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ARTICLE

Equity preferences and abatement cost sharing in international environmental agreements

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Abstract

This paper examines empirically the importance of equity preferences for the formation of international environmental agreements (IEA) for transboundary pollution control. Although it has been shown theoretically that the existence of equity preferences among countries considering an IEA increases the chances for formation and stability of a coalition, empirical assessments of such preferences have been limited to climate change mitigation and single-country studies. We consider the case of marine plastic pollution, of which a large share consists of food and beverage containers, representing a transboundary pollution control problem of increasing policy concern, with properties that lead to distinct considerations for equity and the sharing of abatement costs. We employ a coordinated choice experiment in the United Kingdom and United States to assess preferences for abatement-cost allocations in a marine plastics IEA. Pairs of cooperating countries and the relative allocation of abatement costs are varied experimentally. Results show systematic aversion to both advantageous and disadvantageous inequality with respect to abatement costs but also that the relative strength of advantageous and disadvantageous inequality aversion differs across countries. Across both countries, there is evidence that left-leaning voters generally favor more equal international sharing of abatement costs. Differences of these results from the case of greenhouse gas emission reduction, and implications for current efforts to establish a legally binding global treaty on marine plastic pollution, are discussed.

KEYWORDS
abatement costs, choice experiment, equity preferences, inequality aversion, international environmental agreement, marine plastics

JEL CLASSIFICATION
D63, F53, Q51, Q53

1 | INTRODUCTION

Efforts to remedy transboundary environmental problems generally require international environmental agreements (IEAs) to reach economically efficient and environmentally effective outcomes (Hoel, 1997). Although many transboundary pollutants are of current concern, much of the theoretical economics literature on this topic focuses on climate change as the ultimate global environmental problem (and climate change mitigation as a global public good; Barret, 2005; Finus, 2008). This is also true for the literature on the role of equity preferences in IEAs (Kverndokk et al., 2014; Kverndokk & Rose, 2008).[1] Theoretical contributions on the formation and stability of coalitions for IEAs show that preferences for equal burden sharing between participating countries increase both the size and stability of these coalitions (Lange, 2006; Lange & Vogt, 2003; Vogt, 2016). This finding is based on the theoretical concept of *equity preferences* in decision making, particularly around inequality aversion as one type of equity preference (Fehr & Schmidt, 1999). A related literature finds that many of those involved in the process of international climate negotiations also display a preference toward more equal sharing of abatement costs (Dannenberg et al., 2010; Lange et al., 2007).

Despite robust theoretical evidence that equity preferences are a crucial aspect of transboundary pollution control, empirical estimates of public preferences for how abatement costs are shared across countries within an IEA have, to the best of our knowledge, been assessed solely with respect to greenhouse gas (GHG) emissions and climate change (Cai et al., 2010; Carlsson et al., 2011, 2013; Lee & Cameron, 2008; Ščasný et al., 2017). Moreover, with the exception of Carlsson et al. (2013) and Ščasný et al. (2017), these studies have been conducted in a single country. Given the unique position of climate change in contemporary political, cultural, and policy discourses (Carvalho, 2007), it is far from obvious that equity preferences applicable to GHG reductions and climate-change policy would apply to other types of transboundary pollutants. On the contrary, it seems more likely that the opposite would apply—that equity preferences related to climate policy might have little or no relationship to equity preferences for other types of transboundary problems. As we detail below, the physical processes underlying marine plastic pollution differ from GHG emissions in that there are complex spatial patterns in its release and distribution, so that plastic emissions from any individual "source" location (e.g., country) typically have different impacts on plastic pollution deposited across different "receiver" locations. It is possible, perhaps even likely, that patterns of this type could influence people's preferences for sharing the costs of emissions reductions and cleanup.

This article addresses equity preferences with respect to a transboundary pollutant that is of increasing policy concern: marine plastics (Borrelle et al., 2017). A recent metastudy found plastic bags (14% of items analyzed globally), plastic bottles (12%), food containers and cutlery (9%), and wrappers (9%) to be the most common types of plastic litter in oceanic environments (Morales-Caselles et al., 2021). The reduction of marine plastics pollution—either from reducing plastic waste inputs into the sea or the removal of plastics directly from marine waters—has the characteristics of an international public good, for which IEAs are required to ensure Pareto efficient supply

[1]Other applications of this theoretical literature include control of air pollution linked to acid rain (Mäler, 1989) and the preservation of biological diversity (Alvarado-Quesada & Weikard, 2017; Winands et al., 2013).

(Hoel, 1997).[2] On March 2, 2022 the United Nations Environment Assembly voted in favor of a resolution to form a binding, global IEA addressing this type of plastic pollution by the end of 2024 (UN News, 2022; UNEP, 2022). Details of this IEA will be negotiated in a setting wherein emission reductions and/or clean-up efforts of any one country necessarily affect the amount of plastic in other countries' national waters and exclusive economic zones. Countries may also be harmed by plastics in international waters (e.g., if these plastics cause harm to marine life valued by the public). Yet, although marine plastic is an archetypal example of a transboundary pollutant for which IEAs are necessary to engender effective control, information on preferences for the sharing of abatement costs across countries is (to the knowledge of the authors) entirely unknown. Absent this information, it is impossible to draw conclusions on potential the size and stability of international coalitions (and hence IEAs) for marine plastics control, grounded in the theoretical literature.

The present paper extends the literature on equity preferences in IEAs to the important but largely unstudied (by economists) topic of international marine plastic pollution. We focus on issues that are critical to coalition forming for IEAs but cannot be studied adequately using the unique case of GHG emissions. In doing so, we provide one of the first analyses of equity preferences for transboundary pollution control beyond the context of climate change. The analysis relies on data collected from a coordinated choice experiment survey in the United Kingdom (UK) and United States (US), addressing preferences for the reduction of marine plastic pollution in the North Atlantic. Three treatments are developed. Each is conducted in one country and refers to a specific partner country with which joint marine plastic pollution efforts are being considered: Treatment 1 surveys the UK public with the partner country being the US. Treatment 2 also surveys the UK public but with the European Union (EU) as the partner. Treatment 3 collects parallel data from a US sample with the UK as the partner. The key attribute for the present analysis describes the allocation of abatement costs between partner countries in a future, hypothetical IEA. The research design enables preferences for different cost-sharing arrangements (for example, between the UK and US) to be assessed and compared, holding constant other program attributes such as the amount of plastic reduced in different domestic and foreign locations.

Our study contributes to the literature on equity preferences for IEAs in several ways—all motivated by the theory of coalitions in these agreements. First, we extend the literature on public preferences for cost-burden allocation for remedying international environmental problems from the dominant area of climate change to an equally international and unquestionably important yet less studied environmental issue: marine plastics pollution. Second, we examine parallel preferences for abatement cost allocations of international efforts to reduce marine plastics pollution. That is, we compare responses from an otherwise identical choice experiment conducted in the UK and the US that varies shares of abatement costs in a joint marine plastics reduction program as an additional choice attribute. To the best of our knowledge, this is the first preference elicitation study that does this within the context of equity preferences related to transboundary pollution generally. As we detail below, the experimental design also allows us to delineate inequality aversion from alternative types of other-regarding preferences, such as reciprocity. Third, our study examines whether preferences for abatement cost sharing in the same country vary depending on the identity of the international partner and as a function of political voting patterns.

Results show systematic aversion to both advantageous and disadvantageous inequality across nearly all country pairs—respondents in all countries prefer an equitable sharing of abatement costs within the international coalition. However, the relative magnitude of these preferences varies depending on the countries considered. For example, aversion to advantageous and disadvantageous inequality appears to be equally strong in the US, but UK respondents show stronger aversion to disadvantageous inequality. However, results from the two UK treatments suggest that equity

[2]Specific instruments that have been proposed to address marine plastic pollution include improved waste management on land (Cordier & Uehara, 2019), replacement of plastic with alternative materials (Ellen MacArthur Foundation, 2016), and taxes or outright bans on certain plastic products (Convery et al. 2007; Abbott & Sumaila 2019).

preferences do not vary systematically with the specific identity of the partner country—UK households are equally averse to abatement cost inequality in joint program with the US and EU. Results such as these suggest that "one size does not fit all" when seeking to characterize equity preferences for marine plastics, with equity preferences varying systematically across some dimensions but not others. Although these and other results must be interpreted within the context of the cost-share options offered in the choice experiment, they have implications for the feasibility and design of prospective IEAs on transboundary marine plastic reduction. These implications are characterized in part using a simulation analysis of voting support within each country.

The remainder of the paper is structured as follows. The subsequent section introduces marine plastics as a transboundary pollution problem. Section 3 reviews the theoretical and empirical literature on burden sharing in IEAs. Section 4 sets out the research questions and methods. Section 5 presents the results, which are then discussed in Section 6.

2 | MARINE PLASTICS AS A TRANSBOUNDARY POLLUTION PROBLEM

Many dimensions of marine plastic pollution, transport, and impact differ from those observed for uniformly mixed pollutants such as the GHG responsible for climate change. These characteristics lead to distinct considerations for equity and sharing of abatement costs across countries, and hence for equity preferences. Because marine pollution (of plastics or any other substances) typically affects only littoral countries, such pollution (or its remedy) constitutes a regional—rather than global—reciprocal externality (Mäler, 1990). At the same time, costs for emission reductions or clean-up measures are private in the sense that they are borne only by the country undertaking such efforts. Different policy instruments for the reduction of plastic waste emissions into the environment have been discussed and often focus on the national level (Abbott & Rashid Sumaila, 2019; Alpizar et al., 2020; Oosterhuis et al., 2014).[3] The fact that such emissions are transboundary and require international cooperation has thus far received little attention by economists. This lack of attention notwithstanding, the urgent nature of this unresolved transboundary problem has been highlighted by increasing international attention, including the recent United Nations Environment Assembly vote cited above (UNEP, 2022).

Unlike GHG emissions, plastic emissions are not uniformly mixed. Plastics are discarded into the sea (mainly via rivers; Lebreton & Andrady, 2019; Meijer et al., 2021) but also directly into coastal and marine waters (Galgani et al., 2015). These spatially heterogeneous discharges, combined with the existing pattern of surface and undersea currents and wind flows, lead to complex spatial patterns in release, distribution, and damages (Cózar et al., 2014; van Sebille et al., 2020). These impacts can also vary over time as plastic items interact with environmental conditions, such as wave movements and UV radiation (Andrady, 2011). Hence, unlike GHGs (where a unit of emissions affects the global climate equally, regardless of its geographic source), emissions of plastics from any one country can have different impacts on ambient plastic pollution levels realized across other countries. Moreover, certain types of plastic pollution (e.g., food packaging) can bear identification that allows them to be traced back to particular countries or regions (Falk-Andersson et al., 2019). Given characteristics such as these, equity preferences related to marine plastics reductions—and the relevance of these preferences for the public's willingness to support international collaborations—may differ from those relevant to climate change and other global environmental commons.

[3]In the EU, the Marine Strategy Framework Directive (EC, 2008) stipulates that as one of 11 descriptors, European coastal states have to ensure that marine litter does not cause harm to the coastal and marine environment. In terms of international coordination, only the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention) stipulated in 2014 a set of actions to be taken by the UK and 14 other European countries to reduce marine litter in general (OSPAR, 2014). Yet when evaluated in 2020, less than half of these measures had been fully implemented by the signatory countries (OSPAR, 2021). This action plan was renewed in 2022 (OSPAR, 2022). To the best of our knowledge, the US, which is not among the OSPAR signatories, is currently not part of any relevant international agreement with respect to marine plastics.

Despite the distinct transboundary nature of the marine plastics problem, research on preferences for the reduction of marine plastic pollution has almost exclusively taken a national (or domestic) perspective. For example, recent studies quantify the willingness to pay (WTP) of citizens to reduce plastic pollution domestically (Abate et al., 2020; Börger et al., 2021; Borrelle et al., 2017; Borriello & Rose, 2022; Leggett et al., 2018; Meginnis, Domanski, & Toledo-Gallegos, 2022; Tyllianakis & Ferrini, 2021; Zambrano-Monserrate & Ruano, 2020). Khedr et al. (2023) take a regional perspective, comparing the WTP of citizens in eight EU countries for reductions in macro and micro plastics across all European waters versus only domestically. Yet even regionally focused studies such as Khedr et al. (2023) fail to consider the explicit transboundary nature of the problem (i.e., the transmission of marine plastics between countries) or equity preferences for IEAs to reduce this type of pollution. Hence, this emerging literature provides no insight into equity preferences related to transboundary pollution reductions in the context of marine plastics.

3 | EQUITY PREFERENCES AND INTERNATIONAL ENVIRONMENTAL AGREEMENTS

The research questions and choice experiment design presented in Section 4 are grounded in existing theory related to the potential impact of citizens' equity preferences on IEAs. As noted above, the underlying motivation for the analysis is the importance of equity preferences for the potential establishment and stability of coalitions in IEAs aimed at marine plastic reductions. Although the theoretical literature on the formation and stability of coalitions has produced rather sobering results (e.g., Barret, 1994; Carraro & Siniscalco, 1993; Hoel, 1992), only a small number of studies have examined the role of equity preferences in determining the size and stability of self-enforcing IEAs, and all of these have considered the unique context of global climate change (Lange, 2006; Lange & Vogt, 2003; Vogt, 2016).

By and large, these studies show that the presence of inequality aversion in a large share of negotiating countries facilitates cooperation substantially. For example, Lange and Vogt (2003) consider the effects of preferences for equal payoffs (defined as damages avoided minus control costs) on coalition formation. In their model, the representative agent in each symmetric country considering an IEA cares about both the absolute and relative payoffs from emission reduction. Depending on how many countries place a positive weight on relative payoffs, an equilibrium exists where many countries (>50%) decide to join the coalition. This grand coalition can be stable when countries care enough about equal payoffs.

The assumption of symmetric countries is dropped by Lange (2006), who considers the case of IEAs where developing countries are exempted from emission reduction agreements reached by richer countries. Equity preferences within richer countries toward developing countries are shown to affect emission reductions but not the incentives to cooperate. However, inequality aversion toward abatement targets between the richer countries tends to increase the size of a self-enforcing IEA coalition and to increase overall abatement. Here, inequality aversion is defined over the relative size of emission reductions agreed to by richer coalition members. More equal abatement targets will be preferred to less equal targets by inequality-averse voters. Vogt (2016) takes this a step further by modeling heterogenous payoffs and different levels of inequality aversion. They find that coalitions are internally unstable if well-designed transfer schemes are in place and a player's preferences for advantageous inequality (i.e., inequality that causes the domestic country to pay less) is sufficiently small. This is because a player can gain more by defecting than from losing utility resulting from an increased (yet advantageous) inequality. To understand the impact of changes in inequality aversion one must thus distinguish between advantageous and disadvantageous inequality aversion. With an increase of the latter, the incentive for low payoff countries to leave an IEA goes up, whereas an increase of the former enlarges the set of internally stable coalitions.

The implication of the above literature is that the number of voters in each country who have a preference for equal cost shares may help predict whether an IEA can emerge with "enough" members to achieve substantial abatement of transboundary pollution, getting around the classic free-rider problem. The importance of cost sharing in IEAs is also stressed in Welsch (1993), who formally derives equitable (and efficient) abatement agreements structured by side payment arrangements based on cost share ratios. In such a context, bilateral cost share ratios between countries participating in an IEA are defined as one country's share in another country's abatement costs.

A complementary empirical literature examines whether national representatives who participate in IEA negotiations do indeed exhibit equity preferences (Dannenberg et al., 2010; Lange et al., 2007, 2010). Lange et al. (2007) find that, by and large, participants of international climate negotiations deem equity principles important, whereby support for different interpretations of "equity" can be identified among negotiators from countries with different historical levels of GHG emissions. This examination of equity principles is taken up again by Lange et al. (2010), who examine equal per-capita shares in emission reductions, reductions proportional to emissions (the "polluter pays rule"), equal percentage emission cuts, and exempting poor countries from emission reductions. These authors do not explicitly consider equal cost shares. Their main finding confirms that in Lange et al. (2007), with their definition of the polluter pays principle and the rule of excluding poor countries from emission reduction responsibilities being the most popular among all the equity principles considered. Equity rules were seen as more important, the lower was GDP per capita. In a similar vein, Dannenberg et al. (2010) find that respondents sampled from international climate conference participants differ in their degree of inequality aversion, with stronger aversion against advantageous than disadvantageous inequality. They also find insignificant differences according to the geographic location of respondents. The latter finding, which is consistent with the results in Lange et al. (2007), is not surprising given the uniformly mixing nature of GHG in the atmosphere. This may be different for the case of marine plastic pollution.

A third stream in the literature has conducted empirical investigations into *public* preferences for equity and reciprocity in the field of climate change mitigation. Although some of these studies examine preferences with respect to the international distribution of benefits of climate policies (e.g., Svenningsen & Thorsen, 2020), other studies focus on the distribution of abatement costs associated with climate action (Cai et al., 2010; Carlsson et al., 2011, 2013; Lee & Cameron, 2008; Ščasný et al., 2017). Svenningsen and Thorsen (2020) assess preferences for both the intergenerational and contemporary international distribution of benefits of climate change mitigation in the form of lower disease burdens and lower projected income losses in 2100. A majority of 60% of their Danish sample display altruistic preferences in that they value benefits outside of the home region while concurrently favoring an equal distribution of benefits across world regions. Lee and Cameron (2008) find that support of a US sample for different climate policies increases if GHG abatement costs are shared with other countries. In a convenience sample of college students in the US and Canada, Cai, Cameron, and Gerdes (2010) find that WTP for climate change mitigation depends on the distribution of costs between the US and other countries. WTP of certain groups of individuals is found to be zero unless information about the distribution of costs is provided as a program attribute. Similarly, Carlsson et al. (2011) investigate preferences for different effort sharing arrangements for abating GHG emissions, namely abatement according to historical emissions, according to current emissions levels and proportional to population size. Results suggest clear public preferences for equal per-capita emission reductions, implying that discussions around cost-sharing arrangements within IEAs are crucial.

To the best of our knowledge, only two studies compare equity preferences of citizens of different countries (Carlsson et al., 2013; Ščasný et al., 2017)—again solely in the context of climate policy. We are not aware of studies that assess such preferences for any other type of transboundary pollution. Carlsson et al. (2013) find that respondents in the US and China prefer the burden-sharing rule that benefits their respective country the most. US respondents favor emission reductions based on current emissions whereas Chinese respondents prefer reductions based on historical emissions.

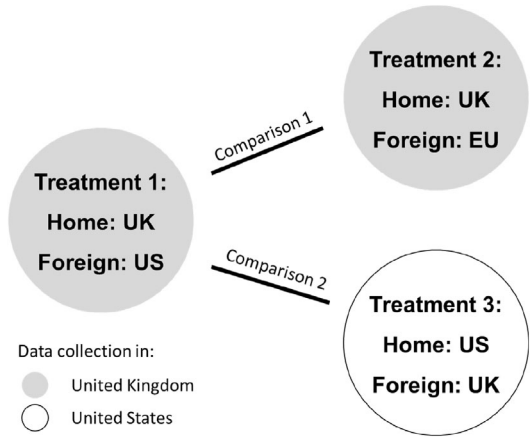

FIGURE 1 Diagram of treatment comparisons.

This is consistent with preferences for burden-sharing rules of IEA negotiators as elicited by Lange et al. (2010). The results of Ščasný et al. (2017) regarding public preferences for climate policies in three European countries suggest that preferences for the international distribution of the cost burden differ by country.

4 | METHODS

Building on this theoretical and empirical literature, this article seeks to answer three central questions related to equity preferences applied to transboundary management of marine plastics. We study these equity preferences as a key determinant of coalition forming for transboundary pollution control:

1. *What are preferences for cost-sharing arrangements in international efforts to reduce marine plastic pollution?* This question can be studied using all three treatments (Figure 1). Do respondents prefer their home country to always pay the lowest possible share or is there a preference for more equitable sharing of abatement costs? Moreover, do preferences vary depending on whether inequities are advantageous or disadvantageous to the "home" country?
2. *Do preferences for cost shares differ depending on the identities of the two countries (or groups of countries) involved?* This question is studied by comparing results across two treatments. Using Treatments 1 and 2, we examine whether preferences for cost-sharing arrangements of the UK samples differ when the partner country is the US or the EU (*Research Question 2a*).[4] In a second two-way comparison, we compare preferences for cost-sharing arrangements of the UK population with a view to the US and vice versa (*Research Question 2b*).
3. *Do preferences for cost allocations follow political voting patterns?* In each treatment, preferences of politically right- (Republican in the US; Conservative and others in the UK) and left-leaning voters (Democrat in the US; Labour and others in the UK) are compared. We hypothesize that left-leaning voters, on average, have stronger equity preferences (i.e., more inequality aversion) and therefore favor IEAs, which share abatement costs more equally. These results provide insight into whether it is possible to predict equity preferences across different countries based on the political affiliation of residents.

[4]Obvious differences exist with the US being located at a much greater distance to the UK than the EU, whereas population size is a lot more similar between the US and EU. Hence, there is reason to hypothesize that equity preferences might differ across country pairs.

4.1 | Theoretical model and choice experiment treatments

As a foundation for the treatment design of the choice experiment and econometric modeling, we use a simple theoretical model that describes household choices over prospective bilateral program to reduce marine plastics. To formalize the model, we begin with a simple random utility framework in which the utility for representative, domestic household n, from program alternative i, involving bilateral cooperation and cost-sharing with foreign country f, is given by

$$U_{nif}(X_{ni}) = V_{nif}\left(\boldsymbol{X_{nif}}\right) + \varepsilon_{nit}. \quad (1)$$

Equation (1) disaggregates total utility $U_{nif}(\cdot)$ into a deterministic component $V_{nif}(\cdot)$ defined by factors observable to the researcher and a stochastic component ε_{nit}, providing a link to the empirical model below. Vector $\boldsymbol{X_{ni}}$ represents a composite set of attributes that characterize program alternative i, including effects on marine plastic pollution in different domestic and foreign locations, cost sharing between countries and the direct cost of the policy to the household (after cost sharing). Subscripting utility with the identity of the collaborating foreign partner (f) allows domestic household utility from an otherwise identical program to vary as a function of the foreign partner with whom the agreement is made. This allows for the possibility that the household's utility for equity preferences and plastic reductions in the foreign country may depend on the identity of that country. For example, the UK public may have different preferences for cost sharing with the US versus the EU.

To further elaborate the model, we disaggregate composite vector $\boldsymbol{X_{ni}}$ into a set of subvectors $\boldsymbol{x_{nif}}$, $\boldsymbol{e_{nif}}$ and $\boldsymbol{c_{nif}}$, such that $\boldsymbol{X_{ni}} = \left[x_{nif}, e_{nif}, c_{nif}\right]$. Subvector $\boldsymbol{x_{nif}}$ represents biophysical plastic reductions in various domestic and foreign locations, such as domestic beaches and coastal waters in foreign country f. Subvector $\boldsymbol{e_{nif}}$ identifies how, proportionally, the total cost of the program is shared with country f. Finally, subvector $\boldsymbol{c}_{\text{nif}}$ represents the direct, binding cost to the domestic household required to implement the program in coordination with foreign country f, after all cost sharing has taken place. The model thereby allows for the possibility that—even for a given set of biophysical impacts and household costs—(1) utility may be influenced by the extent to which costs are shared with the foreign country, and (2) that utility impacts due to cost sharing may further vary with the identity of the foreign partner. It further allows us to disentangle (and thereby identify) preferences for how costs are allocated, apart from preferences for where pollution damage reductions occur.

To simplify the model, we assume that each individual household n chooses among different potential policies with the same foreign partner—such that the bilateral partner does not vary over alternatives presented to the same household. However, different households may be presented with options involving different foreign partners. For example, household $n = A$ may be presented with options only with foreign country $f = f_a$, whereas another household $n = B$ may choose over options with another foreign country $f = f_b$. In the choice experiment that follows below, these foreign partners vary systematically across survey treatments but are the same within each treatment. We also extend the basic model to allow multiple, independent policy choices by each household over different choice occasions t.

Grounded in Equation (1), household n is assumed to choose program alternative i over all other possible alternatives $j \neq i$ if $U_{nif}(\boldsymbol{X_{ni}}) > U_{njf}\left(\boldsymbol{X_{nj}}\right)$. Empirical specifications of (1) are estimated using models for discrete responses over households and policy scenarios, with assumptions regarding the unobservable component of utility, preference heterogeneity, and other model elements determining the most appropriate econometric approach (see Secton 4.4).

The theoretical framework presented above motivated the design of three treatments for the two-country choice experiment. Treatments 1 and 2 surveyed respondents in the UK; Treatment 3 surveyed respondents in the US (Figure 1).[5] Valuation scenarios in all treatments proposed alternative

[5]Note that the comparison between Treatments 1 and 3 can be interpreted akin to a benefits transfer exercise.

TABLE 1 Choice attributes and levels.

Attribute	Explanation	Levels	Coding
Beach	Reduction in the amount of plastic on UK [US East Coast] beaches (items per 100 meters)	Decrease of *0*%, 25%, 50%, 75%, 90%	Linear
Coastal	Reduction in the amount of plastic in UK [US] coastal waters (items per sq km)	Decrease of *0*%, 5%, 10%, 15%, 20%	Linear
Intl	Reduction in the amount of plastic in international waters (items per sq km)	Decrease of *0*%, 3%, 5%, 10%, 15%	Linear
Foreign	Reduction in the amount of plastic in US East Coast [UK] beaches and coastal waters (items per sq km)	Decrease of *0*%, 5%, 10%, 15%, 20%	Linear
Cost split	Percentage of program cost paid by UK (home country) and US (foreign country with whom costs are shared) (percentage of program cost paid by US [home country] and UK [foreign country])	*50*% home–*50*% foreign, 25% home–75% foreign, 75% home–25% foreign	Dummy
Cost	Cost to your household per year paid through an increase in annual taxes and fees	UK version: *£0*, £35, £60, £75, £150, £230 US version[a]: *$0*, $50, $80, $100, $200, $300	Linear

Note: Explanations given from the UK versions. Modifications for US version in square brackets. Status quo option in italics.
[a]These amounts are equivalent using a PPP exchange rate of USD $1 = GBP £0.699569.

bilateral program to reduce marine plastic pollution in the North Atlantic. Plastic reductions were described using a set of choice attributes that included a binding cost to each household required to implement the program. The only difference between treatments was the countries participating in the bilateral pollution reduction effort. Treatments 1 and 2, conducted in the UK, specified as the collaborating country the US and the EU respectively. Data in Treatment 3 was collected in the US and the partner country was the UK.

Three types of systematic comparisons are possible using this three-treatment design, motivated by our primary research questions above: First, equity preferences with respect to IEAs can be compared for program in the same country but with different partner countries (Comparison 1). Second, the same type of preferences can be compared for the two different perspectives of a bilateral IEA (Comparison 2). These two comparisons are illustrated in Figure 1. Third, within each treatment, one can evaluate whether preferences for cost allocations follow political (left vs. right) voting patterns.

4.2 | Choice experiment design

Grounded in the structure outlined above, the choice experiment at the core of the survey questionnaire included six attributes (Table 1). The scenario presented a bilateral marine plastics pollution reduction program. Alternatives were given generic titles (Option 1, 2 and 3), where Option 3 was a business-as-usual status quo with no change in marine plastic pollution and zero household cost. The first four choice attributes quantify reductions in plastic abundance in different locations. These reductions are stated both in terms of the absolute number of pieces of waste plastic and as percentage reductions relative to current levels (Figure 2).[6] Reductions of plastic on beaches (*beach*) and in

[6]Note that the baseline levels of pollution differ by country and hence by treatment. The design further implies that a joint UK–EU program is likely to have a different impact on the UK than a UK–US program in terms of cleanup and welfare. These are the biophysical realities against which any proposal for an IEA on marine plastics must be set. Moreover, this setting follows best-practice guidance for stated preference studies that emphasize the importance of accurate and credible (rather than counterfactual) presentations of baselines (Johnston et al., 2017) to ensure that the benefit assessments of this study are relevant to real-world policies.

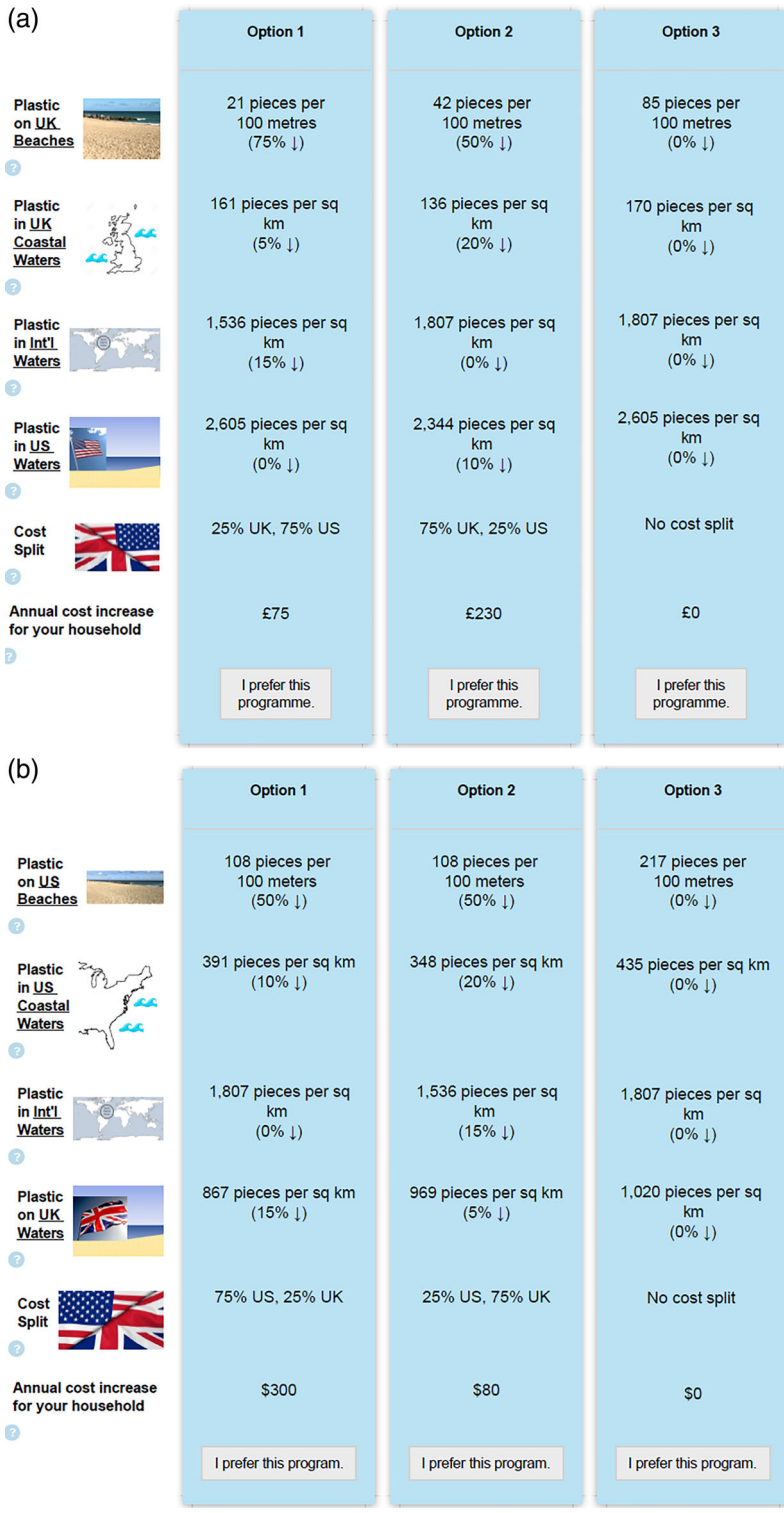

FIGURE 2 Example choice card Panel A: UK–US version (Treatment 1), Panel B: US-UK version (Treatment 2).

coastal waters (*coastal*) of the home country ranged from 0% to 90% and 0% to 20%, respectively.[7] Reductions in international waters (*intl*) and those of the partner country (*foreign*) ranged from 0% to 15% and 0% to 20%, respectively. Baselines and levels for these attributes were informed by data on current plastic levels in various marine and coastal environments, and modeling of potential changes in those levels that could occur due to changes in plastic disposal and cleanup (Eriksen et al., 2014; Jambeck et al., 2015). Arguably, preferences for changes in these attributes constitute the main welfare effects due to reductions in marine plastic pollution. The analysis of preferences of these biophysical reduction attributes will only be reviewed briefly here but is detailed in Meginnis, Börger, et al. (2022).

The focus of the present analysis is on preferences for cost-share arrangements as communicated by the attribute *cost split*. This attribute stipulates how the costs of the joint pollution reduction program would be allocated between partner countries. The baseline for *cost split* is an even or fully equitable split (50% for either country). Alternative levels are (1) 25% incurred by the home country and 75% by the respective partner country and (2) 75% for the home country and 25% for the partner country. In this design, the estimated preference weights for these two levels are indicators of the strength of (1) advantageous and (2) disadvantageous inequality aversion with respect to abatement cost sharing.

At this point, it is worth pointing out the difference between equity and reciprocity preferences.[8] Reciprocity is defined as behavior in response to some kind (or unkind) action (Falk & Fischbacher, 2006). It is therefore a response to the preceding action and its intention. Consequently, Falk and Fischbacher (2006) point out two elements necessary to explain reciprocal behavior: (i) the preceding action and (ii) the intention with which it was carried out. In this vein, experimental settings to assess equity preferences while avoiding confounding with reciprocity seek to isolate choices related to cost-sharing preferences from any type of strategic interaction. These choices are further framed as a situation akin to the one-shot sharing of a pie between two players (Blanco et al., 2011; Dannenberg et al., 2010). Following this approach, the questionnaire did not frame the cost-sharing attribute in a manner that could be interpreted as a reciprocal action in any way. It made no reference to the possible division of costs being proposed by the respective other nation or any other form of strategic interaction. Furthermore, in a series of preparatory focus groups to test the survey materials, reciprocity was not mentioned by participants as a potential concern or interpretation of the choice scenarios, with respect to the cost-share attribute (despite repeated probes regarding how respondents interpreted each attribute in the design and answered each choice question). Rather, these discussions focused solely on how costs were divided, paralleling the "pie-sharing" construct applied in the experimental literature. At the same time, we acknowledge the possibility that—despite the survey framing and evidence from focus groups—it is possible that at least some respondents might have considered issues such as reciprocity when answering choice questions. It is also worth noting that other often-considered, cost-sharing concepts, such as the polluter pays principle, have neither been proposed nor considered as a pragmatic foundation for marine plastics IEAs, as they would be difficult to implement in practice.[9,10]

The final attribute is the cost of the program to each household, paid through an increase in annual taxes and fees. This was presented as the binding cost to the household after all cost sharing.[11]

[7]This reflects the fact that removal of plastic pollution already in the natural environment is most effective on land, whereas necessary technology to clean up waterborne plastic waste is still under development.

[8]We thank two anonymous reviewers for pointing out the necessity for a clear distinction between these concepts.

[9]One reason for this is that the exact contributions of plastic pollution from different countries are still highly uncertain. Although there are a growing number of studies that attempt to quantify plastic flows from land to sea (e.g., Jambeck et al., 2015; Schmidt et al., 2017), the stipulation of an IEA based on the polluter pays principle would require much more detailed quantifications than these, because it would also involve agreeing a set of transfer coefficients, which represent how plastics are transported across the world's oceans.

[10]In addition, participants in preparatory focus groups conducted in the UK and US did not raise the issue of the polluter pays principle or other cost-sharing rules. We interpret this as an indication that the limited selection of cost-sharing rules in the experimental design was taken "as given" by survey respondents and did not impair the validity of the choice responses.

[11]Respondents were not provided any information or indication of actual or potential program costs in the aggregate (i.e., total country-wide or multinational costs)—only the cost share proportions and cost to their individual household. They were further not given information as to the absolute or relative emissions of waste plastic into the North Atlantic (or any other sea) by the participating countries.

Survey materials were developed over a roughly 2-year period from February 2019 to November 2020. The questionnaire and choice experiment section were tested and iteratively revised with input from eight focus groups (4 in the UK, 4 in the US).[12] A pilot survey was carried out with 400 participants in the UK and the US. The experimental design (used to assign attribute levels within each choice scenario) was developed using a Bayesian Db-efficiency criterion for a choice model covariance matrix (Scarpa & Rose, 2008). Diffuse priors were applied (Ferrini & Scarpa, 2007), with signs based on information from focus groups, expert opinion, and theory. Estimated preference weights from the pilots were used to further refine the experimental design. This resulted in a design with a total of 75 profiles blocked into 15 survey versions, each with five choice tasks, the order of which was randomized across respondents. The survey was hosted using Lighthouse Studio (Sawtooth, 2018).

The survey incorporated multiple elements to support valid preference elicitation, following recommended practices (Johnston et al., 2017). These included prompts and acknowledgement questions to emphasize payment and policy consequentiality, reminders of the household's budget constraint, an overview of valid reasons why a household might vote for either Option 1, 2 or 3, and a reminder that "Whatever your reasons, choosing either Option 1, 2, or 3 is legitimate." Respondents were instructed to consider each choice question as an independent and hypothetically binding vote. To emphasize consequentiality, respondents were informed that the survey "has been developed in partnership with government officials who will consider survey results in making their decisions." The choice was framed as a vote between the three competing policy options in each question. Each questionnaire presented the five value-elicitation questions, along with (a) instructions and information summarized above, (b) supporting informational materials, (c) ancillary and supporting questions. Questions were also included to evaluate response quality and identify/screen fraudulent responses (e.g., bot responses).

4.3 | Survey implementation

The main survey was implemented during March 2021, using opt-in internet panels in both the US and UK. For all treatments, respondents were sampled randomly by a survey firm with quotas for age group, gender, and region to approximately represent the distribution of these demographic characteristics across the two populations. In the UK, respondents from the entire country were sampled, whereas in the US only participants from states on the eastern seaboard were recruited.[13] Originally, the two UK samples had 2028 and 2050 cases, respectively.[14] The US sample included 2662 responses. Respondents who did not state information on their preference for a political party[15] were removed, resulting in the treatment sizes displayed in Table 2.[16]

4.4 | Empirical model

Grounded in the theoretical framework presented above, choice responses are analyzed based on an empirical random utility model (RUM) (McFadden, 1974) according to which the utility of respondent n from selecting alternative i in choice occasion t is

[12]The focus groups also explored whether the valuation scenarios were clear and credible for respondents. This provided strong qualitative evidence that (a) respondents viewed the scenarios as credible, (b) they understood the scenarios including different baselines, and (c) importantly, that they considered implications for their welfare.

[13]Connecticut, Delaware, Florida, Georgia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Virginia, Washington DC.

[14]Because the survey was conducted online using an online panel in both countries (now a very common means of survey implementation for choice experiments, see Johnston et al., 2017, p. 342), no response rate as such can be reported. Instead, the respective survey companies continued to sample from their existing panels until the predetermined quote in terms of gender and age groups were complete.

[15]In case respondents did not vote in previous elections, this variable recorded which party they would have voted for.

[16]We did not remove any potential protest respondents prior to analysis. Instead, potential protest respondents and those doubting the effectiveness of the proposed measures were identified by means of three alternative protocols. MXL models run after the removal of each of these groups of respondents yield virtually the same results. These additional models are available from the authors on request.

TABLE 2 Descriptive statistics of treatment samples.

Variable name	Treatment 1: UK–US $N = 2014$		Treatment 2: UK–EU $N = 2033$		Treatment 3: US–UK $N = 2662$	
	Cases	*Share*	*Cases*	*Share*	*Cases*	*Share*
Female	1004	50%	981	48%	1084	50%
Age class						
18–24	243	12%	214	11%	36	1%
25–34	357	18%	357	18%	120	5%
35–44	308	15%	372	18%	342	13%
45–54	363	18%	326	16%	226	8%
55–64	332	16%	334	16%	709	27%
65–74	318	16%	328	16%	805	30%
Above 75	93	5%	101	5%	424	16%
Income brackets						
under $15,000/£12,500	263	13%	262	13%	103	4%
$15,001–24,999/£12,501–20,000	285	14%	315	15%	151	6%
$25,000–34,999/£20,001–30,000	445	22%	450	22%	151	6%
$35,000–49,999/£30,001–50,000	547	27%	487	24%	287	11%
$50,000–74,999/£50,001–70,000	256	13%	270	13%	475	18%
$100,000–149,999/£70,001–100,000	143	7%	168	8%	450	17%
$150,000–199,999/£100,001–150,000	51	3%	63	3%	589	22%
$150,000–199,999/£150,000 +	24	1%	18	1%	229	9%
$200,000+	0	0%	0	0%	170	6%
Prefer not to state	0	0%	0	0%	47	2%
Educational attainment						
No formal qual	80	4%	91	4%	2	0%
GCSE/Olevel/less than HS	384	19%	404	20%	22	1%
A-levels/HS segree	329	16%	343	17%	555	21%
Diploma/NVQ/other tech/associate	332	16%	334	16%	385	14%
Bachelor's	599	30%	548	27%	937	35%
Master's	226	11%	247	12%	592	22%
Doctorate	64	3%	66	3%	153	6%
Prefer not to state	0	0%	0	0%	12	0%

Note: Percentages may not add up exactly to 100% due to rounding. GCSE- General Certificatee of Secondary Education. NVQ-National Vocational Qualification

$$U_{nit} = \boldsymbol{\beta}_n' \boldsymbol{X_{nit}} + \varepsilon_{nit} = V_{nit} + \varepsilon_{nit}. \quad (2)$$

$\boldsymbol{X_{nit}}$ is a vector recording attribute levels of option i and $\boldsymbol{\beta_n}$ is a conforming vector with estimable coefficients. These form the observable component V_{nit} of utility. ε_{nit} is an alternative-specific error term that is assumed to follow a Type 1 Extreme Value distribution. Assuming further that respondent n in each choice situation $t = 1,\ldots,T$ selects the alternative which maximizes her utility, the joint probability of a series of choices $\boldsymbol{y_n} = \langle y_{nt},\ldots,y_{nT} \rangle$ is

$$Pr(\boldsymbol{y_n}|\boldsymbol{X_n}) = \prod_{t=1}^{T} \frac{e^{\mu V_{nit}}}{\sum_{j=1}^{J} e^{\mu V_{njt}}}. \quad (3)$$

Here, μ is a scale parameter that is inversely proportional to the variance of ε, that is, $\mu = \pi\left(6\sigma_{\varepsilon}^2\right)^{-0.5}$, and usually normalized to 1 in choice modeling applications. We further allow for the elements of $\boldsymbol{\beta_n}$ to follow a random distribution to reflect potentially heterogeneous preferences across respondents. To this end, the joint density of the elements of $\boldsymbol{\beta_n}$ can be expressed as $f(\boldsymbol{\theta_n}|\Omega)$, where $\boldsymbol{\theta_n}$ is a vector of random coefficients and Ω is a parameter of the distributions. Specifically, we assume the coefficients of all but the cost attribute to follow a normal distribution. For the cost estimate a lognormal distribution is assumed. This yields the standard mixed logit model (Train, 2009) where the probability of $\boldsymbol{y_n}$ is

$$Pr(\boldsymbol{y_n}|\boldsymbol{X_n},\Omega) = \int \prod_{t=1}^{T} \frac{e^{V_{nit}}}{\sum_{j=1}^{J} e^{V_{njt}}} f(\boldsymbol{\theta_n}|\Omega) d(\boldsymbol{\theta_n}). \quad (4)$$

Because this model does not have a closed-form solution, simulated maximum likelihood is used to estimate $\boldsymbol{\beta_n}$. We use 1000 Sobol draws to simulate likelihood. Models are run in R (R Core Team, 2017) using the package "Apollo" (Hess & Palma, 2019, 2021).

5 | RESULTS

5.1 | Preferences for reductions in marine plastic pollution and cost-share agreements

We begin with a brief review of preferences for plastic reductions in the baseline mixed logit models for each treatment (Table 3). Across all treatments, preferences for reductions in plastic pollution across different marine areas—beaches (*beach*) and coastal waters (*coastal*) of the respective home country, and international waters (*intl*)—are significant and similar in magnitude. On average, respondents prefer higher percentages of pollution reduction in these areas. An exception from this general pattern are preferences for plastic reductions on beaches and in coastal waters of the respective foreign county (*foreign*). Although these are insignificant in Treatments 1 and 2, they are significant in Treatment 3. Unlike respondents in the UK with a respective view to the US and the EU, US respondents place a positive value on plastic reduction on UK beaches and in coastal waters. The parameter "none" is negative and comparably large in all treatments indicating a strong preference for one of the program alternatives. The estimated standard deviations of this random parameter are also substantial, which means that there is a high degree of variation in the support for the program alternatives, which is analyzed in more detail in Meginnis, Börger, et al. (2022).

The primary focus of the analysis, however, is the three research questions on equity preferences. Turning to Research Question 1, results in Table 3 show that preferences for cost shares are not monotonic in the share borne by the respective home country. Instead, respondents in all countries prefer greater equity, that is a 50–50 split. Across all treatments, preference weights for both the 25% (*csplit_25home*) and 75% contribution of the home country (*csplit_75home*) over the omitted baseline arrangement (i.e., a 50–50 split) are negative and significant. However, although preferring an equitable cost share, there is clear evidence that UK respondents do not wish to bear a greater share of program costs; The parameter on *csplit_75home* is substantially larger than the one for *csplit_25home* in both UK treatments (1 and 2). In contrast, respondents in the US sample in Treatment 3 are indifferent between a

TABLE 3 Baseline mixed logit models in each treatment.

	Treatment 1: UK–US		Treatment 2: UK–EU		Treatment 3: US–UK	
Variable name	**Coef.**	**s.e.**	**Coef.**	**s.e.**	**Coef.**	**s.e.**
Mean of random parameters						
None	−3.578***	(0.190)	−4.214***	(0.211)	−3.736***	(0.172)
Beach	0.010***	(0.001)	0.009***	(0.001)	0.012***	(0.001)
Coastal	0.022***	(0.004)	0.019***	(0.004)	0.024***	(0.003)
Intl	0.018***	(0.004)	0.016***	(0.004)	0.021***	(0.004)
Foreign	0.002	(0.003)	0.004	(0.003)	0.007**	(0.003)
Csplit_25home	−0.134***	(0.056)	−0.119**	(0.063)	−0.320***	(0.054)
Csplit_75home	−0.464***	(0.066)	−0.370***	(0.067)	−0.315***	(0.057)
Cost	−3.672***	(0.066)	−3.555***	(0.061)	−3.365***	(0.075)
Standard deviation of random parameters						
None	−3.482***	(0.214)	−3.505***	(0.235)	2.839***	(0.200)
Beach	−0.013***	(0.002)	0.016***	(0.002)	−0.018***	(0.001)
Coastal	−0.038***	(0.010)	0.048***	(0.009)	−0.043***	(0.008)
Intl	0.030***	(0.013)	0.029**	(0.015)	−0.028**	(0.016)
Foreign	0.010*	(0.007)	−0.014	(0.018)	−0.015	(0.029)
Csplit_25home	−0.188	(0.383)	−0.732***	(0.142)	0.692***	(0.119)
Csplit_75home	−0.720***	(0.146)	−0.590***	(0.173)	0.748***	(0.127)
Cost	1.689***	(0.065)	1.721***	(0.055)	2.428***	(0.096)
Number of individuals	2014		2033		2661	
Log-likelihood	−7622		−7561		−9777	
Adj. rho-square	0.307		0.320		0.327	
BIC	15,391		15,269		19,706	

Note: ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. none: alternative-specific constant of the opt-out alternative; beach/coastal/intl/foreign: percentage reduction of plastic on beaches/in coastal waters /in international waters/in foreign waters; csplit_25home/csplit_75home: Home country incurs 25%/75% of the program costs; cost: cost attribute in GBP.

US contribution of 25% or 75% in a joint program with the UK. The simulated 95% confidence intervals of the difference between the two parameters are [0.201–0.460] for Treatment 1 and [0.116–0.389] for Treatment 2, hence both differences are significant. These findings provide robust evidence of preferences for equal contributions by the collaborating countries in a future IEA.

Another way of considering these preferences is by way of marginal WTP for different cost share arrangements (Figure 3). Because marginal WTP of attribute level k is calculated as $mWTP_k = -\beta_k/\beta_{cost}$, where β_k and β_{cost} are the estimated preference weights on the attribute and cost, respectively, these figures are unconfounded by scale factor μ, which cancels out in this calculation. Estimates of marginal WTP are thus comparable quantitatively across models. On the other hand, the fact that WTP estimates are influenced by both β_k and β_{cost} may dilute the pure differences in preferences for cost share arrangements to some extent.

We report estimates of medians of the simulated distributions of marginal WTP, because they are unaffected by the potentially long tail of these distributions, which is a result of the assumed lognormal distribution of the cost parameter.[17] Consistent with the signs of the preference-space utility parameters

[17]Additional models were run in WTP space (Train & Weeks, 2005). Resulting estimates of mean marginal WTP for *csplit_25home* and *cs_75home* are somewhat lower than the medians reported in the paper but exhibit an identical relative pattern (comparing within and across treatments). These estimates, which show worse fit to the data compared to the models in Table 3, are available from the authors on request. Hence, the findings of the analysis are robust whether one assesses impacts on mean or median WTP.

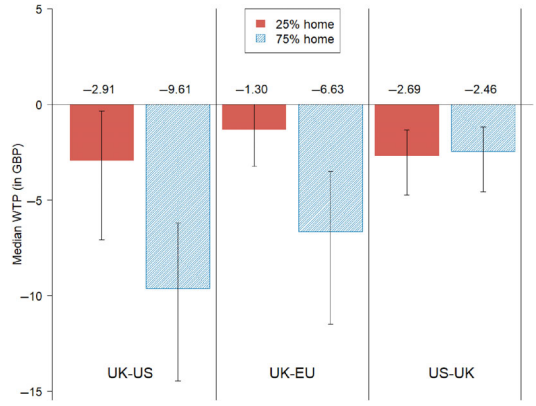

FIGURE 3 Median marginal willingness to pay (WTP) for the "25% home" and "75% home" cost share scheme (compared to the 50–50 baseline) across treatments. Note: 95% confidence intervals are simulated using the procedure suggested by Krinsky and Leslie Robb (1986).

discussed above, median marginal WTP for a home country cost share of 25% (compared to the 50–50 baseline) is negative throughout. This aversion to advantageous inequality is strongest in Treatment 3 (the US sample) and lower in the two UK samples. The WTP for a home country share of 75% may be interpreted as a measure of disadvantageous inequality aversion. It is higher than the WTP for a "25% home" share in the UK Treatments 1 and 2 (complete combinatorial test (Poe et al., 2005): Treatment 1: $p < 0.001$; Treatment 2: $p = 0.002$) but statistically equivalent in the US treatment ($p = 0.425$). Across treatments, the negative marginal WTP estimates for "25% home" do not differ significantly (Treatment 1 vs. 2: $p = 0.229$; Treatment 1 vs. 3: $p = 0.529$; Treatment 2 vs 3: $p = 0.112$). Marginal WTP for "75% home" differs significantly only between Treatments 1 and 3 ($p < 0.001$) and 2 and 3 ($p = 0.014$).

So regarding effects of partner-county identity (Research Question 2a), comparison of the treatments conducted in the UK (Treatments 1 and 2) reveals no differences in average preference patterns. On average, UK respondents prefer a 50–50 split to a 25% contribution by the home country, with a 75% contribution as the least-preferred cost sharing arrangement. This ranking is independent from whether the cost share is part of a joint program with the US or the EU.

With respect to the direction of collaboration, preference patterns in Treatments 1 and 3 reveal a difference. These differences in WTP are driven by changes in cost sensitivity and genuinely different preferences for the cost share arrangements. The average US respondent is indifferent between the home country contributing 25% or 75%. In contrast, the average UK respondent clearly prefers a 25% contribution over a 75% contribution. However, both nonequal cost share options are less attractive than a 50–50 split, across all treatments. This equal program cost share is valued most highly in both countries, however marginal WTP differs somewhat.[18] Hence, for Research Question 2b, we find that average preferences differ when comparing the two different directions of a two-way partnership (UK considering the US vs. the US considering the UK).

5.2 | Predicting outcomes of referenda on IEA adoption

The above results illustrate whether equity preferences have statistically significant impacts on marginal utilities and WTP. However, they do not yet address the question of whether these effects

[18]The quantitative differences in cost share preferences are genuine differences in equity preferences between the two samples as demonstrated by the significant interaction effects of *csplit_25home* and *csplit_75home* in the pooled model (Table A1).

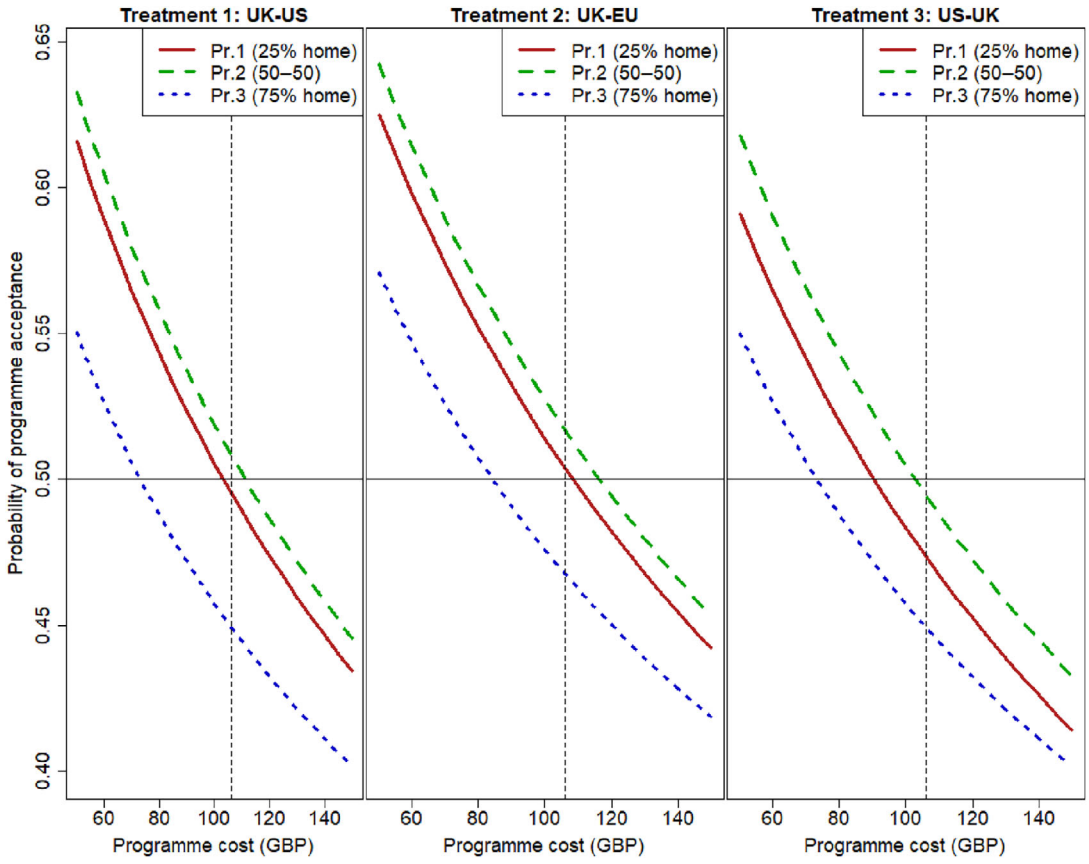

FIGURE 4 Average choice probabilities of different policy program against a "do-nothing" alternative as function of program cost

might have a substantive (or meaningful) effect on whether voters might approve different types of bilateral agreements (i.e., the probability that a bilateral marine plastics reduction program would obtain a majority if a referendum were held in the respective "home" country). To illustrate these effects, three possible program are evaluated in turn against a status quo "do-nothing" alternative. For the sake of illustration, each pollution reduction program sets the level of reductions on beaches, coastal, international and foreign waters to 50%, 10%, 5%, and 10%, respectively.[19] In addition, the cost-share attribute in the program are set as follows:

- Program 1: 25% home, 75% foreign
- Program 2: 50% home, 50% foreign
- Program 3: 75% home, 25% foreign

Choice probabilities are simulated for different household-level program costs ranging from GBP £50 to £150 and are averaged across respondents and choice tasks (Figure 4). Unsurprisingly, the probability of a program being accepted in a binary referendum, that is, obtaining an absolute majority (or average choice probability > 0.5) decreases as a function of cost. However, the maximum cost at which at least 50% of respondents would vote in favor of the program differs across treatments and program. If, for instance, a program of this type at a cost of £106 per annum (PPP equivalent to

[19]Note that other levels of these attributes could have been chosen for this exercise.

TABLE 4 Respondent stratification according to political party association.

Treatment	Type of voter	Respondents	Share of respective treatment
1: UK–US ($n = 2014$)	Left leaning[a]	1349	67%
	Right leaning[b]	665	33%
2: UK–EU ($n = 2033$)	Left leaning[a]	1342	66%
	Right leaning[b]	691	34%
3: US–UK ($n = 2661$)	Democrat	1101	41%
	Republican	830	31%
	Independent[c]	730	27%

[a]including Labour, Liberal Democrat, SNP, Plaid Cymru, Alliance, SDLP, SDP, Sinn Fein, SWP, Yorkshire Party, Libertarian Party, Volt.
[b]including Conservative, DUP, UUP, OUP, NIP, Brexit Party, UKIP, BNP, Heritage Party.
[c]including American, Conservative, Constitution, Federalist, Libertarian Parties.

TABLE 5 Separate mixed logit models for left-leaning and right-leaning voters in Treatment 1 (UK–US).

	Left-leaning voters		Right-leaning voters	
Variable name	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Mean of random parameters				
None	−3.354***	(0.213)	−3.832***	(0.360)
Beach	0.010***	(0.001)	0.009***	(0.002)
Coastal	0.024***	(0.004)	0.018***	(0.006)
Intl	0.022***	(0.005)	0.007	(0.007)
Foreign	0.003	(0.004)	−0.002	(0.006)
Csplit_25home	−0.156**	(0.069)	−0.074	(0.100)
Csplit_75home	−0.472***	(0.078)	−0.460***	(0.127)
Cost	−3.703***	(0.071)	−3.623***	(0.098)
Standard deviation of random parameters				
None	−3.164***	(0.294)	4.215***	(0.389)
Beach	−0.014***	(0.002)	−0.010***	(0.003)
Coastal	0.042***	(0.013)	0.016	(0.033)
Intl	−0.037**	(0.016)	−0.011	(0.022)
Foreign	0.001	(0.013)	0.017	(0.014)
Csplit_25home	−0.287	(0.417)	0.155	(0.434)
Csplit_75home	0.323	(0.335)	1.127***	(0.216)
Cost	1.731***	(0.074)	1.601***	(0.084)
Number of individuals	1349		665	
Log-likelihood	−5143		−2468	
Adj. rho-square	0.304		0.320	
BIC	10,427		5066	

Note: *** ** indicate significance at the 1% and 5% levels, respectively. none: alternative-specific constant of the opt-out alternative; beach/coastal/intl/foreign: percentage reduction of plastic on beaches/in coastal waters/in international waters/in foreign waters; csplit_25home/csplit_75home: Home country incurs 25%/75% of the program costs; cost: cost attribute in GBP.

USD $144) is considered, the type of cost share arrangement has relevant impacts on approval, but only in the UK. In the US sample (Treatment 3), no cost share arrangement would lead to a 50% majority of votes for this program. A majority of UK respondents would vote for a joint program with the US (Treatment 1) if costs were shared equally but not if any other cost shares were proposed. If the country were a joint program with the EU (Treatment 2), however, a majority of UK

TABLE 6 Separate mixed logit models for left-leaning and right-leaning voters in Treatment 2 (UK–EU)

	Left-leaning voters		Right-leaning voters	
Variable name	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Mean of random parameters				
None	−4.268***	(0.265)	−4.182***	(0.363)
Beach	0.01***	(0.001)	0.008***	(0.002)
Coastal	0.02***	(0.004)	0.014**	(0.007)
Intl	0.014***	(0.005)	0.018**	(0.008)
foreign	−0.001	(0.004)	0.015**	(0.006)
Csplit_25home	−0.139**	(0.072)	−0.066	(0.127)
Csplit_75home	−0.281***	(0.077)	−0.566***	(0.132)
Cost	−3.697***	(0.076)	−3.267***	(0.107)
Standard deviation of random parameters				
None	−3.494***	(0.252)	−3.576***	(0.415)
Beach	0.015***	(0.002)	−0.014***	(0.003)
Coastal	−0.039***	(0.012)	−0.067***	(0.016)
Intl	−0.036***	(0.014)	0.026	(0.023)
Foreign	0.014*	(0.010)	−0.03**	(0.018)
Csplit_25home	0.555***	(0.167)	−1.229***	(0.234)
Csplit_75home	−0.353	(0.331)	−0.768***	(0.277)
Cost	1.793***	(0.060)	1.597***	(0.090)
Number of individuals	1342		691	
Log-likelihood	−5071		−2469	
Adj. rho-square	0.310		0.345	
BIC	10,284		5068	

Note: ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. none: alternative-specific constant of the opt-out alternative; beach/coastal/intl/foreign: percentage reduction of plastic on beaches/in coastal waters/in international waters/in foreign waters; csplit_25home/csplit_75home: Home country incurs 25%/75% of the program costs; cost: cost attribute in GBP.

respondents would vote for the program with an equal cost split and one in favor of the home country (25–75). Although these differences in predicted referendum outcomes are rather small, this exemplary scenario analysis nevertheless illustrates that, under certain circumstances, the type of cost share arrangement may be the decisive factor as to whether a country takes a democratic decision to enter into an IEA to reduce marine plastic pollution. In sum, depending on the specific preference structure of the population, there may be policy scenarios where an "appropriate" cost-sharing rule decides whether approval is under or over 50% of the electorate.

5.3 | Heterogeneity and determinants of preferences for cost-share arrangements

We now turn to Research Question 3, addressing whether cost-share preferences differ between respondents who support different political parties. For this analysis we will only consider the measure of advantageous inequality aversion.[20] At the end of the online questionnaire, respondents were

[20]This is arguably the more relevant type of inequality aversion because such equity preferences involve a real trade-off in the sense that individuals prefer a more equal distribution of costs even though this comes at a higher absolute cost to their respective home country. In contrast, for disadvantageous equality aversion it is not clear whether such preferences are motivated by a genuine aversion against inequality or the fact that the unequal distribution disadvantages the respective home country or both. WTP estimates for the "75% home" cost-share arrangement as an indicator of the strength of disadvantageous inequality aversion of different voter groups are displayed in Figure A1 in the Supplementary Materials for completeness.

TABLE 7 Separate mixed logit models for left-leaning and right-leaning voters in Treatment 3 (US-UK).

	Left-leaning (Dem) voters		Right-leaning (Rep) voters		Independent voters	
Variable name	**Coef.**	**S.E.**	**Coef.**	**S.E.**	**Coef.**	**S.E.**
Mean of random parameters						
None	−3.597***	(0.268)	−3.607***	(0.310)	−4.184***	(0.424)
Beach	0.011***	(0.001)	0.010***	(0.002)	0.020***	(0.003)
Coastal	0.022***	(0.005)	0.018***	(0.006)	0.037***	(0.008)
Intl	0.021***	(0.005)	0.010*	(0.006)	0.035***	(0.009)
Foreign	0.010***	(0.004)	0.000	(0.005)	0.009*	(0.007)
Csplit_25home	−0.371***	(0.078)	−0.163*	(0.099)	−0.457***	(0.130)
Csplit_75home	−0.310***	(0.074)	−0.245**	(0.107)	−0.438***	(0.163)
Cost	−3.959***	(0.119)	−3.015***	(0.120)	−2.822***	(0.151)
Standard deviation of random parameters						
None	−2.581***	(0.472)	−2.959***	(0.344)	3.553***	(0.421)
Beach	−0.017***	(0.002)	−0.017***	(0.003)	−0.024***	(0.004)
Coastal	0.036***	(0.013)	−0.025*	(0.016)	0.067***	(0.018)
Intl	0.049***	(0.013)	−0.004	(0.005)	−0.053*	(0.034)
Foreign	0.004	(0.011)	0.024	(0.026)	0.042**	(0.019)
Csplit_25home	−0.670***	(0.171)	−0.738***	(0.214)	−0.694**	(0.342)
Csplit_75home	−0.299	(0.298)	−0.527*	(0.374)	1.719***	(0.283)
Cost	2.291***	(0.180)	2.395***	(0.129)	2.337***	(0.139)
Number of individuals	1101		830		730	
Log-likelihood	−4319		−2917		−2477	
Adj. rho-square	0.283		0.357		0.378	
BIC	8775		5968		5085	

Note: ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively. none: alternative-specific constant of the opt-out alternative; beach/coastal/intl/foreign: percentage reduction of plastic on beaches/in coastal waters/in international waters/in foreign waters; csplit_25home/csplit_75home: Home country incurs 25%/75% of the program costs; cost: cost attribute in GBP.

asked "Which political party do you associate with most?" Responses to this question can be used to classify respondents according to their voting preferences as left leaning or right leaning (Table 4). For the UK samples (Treatments 1 and 2) this means grouping Labour, Liberal Democrat, Scottish National Party and other left-of-center parties as left-leaning. Conservative and voters of other regional or right-wing parties are classified as right-leaning. For the US sample (Treatment 3) respondents are grouped as Democrat (i.e., left-leaning), Republican (i.e., right-leaning) or Independent voters. Only the former two are considered in the subsequent analysis.[21]

Separate mixed logit models for different voter groups in each treatment are displayed in Tables 5–7. Based on these models, Figure 5 reports median marginal WTP for the "25% home" cost-share arrangement over the 50–50 baseline as an indicator of the strength of disadvantageous inequality aversion. In the UK, we do not find statistically significant differences across voter groups using the complete combinatorial method (Poe et al., 2005). In Treatments 1 (UK–US) and 2 (UK–EU), the differences between WTP distributions are insignificant ($p = 0.263$ and $p = 0.170$, respectively).

[21]We also examined whether other respondent characteristics, such as age, income, and awareness for the issue affect program and cost-share preferences. Results (available from the authors on request) show heterogeneous age effects across treatments, whereas higher income respondents and those who are aware of plastics pollution consistently prefer any program. The latter two variables do not affect cost-share preferences. However, political affiliation is arguably the most important characteristic because voting outcomes determine governments and that in turn determines to what extent a certain government may enact the perceived preferences of its voters.

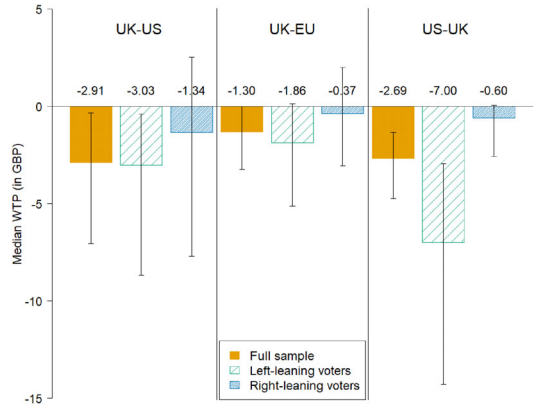

FIGURE 5 Median marginal willingness to pay (WTP) for the "25% home" cost share scheme (compared to the 50–50 baseline) for different subgroups of respondents. Note: 95% confidence intervals are simulated using the procedure suggested by Krinsky and Leslie Robb (1986). In the US–UK treatment, Independent voters are left out.

It should be noted however, that in the UK–US treatment, WTP for the "25% home" cost split is significantly different from zero only for left-leaning voters. For right-leaning voters WTP is virtually zero, and hence this group does not exhibit any advantageous inequality aversion. This pattern also shows in Treatment 2 with the only difference that WTP for left-leaning voters is significantly different from zero only at the 10% level. Yet here too, the WTP as an indicator of advantageous inequality aversion of right-leaning voters is practically zero.

In the US sample, equity preferences of left-leaning (i.e., Democrat) voters are much stronger than those of right-leaning (i.e., Republican) voters. This difference is significant according to the Poe test ($p < 0.001$). In addition, the differences in the WTP of Democrat and Republican voters each from the sample mean of −2.69 are both significant ($p = 0.033$ for Democrat; $p = 0.036$ for Republican). This finding confirms our conjecture that left-leaning voters display much stronger inequality aversion. In this treatment we also see that the WTP for the "25 home" cost-share arrangement is not significantly different from zero for right-leaning voters, indicating that their WTP for a cost split, which is equal at the expense of the home country paying more is practically zero.

6 | DISCUSSION AND CONCLUSIONS

This paper investigates public preferences for cost sharing arrangements in IEAs to curb marine plastics pollution in the North Atlantic. This issue has important implications for current efforts by UNEP and others to control this important transboundary pollutant (OSPAR, 2022; UNEP, 2022), because (i) effective control of marine plastics requires the cooperation of many countries (Borrelle et al., 2017; UN News, 2022), and (ii) economic theory suggests that equity preferences with respect to burden sharing are key determinants of the potential size and stability of coalitions for such IEAs (Welsch, 1993; Lange & Vogt, 2003; Lange, 2006; Vogt, 2016,). Although focused primarily on implications for marine plastics, our paper also presents the first study of equity preferences toward cost-sharing arrangements outside the context of global climate change.

Results are promising with respect to the presence of the type of pro-equity preferences necessary to support IEA coalitions. For example, results show robust public aversion to both advantageous and disadvantageous inequality with respect to the sharing of abatement costs in a bilateral IEA. This result is unaffected by the identity of the partner country (evidenced by comparing Treatments 1 and 2) and by the direction of cooperation (as shown in the comparison of Treatments 1 and 3). In sum, we find strong and robust evidence of the type of equity

preferences (at least among the general public) necessary to support a larger coalition size and greater stability of an IEA for transboundary pollution reductions. We also find that these preferences can be of sufficient magnitude to influence whether such IEAs would gain majority support in a public referendum.

These results stand in contrast to preferences for cost burden sharing found previously in the context of GHG emission reductions. Other experimental and survey-based studies have reported evidence for equity preferences in line with economic self-interest of the respective country for the case of climate negotiators globally (Lange et al., 2010), climate experts and students (Brick & Visser, 2015), and the public in the US and China (Carlsson et al., 2013). This is bad news given the theoretical importance of aversion particularly to advantageous inequality for internal stability of coalitions (Vogt, 2016). However, as evidenced by the current study, this result is different for the case of marine plastic pollution where the public, at least for the bilateral case of the UK and US, prefer equal sharing of abatement costs even if that means accepting a higher contribution of the "home" country to the overall costs of pollution reduction.

We also find evidence of differences between countries in preferences toward different directions of inequality. Similar aversion to both advantageous and disadvantageous inequality was found in the US. However, UK respondents display much stronger aversion to disadvantageous than toward advantageous inequality. Results further indicate that, at least for the case of the UK, equity preferences do not differ across different potential partner countries (here, the US versus EU).

Analysis of preference patterns within each treatment sample reveals stronger equity preferences of left-leaning voters. This effect is most pronounced in the US where Democrat voters have much stronger preferences for an even split of abatement costs compared to Republican voters. In the UK treatments, the picture tends to confirm this finding, yet the differences between voter groups in (negative) WTP for either type of unequal distribution of program costs are insignificant.

Multiple caveats should be considered when interpreting our empirical results. The results presented here should be interpreted within the context of our present case study, the bilateral nature of the (hypothetical) IEA used in the experimental design, and the sample of respondents. For example, the equity preferences elicited with this experimental design are necessarily limited by the cost-sharing options offered in the choice experiment. Our results further reflect the realized sample of survey responses from a set of opt-in internet panels. Although sample demographics appear to be reasonably representative of the sampled areas (Table 1), stated-preference surveys rarely produce samples that are perfectly representative of the target population over both observable and unobservable dimensions (Johnston & Abdulrahman, 2017). In addition, although multiple steps were taken to produce a choice experiment with high consequentiality and content validity, three-alternative choice experiments (the most common structure in environmental economics applications) cannot be considered strictly incentive compatible unless (among other requirements) respondents have uniform priors concerning the preferences of other decision makers (Collins & Vossler, 2009). The presented results should be interpreted accordingly.

These caveats notwithstanding, the presented study provides clear evidence that cost-sharing equity preferences are an important dimension of preferences for transboundary pollution control. Given the difficulties in determining the relative physical contributions of different countries to both the flow and the stock of marine plastics pollution, these results are relevant for ongoing negotiations led by UNEP to agree a plastics IEA by the year 2024. Moreover, although respondents in both the sampled countries appear to support more equitable cost sharing, other aspects of these preferences differ markedly between countries (e.g., preferences for advantageous versus disadvantageous inequality). Results such as these indicate caution when seeking to draw conclusions about equity preferences in particular countries based on results found elsewhere.

As a final note, we emphasize that these results also suggest the potential hazards in omitting information on cost-sharing proportions from choice experiments (or binding referendums) addressing program that require international collaboration. Results here suggest that respondents' choices and preferences over such program likely depend on cost-sharing considerations. This is in line with previous findings on equity preferences with respect to climate change IEAs (Cai et al., 2010). If these considerations are not stated clearly within choice (or real-world referendum) scenarios, respondents might condition their choices on unobservable speculations regarding the type of cost sharing that might occur. To the extent that these speculations differ from actual cost-sharing provisions, such circumstances might lead to misguided inferences.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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