presented a choice between coal and renewables, where the impact on local health concerns (as opposed to climate change) are emphasized, average citizens will be more willing to support renewables.

With these thoughts in mind, our study does contain some important limitations that pave the way for future work. First, we did not vary the amount of pollution that the proposed plants would remove. In future work, one could assess the degree to which citizens would be able to pay more at varying levels of pollution reduction. Additionally, our paper uses relatively crude indicators of experience with air pollution. Future work could use more fine-grained geo-coded measures of pollution levels to generate more precise estimates of the impact of pollution levels on citizen willingness to pay.

Finally, these results are national level averages. However, we know from Vietnam that there are many protests against the construction of coal plants. This suggests that there are vocal pockets of resistance to the construction of coal plants. An interesting area of future work could further explore the micro-level conditions that lead to collective action against coal plant construction.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Laura Bakkensen: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - review & editing, Visualization. **Paul Schuler:** Conceptualization, Methodology, Validation, Formal analysis, Investigation, Writing - review & editing, Visualization.

Appendix A. Supplementary materials

Supplementary materials to this article can be found online at https://doi.org/10.1016/j.enpol.2020.111696.

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[10] The data was collected from: www.powerplantmaps.com/Vietnam.html.

[11] In results not shown, we also re-ran our main models using only responses from the heads of households and found their WTP to be slightly *higher* than non-household heads, reassuring us that non-household heads were not likely to be overstating their preferences due to a lack of history with paying electrical bills.

[12] For example, the Japan Bank for International Cooperation has financed several coal plants in 2019 to be constructed in Vietnam. https://www.jbic.go.jp/en/information/press/press-2019/0419-012106.html.

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