# Model Use in Sustainability Negotiations and Decisions

by

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# Abstract

Sustainability negotiations and decisions require the integration of scientific information with stakeholder interests. Mathematical models help elucidate the physical world and therefore may orient the negotiators in a shared understanding of the physical world. Many researchers suggest collaborative modeling to facilitate integrating scientific information and stakeholder interests. In this thesis, I use methods that enable repeated instances of the same decision; the exploration of alternatives to model use (e.g. learning of a model's logic, relevant information, or irrelevant information); and the exploration of alternatives to collaborative modeling (e.g. using an expert model or not using a model). This thesis comprises two studies that use serious game role-play simulations. The first study is a computer-driven role-play simulation of governmental policy creation and the second is a five-party role-play simulation to negotiate a more sustainable end-of-life for used paper coffee cups. In the first study, model users reached the Pareto Frontier—the set of non-dominated points—more readily (13%) than non-model-users (2.5%) and model users discovered the win-win nature of electricity access with higher frequency (63%) than non-model users (9%). Participants who learned of the model's logic through presentation performed nearly as well as model users. In the second study, model use shortened the (mean) duration of the negotiation from 55 minutes to 45 minutes. Negotiating tables that co-created a model had a higher likelihood of reaching favorable agreements (44% compared to 25%). Model use did not significantly alter the value distribution among parties. Tables of negotiators used the model in two predominant manners: to test alternatives as they generated potential agreements and to verify a tentative agreement. The former resulted in higher mean table values than the latter. Together, these studies demonstrate: that mathematical models can be used in sustainability negotiations and decisions with good effect; that learning about the insights of a model is beneficial in decision making—but using a model is more beneficial; and that collaborative model building can provide better negotiation outcomes than using an expert model and can be faster than not using a model.


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### 3E Game

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### Cup Game

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### Overall Thesis

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## List of Abbreviations and Acronyms

| | |
|---|---|
| $CO_2$ | Carbon Dioxide |
| CSL | Credibility, Salience, Legitimacy |
| Econ | Economy |
| En-ROADS | Energy- Rapid Overview and Decision Support |
| Env | Environment |
| GHG | Greenhouse Gases |
| IPCC | Intergovernmental Panel on Climate Change |
| JFF | Joint Fact Finding |
| KACST | King Abdulaziz City for Science and Technology |
| LCA | Life Cycle Assessment |
| MANOVA | Multivariate Analysis of Variance |
| MIT | Massachusetts Institute of Technology |
| RAINS | Regional Air Pollution and Simulation |
| SE | Social Equity |
| SE4ALL | Sustainable Energy For All |
| UNFCCC | United Nations Framework Convention on Climate Change |

# 1 Introduction

Increasing sustainability is one of the largest and most challenging issues humanity currently faces. While it is well established that human actions are impacting the livability of our planet, determining how to alter these actions is not simple. Such sustainability decisions are difficult because they are set within complex systems that have many stakeholders[1] with varying interests and perspectives. Negotiating a path forward involves not only understanding the physical complexities of the system, but also the social complexities of competing interests. To further complicate the matter, physical world and social components of the decision can be a mixture of win-win and trade-off issues - some issues where interests align and others where a tough choice must be made.

Most sustainability negotiations, such as for a city considering an energy plan to reduce greenhouse gas (GHG) emissions, involve multi-lateral decisions that include different types of information. Making progress towards sustainability requires crossing organizational boundaries and including diverse interests alongside scientific information about a complex enviro-socio-technical system—a system comprised of environmental, social, and technical components. However, parties in sustainability negotiations and decision processes often lack a means of quickly assessing the real-world impact of proposed actions, limiting their ability to reach agreements that benefit the environment and create value for the parties.

To provide better real-time feedback in sustainability decision processes, many researchers have suggested using models that elucidate the physical world (Dowlatabadi, 1995; van Delden et al., 2011; van den Belt et al., 2013). Accordingly, many models have been created to aid sustainability decision making (McIntosh et al., 2005). However, while many such models are now available for use in sustainability and energy-related negotiations and decision processes, research suggests that such models are not as often used by decision makers as the modelers expected (Edwards et al., 2010; McIntosh et al., 2008). See section 2.1 for a more in depth discussion.

One means of increasing the use of models in sustainability decision processes is to engage decision makers in the creation of the models to be used (Bourget et al., 2013; Langsdale et al., 2013; Pahl-Wostl, 2009). This is sometimes called, among other names, Collaborative Modeling for Decision Support, Shared Vision Planning, Mediated Modeling, Group Model Building, Computer-Aided Negotiation, Participatory Modeling (and Participatory Integrated Assessment Modeling) (Langsdale et al., 2013). Many of the applications of this are in environmental contexts, because of the complexity of environmental issues and the intra-disciplinary nature of making decisions involving human systems and the natural environment. Section 2.1 describes this in greater detail.

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[1] The terms "stakeholders" and "parties" are used interchangeably in this thesis. Where there is a distinction that some people have formal authority for the decision (as well as a stake in its outcome), they are called "decision makers."

While this approach holds promise, researchers have not often directly compared, within the same sustainability decision context, whether decision makers are more likely to use models that they co-generate or models provided to them by experts. Furthermore, the different manners in which models are used in sustainability decision processes have not been sufficiently explored. For example, do decision makers tend to use models to test alternatives as they arise in the discussion, to verify a tentatively reached decision, or in some other manner, and to what effect? Furthermore, questions remain about how model use influences individual decision makers making decisions where they have to integrate scientific information and others' interests - and win-in and trade-off decision elements. Those who suggest collaborative modeling as a solution have not sufficiently investigated the impacts of two likely alternatives to co-creating a model: using an existing, expert-created model, or being told the logic and insights of a model. See section 2.1 for more details.

Similarly, negotiation research has demonstrated the utility of single texts to function as a boundary object through bringing parties together around a particular wording of the agreement being negotiated (Susskind and Cruikshank, 1987). However, the potential of models to function as a boundary object in complex multi-party negotiations has not received much attention in the negotiation literature, and many questions remain. How will model-use impact the negotiation process and negotiated outcome? Will the parties use a model created by experts? Will the parties create their own model? When and how will negotiators use a model during the course of the negotiation? Section 2.1 expands on this discussion.

In this thesis I explore the high level questions of: 1) Does model use impact the results— the outcome—of an individual decision makers' sustainability decision, and if so how; and 2) Does model use and/or model authorship—whether the negotiators were given a model or co-crated one themselves—influence the negotiation process and/or the negotiated outcome in multi-party sustainability negotiations, and if so, how.

To address these two overarching questions, I pose several sub-questions for each research project. In the 3E Game, I ask—when compared to learning of the model's insights and logic, to hearing relevant but general information, and to hearing irrelevant information—does model use: 1.a) increase decision makers' ability to create a policy that does what they want it to do; 1.b) increase decision makers' ability to reach the set of optimal outcomes; 1.c) prompt decision makers to change their priorities; and/or 1.d) increase decision makers' consideration of others' interests in their decision. For the Cup Game the sub-questions are: 2.a) will negotiators use a model in a sustainability negotiation; 2.b) does model use and/or model authorship impact the negotiation outcome, and if so how; and 2.c) does model use and/or model authorship impact the negotiation process, and if so how. See Figure 1.

1) Does model use impact the results – the outcome - of an individual decision makers' sustainability decision, and if so how?

When compared to learning of the model's insights and logic, to hearing relevant but general information, and to hearing irrelevant information, does model use:

1.a) increase decision makers' ability to create a policy that does what they want it to do?
1.b) increase decision makers' ability to to reach the set of optimal outcomes?
1.c) prompt decision makers to change their stated priorities?
1.d) increase decision makers' consideration others' interests in their decision?

2) Does model use and/or model authorship - whether the negotiators were given a model or co-created one themselves - influence the negotiated outcome and/or the negotiation process in multi-party sustainability negotiations, and if so, how?

2.a) Will negotiators use a model in a sustainability negotiation?
2.b) Does model use and/or model authorship impact the negotiated outcome, and if so how?
2.c) Does model use and/or model authorship impact the negotiation process, and if so how?

Figure 1. Research Questions Addressed in this Thesis.

I address these questions through two research projects: the 3E Game and the Cup Game. The 3E Game and the Cup Game are both serious game role-play simulations – activities in which participants enact a role for the purpose of learning and/or research (see section 2.2). In these role-play simulations, participants assume a role in a mock decision making process. Acting as that role, participants make a policy recommendation or negotiate with each other. In the first project, the 3E Game, participants must integrate stakeholder information to create a global energy policy and in the second project, the Cup Game, participants negotiate a more useful end of life for used paper coffee cups.

Each of the role-play simulations, provides qualitative and quantitative data about the participants' experiences, the game outcomes they generated in the role-play simulation, and information about which condition the participants' experienced. In both studies, participants filled in a pre survey before engaging in the role-play simulation and a post survey afterwards. I interviewed randomly selected Cup Game participants about two weeks after they played the Cup Game.

The first project in my doctoral dissertation research, the 3E Game, investigates whether model use—compared to learning of the model logic, general relevant information, or irrelevant information—impacts individual decision makers' outcomes in sustainability decisions that involve multiple interests and a mixture of trade-off and win-win issues, and if so how. Participants in the 3E Game use one of four decision support tools: a model; movie about the model's logic; movies about general, relevant information; or a movie about irrelevant information—see section 3.3.1 for more details about each. Based on which of the four types of decision tools a 3E Game participant used, the 3E Game participants are classified into four categories, called "model users," "model logic," "general energy," and "control," respectively.

The 3E Game focuses on the individual decision maker who is integrating information from various stakeholders where there is a mixture of trade-off and win-win issues and the stakeholders do not necessarily agree with each other. Participants in the 3E Game enact the role of a Minister of Sustainability making global energy policy. They have three Directors reporting to them: a Director of the Environment, a Director of Social Equity, and a Director of the Economy. As the Minister, each participant follows four steps: 1) setting initial priorities among the three Es of sustainability (Environment, social Equity, and Economy); 2) utilizing a randomly assigned decision tool (the experimental condition); 3) setting the 15 policy inputs and receiving three outputs (change in global average temperature in the year 2100, the percent of the expected 2050 population with access to electricity, and the global economy in 2100); and 4) reflecting on the experience, including revisiting the priorities. The three model outputs each measure one dimension of the 3Es of sustainability: the temperature change in the year 2100 represents the environmental dimension; the percent of the expected 2050 population with access to electricity represents the social equity dimension; and the global economy in trillions of US dollars represents the economic dimension. See Chapter 3 for a more detailed description.

The 3E Game findings show that participants using the model logic and general energy decision tools matched their priorities better than the participants who used the model and the participants in the control group. Model users did not match their priorities because they outperformed their social equity priority by discovering the win-win nature of the social equity dimension (i.e. increasing the social equity dimension does not harm the environment or economy dimensions). Participants in other categories did not as frequently discover the win-win nature of the social equity dimension. Furthermore, the model users reached the Pareto Frontier—the set of non-dominated policy outcomes—more readily than participants in other categories. Regardless of experimental condition, most participants changed their priorities, with those in the model logic and control experimental conditions changing most often. More participants in the model users experimental condition reported considering their directors' interests "often" or "very often" than did participants in other categories. However, the model users also reported that, in their decision, their own interests were more influential than their directors' interests.

The second project, the Cup Game, is a five-party negotiation role-play simulation that is loosely based on a real-life collaboration to recycle or compost used paper coffee cups. Approximately half of the negotiating tables (groups of five participants) received a Life Cycle Assessment model. The tables could use the model to address two of the five issues they negotiated. Alternatively, they could negotiate as normal without using the model. All the tables had access to the data required for the model, even if they didn't receive the model itself. Therefore, tables not receiving the model could create it. Similarly, tables given the model were free to ignore it. A large percentage (80%) of the tables of negotiators did use a model in the course of negotiating. The use of the model during the negotiation shortened the duration of the negotiation and increased the likelihood of favorable agreements (i.e., agreements that either maximized table value or minimized carbon dioxide emissions). I also found that among the set of negotiating tables that used a model, not all of them used the model in the same manner. The predominant two ways in which the model was used were 1) to test the emissions impact of various alternatives being considered in potential agreements and 2) to verify the effect a tentative agreement would have on emissions before confirming acceptance of that agreement. These two methods of model use are procedurally different. The first uses the model during the exploratory phase while potential agreement packages are being developed. As such, it provides comparatively greater opportunity for negotiators to explore the environmental impact of different alternatives within possible agreements. This manner of model use may yield more creative agreements and/or consideration of a larger number of possible agreements. The second manner of model use employs traditional negotiating methods to arrive at a tentative agreement before using the model to determine the environmental impact, and thus, uses the model later in the negotiating process than the first method.

## 1.1 Thesis structure

The following chapters expand on relevant recent research, address the results of each of the two research projects comprising this thesis, and use these results in tandem to recommend model use in sustainability negotiations and suggest alternatives where model use is not possible. Each of the research projects is a chapter that contains its own literature review, methods, results, and discussions sub-sections. Following these two chapters, a chapter offers recommendations for model use in sustainability negotiations and decision processes. The final chapter offers some concluding points, recommendations suggested by the results of this research, and suggestions for future research. Four appendices provide additional information, including information about the model used in the 3E Game and the role-play simulations used in the 3E Game and the Cup Game.

# 2 Literature Review

In this section, I discuss the literature informing the thesis as a whole. I discuss the concepts motivating the research and the background of role-play simulations and serious games. The two studies addressed in Chapters 2 and 3 contain their own smaller literature reviews that situate the particular study. As do notable negotiation scholars (see for example (Bazerman et al., 2000; Wheeler, 2011), I recognize the connection between the negotiation process and decision making processes and use the terms "negotiators" and "decision makers" interchangeably in this thesis.

## 2.1 Collaborative Decision Making Processes

The study of collaborative decision processes is well established. There can still be much disagreement on values and interests even where negotiators agree on the science (Sarewitz, 2004), therefore focusing on both the collaborative process and on the substantive components is important. Sections 2.1.1 and 2.1.2 explain the background and current advances in research of collaborative modeling processes.

### 2.1.1 Collaborative Decision Making Processes That Use Models

Because models help explicate the physical world, many researchers have suggested that decision makers ought to use models in sustainability decisions (Dowlatabadi, 1995; van Delden et al., 2011; van den Belt, 2004; van den Belt et al., 2013). For example, the regional air pollution information and simulation (RAINS) model was used to explore implementable emissions reduction targets during international negotiations at the convention on long-range transboundary air pollution in Europe (de Kraker et al., 2011; Tuinstra et al., 1999).

Despite the use of the RAINS model and some other early uses of models in sustainability negotiations and decisions, environmental modelers are currently interested in effectively addressing stakeholders' lack of "uptake" of the models produced (Edwards et al., 2010; McIntosh et al., 2011). This observation that stakeholders do not fully use their expertly created models, has led them to the importance of untangling evaluative complexity (Feng, 2012), which is the concept that individual stakeholders likely each have their own interests and interpretations of the situation. Some have suggested that the answer to low stakeholder usage of sustainability models is to include the stakeholders in the modeling process (Cutcher-Gershenfeld et al., 2004; McIntosh et al., 2011; 2008; Rotmans, 2006; van de Riet, 2003). The modeling process is itself a decision making process (McIntosh et al., 2008) where "the science appropriate...will be based on the assumptions of unpredictability, incomplete control, and a plurality of legitimate perspectives" (Funtowicz and Ravetz, 1993). Including the stakeholders helps to gain access to these perspectives. As a representation of a system, models enable users to explore alternative possibilities for a situation without acting within the system; in contrast, Participatory Action Research involves changing the system while studying it (Voinov and Bousquet, 2010).

Many of the researchers encouraging the inclusion of stakeholders in the modeling process use system dynamics modeling. Several of these put forward steps for doing so and statements of why such steps are suggested (for example see: (Langsdale et al., 2013; Voinov et al., 2014)). These describe a whole process from initial stakeholder involvement often, though not always, through the decision itself. Many studies include in-depth participatory action and case studies of stakeholder engagement in the model building process. One limitation of these methodologies, due to the uniqueness of the contexts of such studies, is that they cannot compare alternative processes within the same context or repeated instances of the same context. In this thesis, I use methods that enable the consideration of alternative processes and the comparison of repeated instances of the same decision context.

Indeed, not all sustainability modelers agree that stakeholder participation enhances the outcome, and point out that participation can happen at different stages and in different degrees (Collins and Evans, 2002). Therefore, in addition to whether or not to include stakeholders in the modeling process, those who support stakeholder inclusion must also address the process of how to include the stakeholders. Many collaborative modelers are not sufficiently investigating how the model is used to make the decision - just how it is built. They give more emphasis to the steps involved in building the model with stakeholders than to the description of how models commonly are—or should be used—in the decision. Furthermore, these studies do not discuss alternatives for situations in which decision makers cannot use a model. In this thesis, I offer some insight into different manners of model use in sustainability decisions and a comparison of potential alternatives to model use for situations in which model use is not possible.

Some researchers call for a repository of models for use in collaborative decision processes (see (Voinov et al., 2014)). However, searches of databases of peer-reviewed publications did not reveal studies that explore the difference between decision makers using an expert built model and decision makers using a model they co-created during the decision process. In this thesis, I offer some initial evidence to compare the use of expert built and decision maker co-created models.

In this thesis, I use methods that allow the comparison of alternative processes within a given decision context and the statistical power of repeated instances of a decision context. Furthermore, I give initial insight into different manners of model use, some insight into viable alternatives for sustainability decisions in which decision makers cannot use a model, and a comparison of decision makers using models built by experts and models that they co-created themselves.

### 2.1.2 Science-Intensive Decisions in Environmental Dispute Resolution

Scholars of environmental disputes note that by their nature, environmental disputes are science-intensive (Karl et al., 2007a). In many cases, the disputing parties select an interpretation of scientific facts that supports their interests (Oreskes and Conway, 2010) and combats the interests of other parties leading science to play an adversarial role (Pielke, 2007). This leads to a disputed facts scenario (Schenk et al., 2016). Additionally, the scientific facts can be distributed and disparate, such that various stakeholders each hold a piece of the whole and to better assess the whole system in which the dispute is situated, the pieces must be brought together (Schenk et al., 2016). A third archetype of science-intensive disputes is those in which there is deep uncertainty about the system in which the decision is situated (Schenk et al., 2016).

Participatory dispute resolution processes, like Joint Fact Finding (JFF) - also called joint inquiry, technical advisory groups, adaptive management working groups, science advisory roundtables (Adler, 2014) - convene stakeholders to define the problems pertinent to the conflict or decision. The problem definition phase is collaborative because the framing of the problem can determine which disciplines are relevant and whose values are included (Brugnach et al., 2008). After identifying a facilitation team, the first step is identifying who has a stake in the conflict and whether a participatory process is appropriate. After deciding to continue, the stakeholders then itemize the questions that require scientific research to address. The scientific experts on the facilitation team then lead the discussion to establish a research agenda. Once conducted, the research is translated into materials and reports useful to the decision makers (Adler, 2014; Karl et al., 2007a).

Through the shared process of defining the problem, designing and conducting a research plan to address the problem, and interpreting the results, stakeholders in the JFF process often come to better understand the scientific and nonscientific parts of the decision (Karl et al., 2007b). Through this better understanding of the scientific and nonscientific aspects of the decision, the parties gain more equal abilities to influence the decision (Karl et al., 2007a).

Although they discuss scientific research generally, a search of academic peer-reviewed databases did not reveal studies of JFF[2] that expressly discuss the creation and use of models in environmental disputes. This thesis provides evidence for the utility of models in JFF processes.

As with the steps outlined by the collaborative modeling community above, these scholars offer little evidence comparing the use of collectively created decision materials and expertly created decision materials in the same decision context. By using a different research methodology, this thesis supplements the existing body of case studies.

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[2] Some researchers consider Mediated Modeling to be a form of Joint Fact Finding. In this thesis, I consider Mediated Modeling to be a form of Participatory Modeling distinct from Joint Fact Finding. For readers who consider Mediated Modeling to be a variation of Joint Fact Finding, the studies in this thesis lend further support for including models in Joint Fact Finding. See section 5.1 for more discussion of Mediated Modeling and Participatory Modeling.

## 2.2 Role Play Simulation Serious Games

Serious games have a long history in research and education. Early serous games were largely used for wargaming: the training in and analysis of tactical and operational situations (see Wilson 1968 for a history of wargaming). Policy games, which derived from wargames, study international relations (see (Mayer, 2009) for a history of policy-related serious games). From policy games, serious games have been applied to numerous other contexts, such as business management and strategy—often called "management flight simulators"—(Bakken et al., 1992; Sterman, 2014); environmental concerns (see (MaKinster, 2010; Stokes and Selin, 2014) for examples); and infrastructure planning (see (Grogan, 2014; Kuit, 2005; Mayer et al., 2010; 2004; Meijer et al., 2012; Nefs et al., 2010) for examples). Many serious games are computer-intensive, with many featuring computer simulations.

Role-play simulations are a type of serious games, and there is much evidence to support the use of role-play simulations in research. Many of these are expressly used to teach the participants about the scientific and procedural context in which the role-play simulation is set, and the setting is often environmental (see for example (MaKinster, 2010; Schenk, 2014; Stokes, 2011) (Susskind et al., 2015)).

Other types of role play simulations are designed and used to replicate the real-world and used to study the process and/or outcomes of negotiations (Butler, 1991; Curhan et al., 2009; 2004; Curhan and Pentland, 2007; Ducrot et al., 2014; Elfenbein et al., 2008). Such studies are interested in the procedural components of the negotiations, such as the trust among the parties (Butler, 1999; 1991; Marwan Sinaceur, 2010); the length of the negotiations (De Dreu, 2003; Simonelli, 2011); the impact of different actions and the timing of those actions (Harinck and De Dreu, 2008; Sinaceur et al., 2013); negotiator characteristics and psychology (Imai and Gelfand, 2010; Sullivan et al., 2006); and the different kinds of outcomes reached (De Dreu et al., 2000). Herbst and Schwarz (2011) demonstrate that using students to represent professional negotiators in the role-play simulation yields results similar to using professionals as participants (Herbst and Schwarz, 2011).

Most of the role-play simulations discussed above, in contrast to the other types of serious games, do not involve mathematical models or computer simulations. Rather, the participants are face-to-face in the negotiations and the role instructions are delivered via paper based confidential instructions for each role and general instructions available to all participants (see for example (Schenk, 2014; Stokes, 2011)).

## 2.3 Sustainability

This thesis is contextualized within sustainability decisions. This section takes a step back to define sustainable development and list some characteristics of sustainability decisions.

The classic definition of sustainable development was established by the World Commission on Environment and Development in their 1987 report, which is also known as the Brundtland report: "Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). A less frequently cited passage from the same text continues:

> Sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development and institutional change are made consistent with future as well as present needs. We do not pretend that the process is easy or straightforward. Painful choices have to be made (World Commission on Environment and Development, 1987).

Together these two statements about sustainable development include a list of some topics (i.e. exploitation of resources, investments, technological development, and institutional change), a time horizon that stretches from the present to the distant future, as well as recognition that sustainability requires hard choices.

In 1999, the U.S. National Research Council included the concept of alleviating poverty in their aspiration that the "primary goals of a transition toward sustainability over the next two generations should be to meet the needs of a much larger but stabilizing human population, to sustain the life support systems of the planet, and to substantially reduce hunger and poverty" (National Research Council, 1999).

In 2002, the World Summit on Sustainable Development extended the Brundtland definition by identifying the three pillars of sustainability: economic, social, and environmental (World Summit on Sustainable Development, 2002). In this thesis, the three pillars are referred to as the three Es of sustainability: **e**conomic growth, social **e**quity, and **e**nvironment protection.

In addition to these definitions written by commissions, councils, and summits, several individuals have put forward variants. John Ehrenfeld defines sustainability as "the possibility that human and other life will flourish on the planet forever" (Ehrenfeld, 2008). Some researchers define sustainable development through their discussion of the challenges of sustainability. Kates (2001) asks, "how, over the large and the long, the earth, its ecosystems and its people could interact for mutual sustenance." (Kates, 2000)? For Clark and Dickson (2003), "the challenge of sustainable development is the reconciliation of society's development goals with the planet's environmental limits over the long term" (W. C. Clark and Dickson, 2003).

In their 2005 paper, Kates et al. outline several means by which sustainable development can be defined: by specifying in the Brundtland definition what is to be sustained and what to be developed, by how sustainable development is measured, by what sustainable development seeks to achieve, by the values that "represent or support" sustainable development, and by practice in individual instances (Kates et al., 2005). Though they itemize it as one way sustainable development can be defined, Kates et al. label the definition employed in the Brundtland Report—to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987)—as "creatively ambiguous" (Kates et al., 2005). Such creative ambiguity could lead to false claims (e.g. "greenwashing" (Laufer, 2003)) but also serve to make sustainable development an inspiring concept able to be applied in many situations and at many levels (e.g. international, regional, national, and local) (Kates et al., 2005).

Each of the definitions listed above includes a time component, with many extending from the present to the unspecified distant future. Sustainable development can also occur at shorter-term, medium term (e.g. two generations, the year 2050), and longer term horizons (past the year 2050) (Kates et al., 2005). The long time horizons contribute to uncertainty (Graedel and van der Voet, 2010).

### 2.3.1 Sustainability Decisions

In planning for sustainable development, decision makers must make decisions about what to do, as acknowledged by the World Commission on Environment and Development in 1987. In this thesis, I call these sustainability decisions. Sustainability decisions uses the information produced by sustainability science (B. Clark and Dasgupta, 2014; W. C. Clark, 2007; W. C. Clark et al., 2004; W. C. Clark and Dickson, 2003; Kates, 2000; Levin and W. C. Clark, 2010), which coalesces fundamental and applied research into usable information and seeks to foster action (Kates, 2011). This section describes some characteristics of sustainability decisions and some challenges they present.

Sustainability decisions occur at many levels and involve organizational and individual actors representing the public, private, and non-profit sectors. Sustainability decisions are "systems problems" (Graedel and van der Voet, 2010) that include a mixture of win-win and trade-off components, involve many stakeholders with diverse perspectives and interests, and uncertainty over long time horizons.

Sustainability decisions can involve governmental, corporate/private sector, non-profit, and individual actors and can occur at international, national, state, local, and household levels. The United Nations has been leading a series of negotiations to create global treaties to increase sustainability (e.g. the Minamata Convent on Mercury (United Nations Environment Program, 2014) and the United Nations Framework convention on Climate Change). Many international corporations have undertaken sustainability initiatives with their products and supply chains (e.g. Nike (Henderson et al., 2008) and Starbucks (Czaika, 2010)). A larger discussion of the levels and actors in sustainability decisions is beyond the scope of this thesis.

Sustainability decisions involve "dynamic interactions between nature and society" (W. C. Clark and Dickson, 2003). Because sustainability decisions involve linking earth and social systems (Gladwin et al., 1995; Reid et al., 2010), they require a systems view (Gladwin et al., 1995; Graedel and van der Voet, 2010). One early effort to link earth and social systems resulted in the IPAT identity (Reid et al., 2010). In 1972, Ehrlich and Holdren proposed the IPAT identity, which states that the impact (I) to the environment equals the population (P) multiplied by the income per person—called the affluence of the population (A), multiplied by the technological impacts per unit income (T) (Ehrlich and Holdren, 1972).

Sustainability decisions involve a mixture of win-win and trade-off issues. Win-win issues, sometimes called "all-gain issues," are those in which all parties achieve a satisfactory result (Susskind and Cruikshank, 1987). In a single-party situation, win-win issues are those issues that can be optimized without negatively impacting other issues. Trade-off issues involve a choice: gaining in one necessarily means losing in another. Researchers who have investigated these aspects, include Graedel and ver Voet (2010) who discuss such issues as "overlapping needs" and give examples such as providing food, water, energy, and technology to a growing world population (Graedel and van der Voet, 2010).

Sustainability decisions involve many stakeholders, who very often have different perspectives and interests (Winn et al., 2012). Not only are there a plethora of perspectives, but also these perspectives must be integrated with scientific information to create a viable path forward. If decision makers fail to consider the scientific aspects of a sustainability decision, they risk "negotiating nonsense" (van de Riet, 2003). Both within and outside the context of sustainability decisions, many researchers have studied the inclusion of stakeholder preferences alongside scientific information (more generally: (Adler et al., 2011; Karl et al., 2007; Tidwell and van den Brink, 2008), and the stakeholder's view of the legitimacy of the information: (Cash et al., 2003a; Eckley, 2001) ). This research is discussed in greater detail in sections 2.1, 5.1 and 5.2.

Sustainability decisions involve uncertainty (Winn et al., 2012) and emergent behavior (Graedel and van der Voet, 2010). Some of the uncertainty derives from the complexity of the intertwined social and environmental systems, each of which is itself a complex system. The uncertainty aspect of sustainability decisions is not highlighted in this thesis.

Sustainability decisions often involve a long time horizon starting in the present and stretching into the distant future (Slawinski and Bansal, 2012; Van der Byl and Slawinski, 2015). However, as discussed above, Kates (2005) identifies three different time horizons: shorter term, medium term (through the year 2050, also called two-generations), and long term (past the year2050) (Kates et al., 2005).

To address sustainability decisions, some researchers have called for more and better quantitative methods to enable the study of the physical systems involved in sustainability decisions (Dowlatabadi, 1995; van Delden et al., 2011). For example, Reid et al. (2010) include in their list of grand challenges the need for "an *enhanced Earth system simulator* [emphasis added] to improve our ability to anticipate impacts of a given set of human actions or conditions on global and regional climate and on biological, geochemical, and hydrological systems on seasonal to decadal time scales" (Reid et al., 2010). This line of research is discussed in more depth in sections 2.1 and 5.1.

# 3 The 3E Game: The impact of model use in a decision maker's setting of sustainability policy

## 3.1 3E Game Introduction

Improving sustainability involves ensuring that "development meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). "Sustainable development is not a fixed state of harmony, but rather a process of change. ... [T]he process is [not] easy or straightforward. Painful choices have to be made" (World Commission on Environment and Development, 1987). Sustainable development involves human choices and actions, and as such, different people can and likely will have different perspectives and opinions.

Sustainability challenges, vis-à-vis development, involve making decisions about what to change and how to change it. In order to determine what to do and how to do it, decision makers must grapple with scientific information about the physical world, as well as preferences and interests in the social world.

Mathematical models, such as system dynamics models, can help elucidate the physical world (Dowlatabadi, 1995; van Delden et al., 2011; van den Belt et al., 2013) and can enable the comparison of multiple potential future outcomes (Morgan, 2011). Accordingly, many models have been created to aid sustainability decision making (McIntosh et al., 2005). Despite the existence of many models intended for use in sustainability and energy-related negotiations and decision processes, decision makers are not using these models as often as expected (Edwards et al., 2010; McIntosh et al., 2008).

One potential reason that decision makers are not frequently using models to aid in sustainability decisions is they are not aware of how model use might impact their decision. Much of the research available about model use in sustainability decisions uses case study or action research methodologies (for example, see (Beall and Zeoli, 2008; Videira et al., 2004)). Two of the strengths of these methods are that they allow researchers to explore a particular situation in great depth and that they usually involve real-life decision makers and decisions. However, these methods are not able to compare repeated instances of the same situation or alternative process approaches within one decision situation.

In this study, I employ a role-play simulation—called the 3E Game—as a serious gaming experiment to enable the comparison of multiple different participants making the same hypothetical decision. As such, this study complements existing studies of the usefulness of models in sustainability decisions.

In helping to create understanding of the scientific aspects of a decision, models also might provide a means through which decision makers can assess their own interests and identify those of other stakeholders. In this way, model use might also impact the decision makers' abilities to make sense of the preferences and interests in the social world.

Participants, playing the role of Minister of Sustainability, go through four steps: 1) set their priorities (in the pre-survey), 2) utilize decision tools, 3) submit a policy, and 4) reflect on their decision and revisit their priorities (in the post-survey). Each participant goes through these same four steps, with the difference among the categories of participants being which of the four randomly assigned decision tools they utilize in step two. The decision tools are described in more detail in section 3.3.1. These four types of tools enable me to compare model use to learning of the model logic via a presentation, relevant information that is not specific to the decision at hand, and irrelevant information. Through these comparisons I can investigate the impact of model use on decision makers' policy recommendations, priorities, and consideration of others' interests. This will help determine whether it is important for decision makers to use a model in their decision or if explaining the logic of the model or explaining relevant but general information is sufficient.

In the following sections, I describe the methods I used, the results I found from the one hundred nineteen participants that have played the 3E Game, and I discuss the results. In the methods section, I describe the serious game role-play simulation and the data I collected from it. In the results section, I discuss the results in each of the four experimental conditions. The discussion section brings the findings into the real world and suggests future research.

## 3.2 3E Game Research Problem, Objectives, and Recent Research

To investigate how models impact sustainability decisions, this study addresses four questions: 1) whether and how a model helps decision makers create a policy that matches their stated priorities; 2) whether decision makers using a model more readily create optimal policy outcomes; 3) whether model use influences decision makers to change their priorities; and 4) whether decision makers using a model consider others' interests in their decision.

I hypothesize that model use will help decision makers reach their stated priorities more readily. Models have been shown to help elucidate and educate (McIntosh et al., 2005). Decision makers who use a model can explore potential policies choices and measure their impacts/outcomes (Morgan, 2011). These investigations will lead to greater understanding of the system in which they are making decisions and of the possible impacts of various policy inputs. Understanding the impacts of policy inputs will enable them to control the policy inputs to create their desired outcome.

I hypothesize that model use will increase the likelihood that decision makers create an optimal policy. As stated above, models help decision makers understand the system in which their decision is situated (McIntosh et al., 2005) and enable the consideration of alternatives (Morgan, 2011). Not only is this useful in creating a policy to bring about a desired result - match priorities - it is also beneficial in creating optimal policies.

I hypothesize that because model users, compared with non model users, will have a better understanding of the decision situation, they will be more likely to change their stated priorities. As decision makers learn more about the physical world characteristics of the decision they are facing, what they learn might lead them to change their priorities. For example, they might learn that something they thought was a trade-off decision is more like a win-win. When making a trade-off decision between two alternatives, a decision maker will have to choose which to gain more of and which to gain less of. Contrastingly, in a win-win decision between two possibilities, a decision maker can gain both because the possibilities are not competing. In the 3E Game, as decision makers learn that they can easily achieve more of a particular dimension of sustainability (one of the three Es: environment, social equity, or economy) without consequence to other dimensions they value, they might come to value that easy-to-achieve dimension more than they initial did. In another example, participants might discover that a dimension of sustainability that they thought would be relatively easy to achieve is quite difficult given how highly they have prioritized the other dimensions. Consequently, they might increase the proportion at which they prioritize the harder to achieve dimension in order to ensure they achieve it. Alternatively, they might decide the harder to achieve dimension is not worth the extra effort required and therefore lower their prioritization of the hard to achieve dimension.

I hypothesize that because model users will better understand the decision situation, they will better understand others' perspectives and take them into account in the subsequent decision. Even when they agree on the overall objectives of increasing sustainability, reasonable people can still prioritize differently among the dimensions of sustainability (Pielke, 2007). For example, someone working in development might prioritize giving access to electricity over other forms of sustainability such as reducing emissions.

## 3.3 3E Game Methodology

This study is a role play simulation conducted as an experiment with four different participant experiences: using a model; watching a movie about the model logic; watching general energy movies; and watching a movie unrelated to the decision. Each of these experiences lasts approximately 20 minutes and the full experiment lasts about an hour. The experiment is computer driven and participants do the experiment by themselves with a researcher available to answer clarifying questions.

Participants are role-playing as the Minister of Sustainability making a global policy recommendation. They are told they have three directors reporting to them: the Director of the Environment, the Director of Social Equity, and the Director of the Economy. The Director of the Environment wants the Minister of Sustainability (the participant) to keep the change in global average surface temperature under two degrees Celsius through year 2100, as was agreed in the Cancun Agreements (United Nations Framework Convention on Climate Change, 2011). The Director of Social Equity wants the Minister of Sustainability to give electricity access to as many people as possible by the year 2050, and the Director of the Economy wants the Minister of Sustainability to grow the Gross World Product (global economy) as large as possible by the year 2100. The Minister is told to balance these requests.

As mentioned in section 3.1, participants completed four steps in the experiment (see Table 1). The first step is setting priorities. Participants state their prior preferences among the environment, social equity, and the economy by allocating 100 points among the three. They also estimate how believable, relevant, and inclusive of multiple perspectives they expect the decision tool they will use in the experiment will be; these are credibility, salience, and legitimacy, respectively. Credibility, salience, and legitimacy are attributes that individual users of the decision tools ascribe to the decision tools (or other information) (Cash et al., 2003a; Eckley, 2001). The way an individual interprets the credibility, salience, and legitimacy of a decision tool influences how effective she believes the tool to be and how much the tool and the information it produces will influence her actions (in this 3E Game context, her action is the policy she recommends) (Cash et al., 2003a; Eckley, 2001). These credibility, salience, and legitimacy measures of the participants' expectation—before they have used the decision tools—provide a baseline to compare their post-usage ratings.

Table 1. Steps Participants Follow in the 3E Game Experiment.

| Step | Description of Activities in the Step |
|---|---|
| 1. | **Set priorities**: allocate 100 points to environment, social equity, economy; pre-rate the decision tool for credibility, salience, and legitimacy |
| 2. | **Use decision tool**: For 20 minutes, use the randomly assigned decision tool. The four tools are: the En-ROADS model, a movie about the model logic, general energy movies, and a control movie. See Table 3. |
| 3. | **Submit policies 1 and 2**: Enter the 15 inputs for the policy and receive the three policy outputs (policy 1). Submit an amended policy (policy2) and receive the updated policy outputs. |
| 4. | **Reflect on decision and revisit priorities:** select either policy 1 or policy 2; re-allocate 100 points to environment, social equity, economy; rate the decision tool for credibility, salience, and legitimacy; what information was missing; indicate which was hardest decision; how often they considered the three directors' interests and how influential these interests were. |

Next, in step two, participants use a randomly assigned decision tool. That is, they either use the model for 20 minutes or watch the model logic movie, the three general energy movies, or the control movie. In step three, participants enter policy inputs and receive the policy output, which a researcher generates using the Energy – Rapid Overview Decision Support (En-ROADS) model (described in section 3.3.1). Participants are able to enter a second policy and are given feedback on the second policy in the same manner as on the first policy. Then, in step four, they re-rate the credibility, salience, and legitimacy of the materials they used, select either policy one or policy two, restate their preferences, and respond to questions about their experience setting the policy. Among these questions are: indicate what information, which they did not have, would have been helpful in making the decision; which was their hardest decision to make; how much they took their directors' interests into account; and whose interests (theirs, their directors', or both theirs and their directors') were more influential.

The policy that each participant submits in step 3 (see Table 1) has fifteen inputs and three outputs. The inputs are described in Table 2. The three outputs are the average global temperature change (from preindustrial) in the year 2100 in degrees Celsius, the number of billions of people with access to electricity in 2050, and the global economy in trillions of US dollars in the year 2100.

Table 2. The 3E Game Policy Inputs.

| Policy Input | Description |
|---|---|
| Energy Access | Set the percent of people currently without access to electricity who will gain access. That is, of the total number of people who do not currently have access to electricity, set the percent that will gain access under this policy you are developing. Choose a number between 0% and 100% in increments of 1%. |
| Kilowatt-hours per person per year | Select the amount of electricity each person will use each year. Choose a number between 0 Kilowatt-hours per person per year and 20000 Kilowatt-hours per person per year in increments of 50 Kilowatt-hours per person per year. |
| Carbon Density Index | Set the carbon density of the electricity given to those who will gain new access to electricity under this policy. The lower the index, the less carbon is emitted in providing electricity to those who newly gain access to it. Choose a number between 1 and 3 in increments of 1. |
| Efficiency Improvement: Stationary | Select a number between -1 and 7 in increments of 0.1. A negative number results in a decrease in efficiency and a positive number results in an increase in efficiency. |
| Efficiency Improvement: Mobile | Select a number between -1 and 7 in increments of 0.1. A negative number results in a decrease in efficiency and a positive number results in an increase in efficiency. |
| Emissions Price | Set the price those who emit carbon dioxide will have to pay to emit it. Choose a number between 0 and 100 in increments of 1. |
| Emissions Price Start Year | Choose a year between 2015 and 2100 when the Emissions Price you specified above will start. Increments of 1 year. |
| Short Term Economic Growth Rate | Set the percent the economy will grow per year. Choose a value between 1% and 7% in increments of 0.1%. The value you choose is a percent increase in the Short Term Economic Growth Rate. |
| Long Term Economic Growth Rate | Choose a percent increase between -1% and 5% in increments of 0.1%. A negative percent increase is a decrease in the Long Term Economic Growth Rate. |
| Cost reduction of Biofuel energy supplies | This reduction in cost is due to the results of Research & Discovery results being commercialized. Choose a number between 0% and 99% in increments of 1%. |
| Cost reduction of Renewable energy supplies | This reduction in cost is due to the results of Research & Discovery results being commercialized. Choose a number between 0% and 99% in increments of 1%. |
| Cost reduction of Nuclear energy supplies | This reduction in cost is due to the results of Research & Discovery results being commercialized. Choose a number between 0% and 99% in increments of 1%. |
| Cost reduction of Natural Gas energy supplies | This reduction in cost is due to the results of Research & Discovery results being commercialized. Choose a number between 0% and 99% in increments of 1%. |
| LULUCF | Set the percent of emissions reduction, below Business As Usual (BAU), due to Land Use Land, Use Change, and Forestry actions. Choose a number between 0% and 99% in increments of 1%. A 0% change is Business As Usual (BAU). |
| Other GHGs | Set the percent of emissions reduction, below Business As Usual (BAU), of other Greenhouse gases (such as methane, the f-gases, nitrous oxide, ozone). Choose a number between 0% and 99% in increments of 1%. A 0% change is Business As Usual (BAU). |

### 3.3.1 Experimental Conditions: En-ROADS Model, Model Logic, General Energy, or Control

As mentioned in section 3.3 the four experimental conditions correspond to four different decision tools which participants are randomly assigned to use in step 2 of the experiment.

The model used in this experiment is the Energy – Rapid Overview and Decision-Support (En-ROADS) model (Siegel et al., 2015). En-ROADS was built and is maintained by Climateinteractive (www.climateinteractive.org); Ventana Systems (www.ventanasystems.com); the research team at ClimateWorks Foundation (www.climateworks.org); University of Massachusetts Lowell Climate Change Initiative (www.uml.edu/Research/Climate-Change/); and Prof. John Sterman of MIT. The purpose of En-ROADS is to teach policy makers (and others) about the impacts of energy policies on global average temperature change, access to electricity, and the economy.

The 3E Game uses the Sustainable Energy for All (SE4ALL) user interface, which was built for the United Nations – World Bank initiative by the same name. The SE4ALL interface has fifteen inputs that are delineated in Table 2. This experiment measures three outputs as representatives of the three dimensions of sustainability: global average temperature change in the year 2100, the number of billions of people with access to electricity in 2050, and the global economy in 2100 – measured as the gross world product. The temperature and global economy are measured in the year 2100 because they are measures that have a long time horizon. The number of billions of people with access to electricity is measured in a shorter amount of time (50 years earlier) because people without access to electricity want access quickly; they do not want to have to wait to have the health, educational, employment, and living standards benefits afforded by electricity access.

The movie about the model logic walks through the connections among access to electricity, the economy, and temperature rise. It discusses why greenhouse gases (GHG) are linked to temperature change and that different fuel sources emit different amounts of GHG. It also demonstrates how to create extreme policies in a model for identifying ranges (Czaika, 2015).

Those who are randomly assigned to the general energy movie condition watch three different movies about energy. The first is an MIT Energy Initiative movie about making batteries from dirt that will enable people to store solar-generated electricity for use around the clock (Sadoway, 2014). The batteries can be made locally in each country so that nations can develop energy independence and their own economies. The second movie is also an MIT Energy Initiative movie; it features then-Governor of Massachusetts, Deval Patrick speaking at MIT on Earth Day in 2013 about Massachusetts' strides in renewable energy (Patrick, 2013). The third is a National Geographic movie about renewable energy (*Alternative Energy*, 2009). Participants in the control condition watch a movie that is irrelevant to the topics of energy, social equity, the environment, and the economy.

It is a movie about the Ebola outbreak in Africa created by Vice News (Larsen, 2014).

Table 3. Experimental Conditions in the 3E Game.

| Abbreviation | Experimental Condition |
|---|---|
| Model Users | Playing with the En-ROADS model for 20 minutes (Siegel et al., 2015) |
| Model Logic | Watching a 20-minute movie about the logic in the En-ROADS model (Czaika, 2015) |
| General Energy | Watching 20 minutes of movies conveying general energy information. (*Alternative Energy*, 2009; Patrick, 2013; Sadoway, 2014) |
| Control | Watching a 20-minute movie about the risk of Ebola due to eating monkey meat. (Larsen, 2014) |

## 3.4 3E Game Results

This study addresses the research questions itemized in section 3.2. The responses detailed in sections 3.4.1 through 3.4.5 are based on analysis of the data from 119 participants, though for some questions some participants chose not to respond. For each question addressed in sections 3.4.1 through 3.4.5, the number of participants responding to the relevant questions is stated below.

### 3.4.1 Matching Policy Outcome to Priority

To investigate whether participants using the model are more successful at creating policies whose outcomes match their stated priorities, I determine how well data from participants, in each of the four experimental categories, fit the Multivariate Analysis of Variance (MANOVA) regression model described in equation 1. Equation 1 is based on what is expected in the research question: if participants are able to create a policy whose outcome matches their priorities, then their outcome will be well predicted by the priorities. If participants are not able to create a policy whose outcome matches their priorities, then the priorities will not sufficiently predict the observed outcomes. One can observe how well fit the regression model (equation 1) is by the F statistics and corresponding p values. Note that rather than seeking to determine which regression model fits the data the best, this analysis asks how well the data fit a theoretically derived model.

$$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + e \qquad (1)$$

In this model, Y is the vector policy outcome (temperature, percent access, global economy), $x_1$ is the number of points the participant allocated to the environmental sustainability dimension, $x_2$ is the number of points the participant allocated to the social equity sustainability dimension, and $x_3$ is the experimental condition (model, model logic, general energy, or control). Fitting this MANOVA regression model the to data indicate that the environmental preference points and the experimental condition are highly significant, and that the social equity points are significant at the ninety percent level, as seen in Table 4 below. The significance of the environmental and social equity preference points indicates that the preference points predict the policy outcomes. The significance of the experimental condition shows that participants in at least one of the four experimental conditions performed differently than the participants in the other categories. Thus, there is evidence to suggest that the policy outcomes differ by the preference points and the experimental condition.

Table 4. Matching Policy Outcome to Stated Priorities: MANOVA Regression Results for all experimental conditions. The environmental preference points and experimental condition are highly significant; the social equity preference points are significant at 0.1 level. Three outliers have been removed. (Significance codes: **** = 0; *** = 0.001; ** = 0.05; *= 0.1).

| **Term** | **Df** | **Pillai** | **Num Df** | **Den Df** | **F statistic** | **P value** |
|---|---|---|---|---|---|---|
| Env points | 1 | 0.17847 | 3 | 100 | 7.2414 | 0.0001908**** |
| SE points | 1 | 0.06293 | 3 | 100 | 2.2385 | 0.0884168* |
| Condition | 3 | 0.42095 | 9 | 306 | 5.5494 | 4.303e-07**** |

Table 4 indicates that the environmental preference points and the social equity preference points predict the three-dimensional policy outcome (temperature, electricity access, and global economy) and that participants in at least one experimental condition performed differently than participants in the other categories. To investigate which policy outcome variables differ, I ran them one at a time—the univariate F-tests (see Table 5). In predicting the temperature dimension of the policy output, the environmental preference points (p value = 0.0001) and the experimental condition (p value = 4.155e-06) were very significant and the social equity preference points (p value = 0.03071) were significant. Therefore, for the temperature dimension of the policy output, the preference points were influential and participants in at least one of the four experimental categories performed differently than the others.

In predicting the access dimension of the policy output, the experimental condition was highly significant (p value = 3.57e-05), indicating that the participants in at least one of the experimental conditions performed differently than the participants in the other experimental conditions in the access dimension of the policy output. For global economy, the environmental points and the social equity points were significant at the ninety-percent level (p values: 0.0645 and

0.0545, respectively) in predicting the global economy. The experimental condition was also significant at the ninety-percent level (p value = 0.0749). Therefore, in the global economy dimension, there is some indication that the preference points were influential and that the experimental condition mattered.

Table 5. Matching Policy Outcome to Stated Priorities: Differences in Policy Outcome Dimensions. The experimental condition was highly significant in predicting the temperature and the access dimensions, and significant at the ninety percent level in predicting the economy dimension. The preference points were also significant in predicting the temperature dimension, and to a lesser degree, the economy dimension. (Significance codes: **** = 0; *** = 0.001; ** = 0.05; *= 0.1).

| Response | Term | Df | Sum Square | Mean Square | F statistic | P value |
|---|---|---|---|---|---|---|
| Temperature | Env points | 1 | 2.531 | 2.5307 | 15.829 | 0.000113**** |
| | SE points | 1 | 0.768 | 0.7677 | 4.802 | 0.03071** |
| | Condition | 3 | 5.7275 | 1.90917 | 10.5194 | 4.155e-06**** |
| | Residuals | 102 | 16.308 | 0.1599 | | |
| Access | Env points | 1 | 0.106 | 0.1061 | 1.846 | 0.177 |
| | SE points | 1 | 0.031 | 0.0305 | 0.531 | 0.468 |
| | Condition | 3 | 1.494 | 0.4979 | 8.660 | 3.57e-05**** |
| | Residuals | 102 | 5.864 | 0.0575 | | |
| Global Economy | Env points | 1 | 2497442 | 2497442 | 3.492 | 0.0645* |
| | SE points | 1 | 2706352 | 2706352 | 3.784 | 0.0545* |
| | Condition | 3 | 5086264 | 1695421 | 2.371 | 0.0749 * |
| | Residuals | 102 | 72948833 | 715185 | | |

To understand which experimental conditions performed differently, I ran MANOVA analysis for each experimental category (see Table 6). Looking at the predictive value of the points within each experimental condition category, shows that the regression model in equation 1 fits the best for the model logic and general energy movies experimental conditions. In the model logic category, the environmental preference points and the social equity preference points are both statistically significant (p values: 0.01784 and 0.01656, respectively). In the energy movies category, the environmental preference points are significant (p value = 0.02963). The regression model in equation 1 does not fit the model users or the control. For these groups of participants, their preference points did not predict their policy outcome.

Table 6. Matching Policy Outcome to Stated Priorities: Differences by Experimental Condition. The regression model in equation 1 fits the data in the model logic and energy movies experimental conditions best. The model users category has an outlier removed and the model logic category has two outliers removed. (Significance codes: **** = 0; *** = 0.001; ** = 0.05; *= 0.1)

| Experimental Condition | Term | Df | Pillai | Num Df | Den Df | F statistic | P value |
|---|---|---|---|---|---|---|---|
| Model Users | Env points | 1 | 0.184328 | 3 | 24 | 1.80786 | 0.1727 |
| | SE points | 1 | 0.064202 | 3 | 24 | 0.54885 | 0.6537 |
| Model Logic | Env points | 1 | 0.36165 | 3 | 22 | 4.1547 | 0.01784** |
| | SE points | 1 | 0.36626 | 3 | 22 | 4.2381 | 0.01656** |
| Energy Movies | Env points | 1 | 0.35492 | 3 | 20 | 3.6679 | 0.02963** |
| | SE points | 1 | 0.12504 | 3 | 20 | 0.9527 | 0.43412 |
| Control | Env points | 1 | 0.192113 | 3 | 22 | 1.74384 | 0.1874 |
| | SE points | 1 | 0.088857 | 3 | 22 | 0.71516 | 0.5534 |

The participants were similar to each other in preference points, regardless of the experimental condition they were randomly selected into. Therefore, the differences in ability to match priority points is largely due to the differences in their resulting policies, not to their stated priorities. The model users' policy outcomes had the lowest average and median temperature change (2.3 and 2.1 degrees Celsius, respectively). Furthermore, the model users had the highest average and median values for the percent of the population with access to electricity in 2050 (98% and 100%, respectively). The model users had the second highest average global economy value, 1235 trillion US dollars. This average is influenced by one particular point that is discussed later in section 3.4.2. The model users also had the second highest median value for the global economy (540 trillion US dollars). Therefore, the model users had the lowest temperatures, the highest percent access, and the second highest global economy values.

One possible explanation for what is happening within the model-using category is that the model users discovered that the dimension of social equity is modeled as near win-win. That is, the temperature impact of giving access to more individuals can be kept low when the source of the electricity given is renewable. Sixty three percent (63%) of the model users gave one hundred percent access to electricity compared to seven percent (7%) of the model logic participants, twelve percent (12%) of the general energy participants, and seven percent (7%) of the control participants. The median percent access for model users is 100% access to electricity, whereas for the other 3 categories, the median is not above 98% access to electricity, see Figure 2. By discovering this win-win, the model users outperformed their social equity priorities.

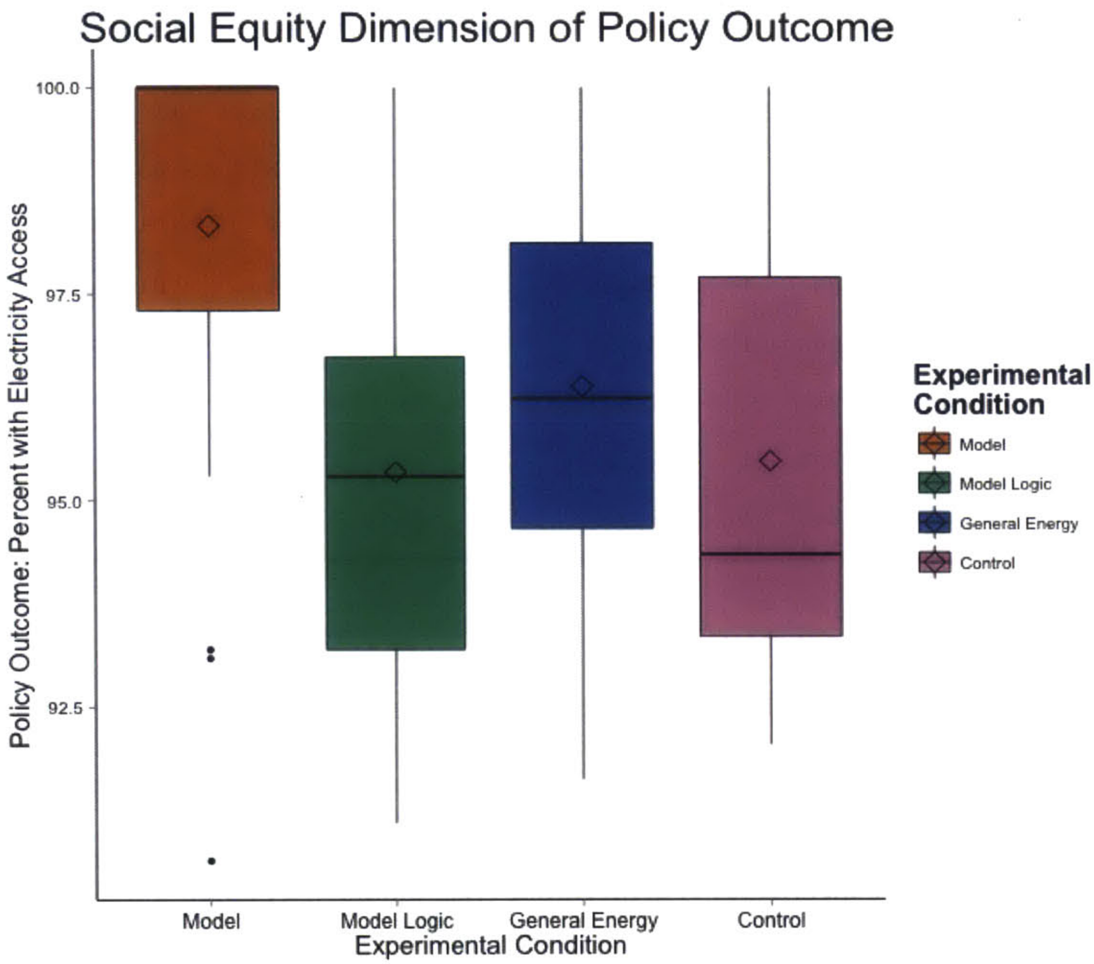


Figure 2. Social Equity Dimension of Policy Outcome Skews Higher for Model Users (red boxplot on left). The diamond in each boxplot is the mean for that experimental condition. This shows that more of the model users reached 100% access for the social equity dimension.

### 3.4.2 Pareto Frontier

Regardless of whether they met their own stated priorities, model users were more readily able to find policies on the Pareto Frontier. The Pareto Frontier is the set of policy outcome points where for a participant to do better in one policy dimension, he or she would have to do worse in at least one other dimension (Mattson et al., 2004). The only participants to reach the Pareto Frontier are those who either used the model or who watched the movie about the model logic. A higher percentage of participants who used the model (14%) reached the Pareto Frontier; only seven percent (7%) of participants who watched the movie about model logic reached the Pareto Frontier.

Figure 3 displays the one hundred nineteen points of participants who identified a preferred policy outcome. The circles outlined in black are dominated points – points that are not on the Pareto Frontier. The filled in circles in vermillion (model users) and bluish green (model logic) are the non-dominated points. Notice the cluster of points in the left hand back corner of the graph. This set of points represents the policies that provide both environmental protection and optimal access to electricity. The points in this set that are the tallest (highest value in global economy) represent those points that achieve gains in all three dimensions. The vermillion and bluish green points on the left hand side towards the front provide strong environmental protection, but low values of global economy and comparatively lesser access to electricity. The outcome represented by the tallest vermillion point at the back [temperature = 3.7, access = 100%, global economy = 15000] provides the strongest global economy and complete access to electricity, but provides comparatively little environmental protection.

Note that reaching the Pareto Frontier is not the same as matching policy outcome to one's priorities. For example, one participant, whose policy outcome is [temperature = 3.7, access = 100%, global economy = 15000] – discussed above, can reasonably be described as not reaching his/her stated priorities of sixty (60) priority points for the environment, thirty-six (36) for social equity, and four (4) points for the economy. Indeed, this participant has the highest global economy of any participant despite having considered economic growth as a comparatively low priority – among the lowest of all participants. Though, with less extreme differences between priority point allocation and policy outcome, making a participant-by-participant assessment would involve thresholds that require an overlay of values. Thus, this extreme case is used for explanation only.

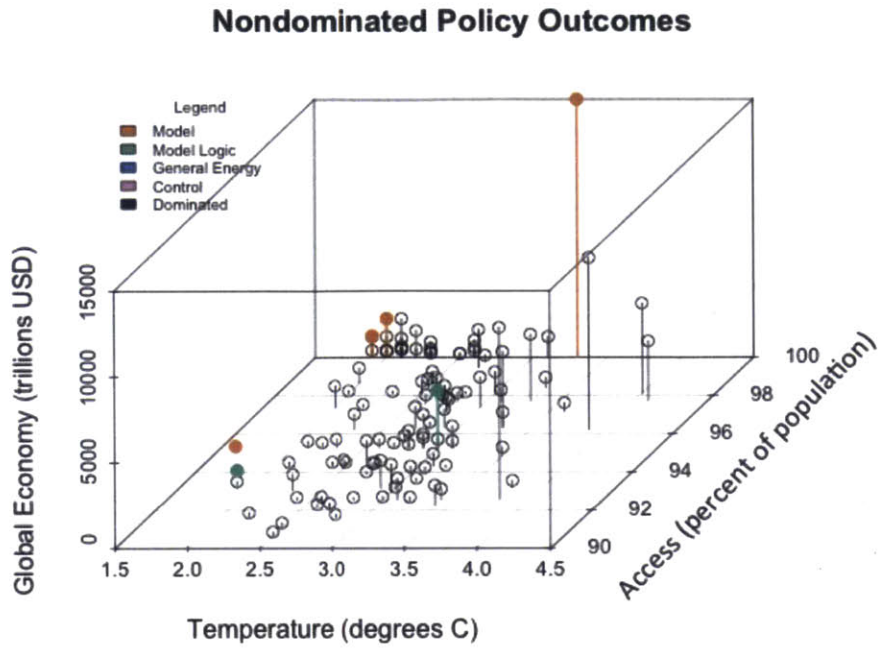


Figure 3. Non-dominated Policy Outcomes. More model users created non-dominated policies than did participants who watched the movie about model logic. No participants who watched the general energy and control movies created non-dominated policy outcomes.

### 3.4.3 Change in Priorities

In each experimental category, half or more made a change in their priorities (see Table 7). A higher percentage (72%) of participants who watched the control movie changed priorities than in any other group. The participants in the group that watched the movie about the model logic group changed priorities with the next highest frequency (71%), followed by the model users (60%) and the general energy category (59%). These numbers of participants who changed priorities (by category) are not significantly different from each other. Less than half of the model users retained their stated priorities and those that did change moved points from the environment towards social equity and economy.

Table 7. Percent of Participants, by Category, Who Changed Priorities. Most Participants changed their priorities after submitting their policies.

| Experimental Condition | Changed Priorities |
|---|---|
| Model | 60% |
| Model Logic Movie | 71% |
| General Energy Movie | 59% |
| Control Movie | 72% |

### 3.4.4 Consideration of others' interests

Does the Minister of Sustainability consider the interests of his/her three directors—the Director of Environment, the Director of Economy, and the Director of Social Equity—when creating policy? Each of three directors encourages the Minister to create a policy that prioritizes his/her area. When asked how frequently they considered their directors' interests, a larger percentage (70%) of the participants who used a model responded "often" or "very often" compared to the other categories (53% in model logic, 45% in general energy, and 64% in the control category); see Table 8.

Table 8. Ratings of How Often the Participant Considered Her Directors' Interests. More participants who used a model reported that they considered their directors' interests "often" or "very often" than participants in any other category. The control category has the second highest incidence of "often" or "very often" ratings and the general energy had the lowest.

| Experimental Condition | Percent rating "often" or "very often" |
|---|---|
| Model | 70% |
| Model Logic Movie | 53% |
| General Energy Movie | 45% |
| Control Movie | 64% |

When asked which were more influential in their decision, their own interests as the Minister of Sustainability, their Directors' interests, or both, more of the model users responded that their own interests were more influential than in any other category (62%). Participants in the general energy movie category were more evenly split about whose interests were more influential in their policy recommendation - their own interests alone (45%) or their own and their ministers' together (45%). See Table 9.

Table 9. Whose Interests were More Influential? Compare to participants in other categories, more participants who used a model reported that their own interests were more influential in their policy recommendation their directors' interest or a combination of their own and their directors' interests.

| Experimental Condition | My own interests were more influential | My Directors' interests were more influential | Both my interests & my Directors' interests were equally influential |
|---|---|---|---|
| Model | 62% | 17% | 21% |
| Model Logic Movie | 60% | 13% | 27% |
| General Energy Movie | 45% | 10% | 45% |
| Control Movie | 31% | 24% | 45% |

### 3.4.5 Confirmation of Intervention

To verify that the intervention is working, I measure the participants' assessments of the credibility, salience, and legitimacy of the decision support materials—the decision tools—they used in the experiment. Credibility, salience, and legitimacy are attributes individuals ascribe to the decision tools: the model or movies they used in making their policy decisions. A decision maker will rate a decision tool high in credibility when she/he thinks the decision tool was accurate and valid. A high salience rating means the decision maker thought the decision tool was relevant and helped address the decision as she/he understands it. A high legitimacy rating means that the decision maker believes that the decision tool includes and allows for multiple perspectives (Cash et al., 2003b). Credibility, salience, and legitimacy were each measured by two survey items in the pre-survey and the same two items in the post-survey. Each participant's measure for credibility was the mean of his/her response to the two credibility survey items. Salience and legitimacy were calculated similarly. In the pre-survey, when participants rated the decision materials they were about to use, they did not know what those decision tools were yet. That is, they did not know to which category they had been randomly assigned. The credibility questions were: "the materials my staff made for me are credible" and "the materials my staff prepared for me are generally thought of as being valid and accurate." In these and the following questions "the materials my staff made for me" are the decision tools that comprise the experimental conditions. The salience questions were: "the materials my staff made for me are relevant to this decision" and "my staff understands the decision I am facing." The legitimacy questions were: "the materials my staff made for me include input from many regions and groups," and "in making these materials, my staff consulted people from many different places."

The initial values of these ratings are similar regardless of experimental condition, indicating that the participants' expectations of the materials they were about to use were comparable across experimental conditions. The differences in ratings by experimental category were not significant for salience and legitimacy. For credibility, the only significant difference (p value = 0.02167) was between the general energy category and the control category; the other experimental categories were not significantly different from each other. Even with the significant difference between the general energy and control ratings for credibility, one can consider the pre ratings sufficiently similar to each other to conclude that the participants' expectations of the materials they were about to use were comparable to each other regardless of experimental category.

When looking at the participants' post ratings across experimental categories for each of credibility, salience, and legitimacy, some differences arise. The most notable differences occur in the salience ratings. Model use was significantly different than the general energy (p value = 0.006418) and the control (p value = 2.773e-06). Model logic was significantly different than control (p value = 0.0004454) and the general energy was also significantly different than the control (p value = 0.01483). Therefore, the control group was significantly different from every other group in participants' post-use ratings of the decision tools' salience. For legitimacy, model use was (with rounding) significantly different than the model logic group (p value = 0.05342) and was significantly different than the control group (p value = 0.003465). None of the other experimental condition groups were significantly different from each other in their post-use legitimacy ratings of the decision tools. None of the credibility post ratings are significantly different by experimental category.

Therefore, when the participants re-rated the materials, after using them, the ratings by category (approximately) decrease as by experimental condition. For credibility, salience and legitimacy, the participants who used the model had the highest ratings (tied with general energy for credibility) and the control group had the lowest. For salience, the ratings strictly decrease as relevant information decreases. Model logic and general energy have the same post-use legitimacy ratings. This demonstrates that the treatments are working because as the amount of information pertinent to the policy creation decreased (salience), so too did the participants' ratings and the control group rated lowest in all three of credibility, salience, and legitimacy.

The three treatments have a comparable credibility rating and the control has a lower credibility rating. This is consistent with the treatments working because the sources for the three treatments were reputable (MIT and National Geographic). Participants could ascertain the source of the movies via the websites used to access the movies. The Control Movie received the lowest credibility rating, which is likely explained because it is from a relatively new and informal news source (Table 10).

Table 10. Mean Credibility, Salience, Legitimacy Ratings. The participants' pre ratings of the materials they were about to use are comparable. The participants' ratings after using the materials shows that the salience and legitimacy ratings decrease by treatment category and that the control group has the lowest ratings, which indicate that the treatments are working.

| Experimental Condition | Credibility Rating (Pre) | Salience Rating (Pre) | Legitimacy Rating (Pre) | Credibility Rating (Post) | Salience Rating (Post) | Legitimacy Rating (Post) |
|---|---|---|---|---|---|---|
| Model | 3.9 | 4.0 | 3.9 | 3.9 | 4.2 | 3.7 |
| Model Logic Movie | 3.8 | 3.9 | 3.7 | 3.8 | 3.9 | 3.2 |
| General Energy Movie | 4.1 | 3.9 | 4.0 | 3.9 | 3.5 | 3.2 |
| Control Movie | 3.8 | 3.8 | 3.9 | 3.4 | 2.7 | 2.7 |

## 3.5 3E Game Discussion

This study complements existing studies of model-use in decisions processes (such as those by (Beall and Zeoli, 2008; Videira et al., 2004)) by comparing—in a single sustainability policy decision context—model-use with presentations of the model's logic, of relevant but general information, and irrelevant information. One hundred nineteen participants played, and finished, the 3E Game, in which they enacted the role of Minister of Sustainability. By comparing use of the model with learning of the model's logic via a presentation, I can study whether the medium conveying the information matters and identify possible alternatives for situations in which decision makers cannot use a model. By comparing learning of the model's logic with general, relevant information and with irrelevant information, I can study whether the content of the decision tool matters (the model and the movies used in this study).

Participants who watched a movie about the model logic or about general but relevant information matched their policy outcomes to their priorities better than participants who used a model or watched the control movie. One possible explanation for why model users did not match their stated priorities well is that they outperformed their social equity priorities by discovering the near win-win nature of the social equity measure (percent of population with access to electricity). That a much larger percent of model users maximized the social equity dimension than participants using other decision tools supports this explanation.

Model users reached the Pareto Frontier more readily than participants in the other experimental conditions. Participants in the model logic condition were the only other participants to reach the Pareto Frontier. Furthermore, model users were clustered around the lowest temperature-highest percent access-high global economy corner of the policy trade space. The participants in the other categories were more scattered in the trade space of policy outcomes.

More than half of all participants changed their stated priorities. The control group, closely followed by the model logic group changed their priorities the most frequently. The general energy and model using participants changed their priorities less often than the control and model logic, but about sixty percent of these groups changed. Thus, one can conclude that the decision tools used were not influential in whether participants changed their stated priorities.

Although model use seems to have impacted the consideration of others' interests, it did not make those interests more influential in the decision. Model users reported considering others' interests more readily than did participants in any other experimental condition. However, for the model users, their own interests were much more influential than these others' interests.

The intervention of giving participants decision tools with different packaging (using a model versus a movie presentation) and amounts of relevant information was effective. The salience (how relevant and appropriate the decision tool is to the decision at hand) decreased as the packaging became less interactive and less relevant. The control group had the lowest ratings for salience, credibility (how believable the decision tools are) and legitimacy (the inclusiveness of different perspectives in the decision tools), and the model users had the highest.

The evidence demonstrated in this study indicates that not only did the participants rate using a model as more helpful (in terms of credibility, salience, and legitimacy) in making a decision, but those who used the model also had better outcomes—they more readily identified the win-win dimension and more frequently reached the Pareto Frontier. This confirms the findings of previous research (Dowlatabadi, 1995; van Delden et al., 2011; van den Belt et al., 2013). However, model use was not linked to matching one's priorities, having others' interests influence the decision, though it was linked to a more frequent consideration of others' interests.

Decision makers who cannot use a model in a decision are still encouraged to learn of the insights of models appropriate to the decision. Participants in this study who learned of the model's logic via presentation reached the Pareto Frontier (though with less frequency than the model users), and better matched their policy outcomes to their stated priorities than did the model users. However, they did not as readily discover the win-win nature of the social equity dimension, as did the model users. Furthermore, they reported less frequently considering others interests than model users and were nearly as likely as model users to consider their own interests as more influential than the interests of others.

This study suggests areas of future research, such as repeating the same test with another model to determine if these results are generalizable beyond the En-ROADS model. In addition to exploring the generalizability of this study, such a study would also lead to a comparison of model characteristics and decision makers' perspectives of those characteristics. Additionally, questions such as would the others' interests – in this case the Directors reporting to the Minister –

would be better tested if the role-play simulation involved other participants or research confederates playing the roles of these Directors.

# 4 The Cup Game: Model use in a multi-party sustainability negotiation

## 4.1 Cup Game Introduction

Addressing complex environmental and sustainability challenges often requires collaboration among stakeholders to design and implement solutions. Sustainability negotiations often involve some issues that are based on physical and environmental constraints and other issues that involve stakeholder preferences. Collaborative modeling has been applied in multi-stakeholder environmental challenges as a means for stakeholders to make sense of the physical world components of sustainability. This study investigates whether model use and/or model authorship—whether the negotiators were given a model or co-created one themselves —influences the negotiated outcome and/or the negotiation process in multi-party sustainability negotiations, and if so, how. By using a serious gaming simulation to provide repeated and comparable instances of the same contextual situation, varying only model use, this study quantifies model influence on negotiating outcomes and identifies negotiation process insights about how modeling can inform complex, multi-stakeholder negotiations.

A substantial body of work has examined the use of modeling in policy applications. Modeling enables the study of full physical systems including interrelated components (Dowlatabadi, 1995; van Delden et al., 2011) and allows for the consideration of multiple different futures and possibilities (Morgan, 2011). In particular, researchers who study collaborative modeling (also called: Mediated Modeling, and participatory modeling among other names (Tidwell and van den Brink, 2008) and used interchangeably herein) typically look at situations involving large numbers of stakeholders, and that often result in policy recommendations. These studies are frequently set in the public sector. The models used tend to be complex, large, and predictive in nature, and are often dynamic. Furthermore, there is often a focus on expert modelers working alongside stakeholders, who will be impacted by the resulting policy, and decision makers. System dynamics modelers who practice mediated modeling (Langsdale et al., 2009) (van den Belt et al., 2013) employ expert modelers to collaborate with stakeholders to build a system dynamics model to address the stakeholders' problem. Likewise, integrated assessment researchers often work with stakeholders directly (Mustajoki et al., 2013; Pope et al., 2004). Collaborative modeling research has focused on evaluating the participatory process, and some have explained the mechanism of the observed effectiveness of collaborative modeling as the co-production of knowledge (Funtowicz and Ravetz, 1994; 1993) and social learning (McIntosh et al., 2011).

This study complements existing studies of collaborative modeling by using methods that can compare repeated instances of the same situation. Much of the research assessing collaborative modeling utilizes case studies, for example, managing the Ria Formosa coastal zone in Portugal (Videira et al., 2004) and the decision on sage-grouse protection and land use in Washington state (Beall and Zeoli, 2008). Videira et al. (2004) find that the participants credit the collaborative modeling process with organizing their ideas and conversations. Beall and Zeoli (2008) conclude that when stakeholders and experts learn how to work together, scientific findings can be coalesced with long term planning. Although the case study method has many benefits (e.g. using the actual decision makers), one of its drawbacks is its inability to test repeatedly with the same situation. Testing repeated instances in the same situation allows for statistical comparison and enables the comparison of controlled differences. Because of the complexity of the case studies in collaborative modeling research and their protracted timeline, it is often hard to isolate concepts of interest such as the manner in which a group uses a model and the impacts model use has on the resulting outcome (De Dreu et al., 2006; Ducrot et al., 2014; van den Belt et al., 2013).

Many serious gaming studies combine unstructured social interactions with a dynamic computer simulation (for examples see (Grogan, 2014; Kuit, 2005; Mayer et al., 2010; 2004; Meijer et al., 2012; Nefs et al., 2010). These computer simulations are central to the game and the participants' experience with it. Other types of serious games exists (e.g. role-play, board games, behavioral, etc. (Klabbers, 2005)), many of the existing studies cover computer assisted and computer supported serious games wherein a dynamic computer simulation is central. Serious games that do not use a computer simulation can also involve science information (Schenk and Susskind, 2014; Susskind, 2010). These are often called role-play simulations. Many role-play simulations of environmental situations are used to educate the participants and study games as teaching tools (see for example (MaKinster, 2010; Stokes and Selin, 2014)). Other role-play simulations are used to represent real world negotiations and study negotiators and negotiations (Butler, 1991; Curhan et al., 2009; 2004; Curhan and Pentland, 2007; Ducrot et al., 2014; Elfenbein et al., 2008), though these are often not set in environmental or sustainability situations.

Serious gaming role-play simulations offer an opportunity to identify, in a more controlled setting, the pathways of influence by which model use might influence collective sustainability decision making. Using a serious gaming role-play simulation research design, ensures each negotiating table receives starting instructions that differ only by the intervention (whether or not the model is given). This enables comparing multiple instances of the same initial conditions.

Serous gaming leaves the social interactions unfettered (Corrigan et al., 2015), which enables the study of, as Mayer (2009) terms it, the "chaotic messy" of people interacting with each other (Mayer, 2009). This is important in the Cup Game study design because it lets the participants themselves determine whether or not to use a model. A table of negotiators (participants) that was not given the LCA could co-create it and a table given the LCA could ignore it. By leaving the social interactions to the participants' discretion, including whether they use the model, I can study the participants' inclination toward using a model in the negotiation, and compare the use of an expert-given model with a co-created model. By using surveys before and after the role-play simulation and interviews a few weeks later, I gain more insight into the respective impacts of model use, model authorship, and the manner of model use.

The context of the game is based on a real-world sustainability challenge focused on recycling and/or composting used paper coffee cups. I use the game to identify whether using an LCA of the carbon dioxide ($CO_2$) emissions reduced in the new post-consumer paper coffee cup system influenced the process or outcome of negotiations, or both. I also investigate how the authorship of the model and two different means of using the model impact these elements.

The unstructured social interactions inherent in serious games allow me to study the impacts of model use and of model authorship. Tables of negotiators—parties negotiating with each other usually while seated around a table—that did not receive a model were free to formulate the model. Tables receiving the model were free not to use it. Therefore, some of the tables that used a model received it from experts and other tables co-generated it during the negotiation itself. Furthermore, tables of negotiators were free to use the model however they wanted during the negotiation. This revealed two dominant manners of model use. I will discuss results below by whether or not a table used a model (regardless of whether it was a co-created or expert given model) and whether the model's authorship mattered (was it a co-created model or an expert given model).

I hypothesize that model use will impact the negotiation process by providing a structured means for the negotiators to make sense of the alternatives they are selecting among (as is suggested by researchers studying modeling such as (Dowlatabadi, 1995; Morgan, 2011; van Delden et al., 2011). I expect models to provide this structured means of assessing alternatives whether this assessing is done while the parties are creating an agreement package or while they are verifying a tentative agreement. I expect that the impact to the negotiating process will manifest in measures of negotiation outcome and in the negotiation process measure, negotiation duration. Given the similarities of the participants, one can reasonably attribute the negotiated outcome and negotiation process differences to the difference between model use and lack of model use and co-creating a model versus using an expert given model.

Similarly, I hypothesize that model use will increase the number of favorable agreements (in this role-play simulation, those agreements that minimize carbon dioxide emissions and the agreement that maximizes the negotiated value) because it will help negotiators identify the environmental consequences of negotiation alternatives (van Delden et al., 2011; van den Belt, 2006). Once they know the environmental impacts of the different alternatives under consideration, the parties can create or select an agreement that meets their environmental goals. Furthermore, when a table of negotiating parties co-creates a model for use during the negotiation, their level of understanding of the context is higher than if they had blindly used a model given to them that they did not seek to understand.

Therefore, I expect that the tables that co-create a model will have a higher frequency of favorable agreements than tables that use the given model.

Because model use provides more insight into the alternatives being considered (Pielke, 2007), it is possible that a negotiator could use the model to capture more value for him/herself. To investigate whether this is happening, I assess the value distribution among the negotiating parties. Furthermore, at tables that co-create a model, the model logic is more transparent and discussed. Therefore, these tables are less vulnerable to individual parties not sharing the model insights than are tables using a model given to them.

By helping the negotiators make sense of the alternatives they are deciding among, model use is expected to reduce the negotiation duration. When the negotiating parties co-create their own model during the course of the negotiation, they are taking time away from negotiating to create a tool to help them make sense of the alternatives. Because of this competing use of their time, tables of negotiating parties that co-create a model are expected to have a longer negotiation duration than tables of negotiators that do not use a model.

During a five-party negotiation, such as this role-play simulation, there are multiple manners for using a model. For example, the negotiators can consult the model as each new alternative is discussed and create an agreement based on the model's output. Alternatively, the negotiators can negotiate as normal and then verify that an agreement that they have tentatively agreed to reduces the carbon dioxide emissions satisfactorily. A third possibility is that some parties could use the model secretly without letting the other parties know that the model exists, and use it for selfish gains. In the unstructured social interactions in this serous game role-play simulation, I expect each of these.

In the following sections, I discuss the methods I used, the results I found from the 74 tables of 5 participants that have played the Cup Game, and I discuss the results. In the methods section, I describe the serious game role-play simulation and the data I collected from it. In the results section, I discuss the results on the negotiated outcome and negotiation process. The discussion section brings the findings into the real world and suggests future research.

## 4.2 Cup Game Methods

This study uses multiple methods: it is a serious game negotiation role-play simulation, with surveys, and interviews. I use both quantitative and qualitative data to investigate how parties are using models in sustainability negotiations and the impact of model use on negotiation process and outcome. Below, I describe the context of the serious gaming simulation (section 4.2.1), and the research design (section 4.3).

### 4.2.1 Serious Game Negotiation Role-play Simulation

The Cup Game is a negotiation role-play simulation loosely based on the initiative Starbucks Coffee Company launched to recycle and/or compost used paper coffee cups. Used paper coffee cups contain high quality paper fibers that could be used in other paper products. However, it is uncertain whether these used cups can be recycled in large quantities in paper mills because they have a coating on the inside of the cup, frequently have plastic lids still attached, and often also have food residue. The coating, plastic lids, and food residue are likely to pose problems for the paper pulping process in most paper mills. Food residue is not a problem in most composting plants; however, the plastic lids would need to be of a plant-based plastic for composting to be viable. Whereas composting may have fewer technical hurdles to processing used coffee cups in bulk, composting would not take advantage of the strong paper fibers in the cups, as recycling could.

In response to their customers' concern over how many Starbucks paper cups were going to landfills, Starbucks set a goal of giving used paper coffee cups a more useful end of life. Starbucks convened a first round of stakeholders from across the post-consumer paper cup supply chain in late 2009, held a workshop in January 2010 to invite new stakeholders that the 2009 workshop identified as relevant, and then held a summit with this extended stakeholder group in April 2010. I co-facilitated the January 2010 workshop and assisted with the April 2010 workshop (Czaika, 2010b).

The interests and priorities of the roles in this serious game role-play simulation derive from those of the stakeholders in the real-life used paper coffee cup supply chain system, as communicated through interviews and in the January and April 2010 workshops. Additionally, the stakeholder dynamics in the real world scenario are re-created, in a simplified manner, in the Cup Game as the game mechanics and coalition structure.

In role-play simulations, participants enact a role, imagining they were this person. Role-play simulations have a long history in negotiation research (Butler, 1991; Ducrot et al., 2014). In the Cup Game, participants play the roles of 5 stakeholders from the paper cup supply chain convening to make decisions about an upcoming pilot test to determine the feasibility of composting and recycling used paper coffee cups. Each group of five negotiators, called a negotiating table, either receives an LCA pertinent to two of the five issues in the negotiation, or does not receive the LCA. These parties have five issues they must decide, and each issue has a finite number of alternatives from which they may choose. Each party has an individualized point structure for these alternatives. The parties are representatives from a coffee retail company, a cup manufacturing company, a recycling company, a compost company, and a waste collection company (hauling company). The coffee retailer has convened this group of representatives from these organizations to design a system seeking to provide a better end of life for used paper coffee cups.

Each table receives all the data necessary for the LCA, regardless of whether the table received the set of equations forming the LCA (the model). However, these data are distributed among the five parties. Participants playing the parties have to decide whether, when, and how accurately to share the LCA data they are given.

Tables can reach agreement on all five issues (called an agreement) either by using the LCA alongside their points or by using solely their points.

The differences in the roles' priorities are designed to be such that no coalitions are stable. That is, they are unstable in the sense that parties may want to leave a coalition and outsiders to the coalition may wish to join (Nagashima et al., 2009). In a simple game like the Cup Game, an unstable coalition structure is a situation where if one party finds another party that agrees with her on which alternative to select for one issue, that party will disagree with her on at least one other issue. The unstable coalitional structure mirrors the real world case and retains the multilateral nature of the game.

The parties are working toward the environmental goal of reducing carbon dioxide emissions by 110,000 pounds (49.9 metric tons) in the pilot test. If a table's agreement meets or exceeds 110,000 pounds of $CO_2$ savings, each of the five parties will receive bonus points added to their negotiated points. The LCA model rules out some alternatives on two of the issues as not fulfilling the environmental sustainability goal. Alternatively, tables can reach this environmental goal strictly through negotiation based on their preference points. The parties are not told outright that they share this same specific target value (110,000 pound emission savings) and the same reward for reaching it, though they might establish these during their negotiation talks.

Company preference (strategy) drives each party's preference structure for the other three issues. These issues are related to the timing of the start of the pilot test, whether the composition of the larger, longer term system will be specified in this negotiation and what it will be; and whether the pilot will be open to outside observers like Environmental Non-Governmental Organizations and the media.

That the model is optional allows me to investigate the role it plays in the negotiation process and how it influences the negotiated outcome, and enables me to study the role of model authorship. Sustainability negotiations require engagement with "coexisting different interpretations...often perceived as conflicting certainties" (Klabbers, 2005), what Funtowicz and Ravetz (1993) term "post-normal science." Thus, the setting of a sustainability negotiation enables me to juxtapose the differing interpretations with a model pertinent to the problem at hand. This pairing allows me to assess how well the parties integrated their differing perceptions without "negotiating nonsense" (van de Riet, 2003). By considering repeated instances of tables of negotiators grappling with how to create a better end of life for used paper coffee cups we look at the impact to negotiation process and negotiated outcome between tables that used a model and those that did not, and among those that did use a model, by who authored the model, an expert or the parties themselves.

## 4.3 Cup Game Research Design

### 4.3.1 Role-Play Simulation

In the Cup Game, each participant is randomly assigned a table and one of the five roles at the table (the coffee retailer, the cup maker, the recycler, the composter, and the hauler). At approximately half of the tables, one party at the table receives an LCA model, and at the other half of the tables none of the parties receives an LCA model. The participants are asked to decide on one alternative for each of the five issues before them. Some tables might not reach an agreement within the allotted timeframe.

Each participant receives a set of instructions specialized for his/her role (Confidential Instructions) and a copy of the General Instructions, which are identical for all roles. Each role's confidential instructions delineate that role's priority among the five issues and the role's priority among the alternatives for each issue. These priorities are communicated to the participants through a points system. Each alternative is given a point value. By rank ordering the point values of alternatives within each issue, the participants can determine the role's priority choices for that issue. By rank ordering the points overall, the participant can determine her role's priority among the issues. Participants are told not to share with each other the point value of any alternative, though they are encouraged to share their priority rankings among the alternatives.

To enter into an agreement, each participant must meet or exceed a point threshold. These point thresholds are unique to the role. During the negotiation time, participants determine the number of points they will receive in a proposed agreement by adding up the points she would obtain from the five selected alternatives (one for each of the five issues). A party's score overage is a normalized value calculated by dividing the number of points attained by the party's threshold to join an agreement. The score overage is used to compare value allocation among the parties.

The confidential instructions also contain data for the LCA analysis. As noted above, these data are dispersed among the roles, as it would be in a real negotiation. For example, the hauler has information about driving distances, truckload capacity, and carbon dioxide emissions per mile. Only by sharing their data accurately, can the table discern the full picture of carbon dioxide savings in the proposed pilot test.

Each party has at least one piece of information necessary for the LCA model. However, at intervention tables, only one party, the Cup Maker, is given the LCA model equations. This reflects the real-life possibility of imbalance in information available.

The LCA model is purposefully simplified so the participants can grapple with it within the context of a negotiation including other issues, and within a short time frame. The model is thus not the focus of their activity, but rather a helpful tool for them to reach their goal of creating an agreement that saves a certain amount of carbon dioxide in a pilot study. The basic structure of the LCA is depicted in equations 2 through 12.

$$tons\ composted = tons\ cups\ collected * percent\ in\ compost \tag{2}$$

$$trucksloads\ to\ compost = \frac{tons\ composted}{tons\ per\ truckload} \tag{3}$$

$$pounds\ CO_2\ emitted\ trucking\ compost = miles\ to\ compost\ facility * truckloads\ to\ compost * \frac{CO_2\ emitted}{mile} \tag{4}$$

$$pounds\ CO_2\ saved\ composting = tons\ composted * \frac{pounds\ CO_2\ saved}{ton\ composting} \tag{5}$$

$$net\ pounds\ CO_2\ from\ composting = pounds\ CO_2\ saved\ composting - pounds\ CO_2\ emitted\ trucking\ compost \tag{6}$$

$$tons\ recycled = tons\ cups\ collected * percent\ in\ recycling \tag{7}$$

$$trucksloads\ to\ recycle = \frac{tons\ recycled}{tons\ per\ truckload} \tag{8}$$

$$pounds\ CO_2\ emitted\ trucking\ recycling = miles\ to\ recycling\ facility * truckloads\ to\ recycle * \frac{CO_2\ emitted}{mile} \tag{9}$$

$$pounds\ CO_2\ saved\ recycling = tons\ recycled * \frac{pounds\ CO_2\ saved}{ton\ recycled} \tag{10}$$

$$net\ pounds\ CO_2\ from\ recycling = pounds\ CO_2\ saved\ recycling - pounds\ CO_2\ emitted\ trucking\ recycling \tag{11}$$

$$net\ pounds\ CO_2 = net\ pounds\ CO_2\ composting + net\ pounds\ CO_2\ recycling \tag{12}$$

The LCA model can be used in multiple ways at the negotiating table. In her Cup Game instructions, one party (the Cup Maker) receives the model and encouragement to "share it [the LCA model] with the other parties to determine the amount of carbon dioxide saved with different alternatives for [some issues]." However, this party receives no further instruction on how or when to share the model. This is purposefully left up to the discretion of the participant.

Giving the parties point values on each alternative was a research design choice that enables calculating the table score and the value maximizing agreement. The table score is the sum of the individual scores for each of the five parties. The value maximizing is that agreement with the highest sum of the individual scores; it is the highest table score.

The Cup Game's value maximizing agreement includes the second best environmental sustainability alternatives. This research design choice forced the participants to choose between maximizing the environmental benefits of their agreement and maximizing their earned value. Furthermore, it is methodologically important because the difference between the carbon dioxide savings in the value maximizing agreement (which includes the second best environmental alternative) and the suite of agreements that include the alternative that produces the most carbon dioxide savings (best environmental alternative) is designed so it cannot be easily estimated without the use of a model. The difference among the environmental alternatives is small enough that the participants cannot estimate the impact each will have on carbon dioxide savings. Therefore, in choosing among the alternatives on the environmental issues, the parties must either calculate the carbon dioxide savings using an LCA, or use their respective priority points as is done with the non-environmental issues.

### 4.3.2 Surveys

Each participant is asked to complete a pre survey and a post survey. The survey data serve to help rule out alternate explanations and to gather information about the participants' experience playing the Cup Game.

To rule out the explanation that model usefulness depends on the individuals' comfort with quantitative data and models, participants indicate their comfort with numerical data. The pre-survey also helps to establish their initial opinion about the use of numerical data in sustainability negotiations, and their starting opinion of each role's commitment to sustainability.

The post survey repeats the above measures, in addition to asking more questions about their use of the LCA model, how much they trust the data other parties shared, and their opinions about the outcome.

#### *4.3.2.1 Interviews*

Some participants were interviewed a week or two after the role-play simulation to gain more insight into how they used the model or why they did not use it.

The semi-structured interviews are between 20 and 30 minutes, are recorded if participant permission is given, and transcribed. The interview data help triangulate whether and how tables used the LCA model, provide insight into the nature of the conversation at the table during the negotiations, and to elucidate participants' opinions about model use in sustainability negotiations and their opinions about the roles' commitment to sustainability.

### 4.3.3 Participant Recruitment

Subjects are diverse professionals and students in sustainability-related fields from different world regions. Butler (1991) demonstrated that the outcomes of student subjects matched that of experienced professionals and Herbst and Schwarz (2011) confirm students trained in negotiation perform comparably well to professional negotiators (Herbst and Schwarz, 2011).

## 4.4 Cup Game Results

The data include 370 participants grouped into 74 tables of five participants at each table, 37 interviews, and 291 pre-survey and 215 post-survey responses. Approximately half of the 74 tables (Table 11) were given an LCA.

### 4.4.1 Prevalence of Model Use

Not all the tables that were given a model used it, and some that were not given a model created one on their own. At a few tables, some participants decided not to share the LCA data they were given in the confidential instructions, thwarting their tablemates' attempts at using a model. At a few other tables, one role collected data and used the model clandestinely and without sharing the model's results. Fifty-nine tables used a model, with 32 tables using a given model and 27 creating their own. Seven tables did not use the LCA they were given, and eight were neither given an LCA nor created one.

I compared tables that used the given LCA model, those that created an LCA model, and those that did not use an LCA model, considering the impact on negotiation process and on negotiated outcome. In particular, I consider the process characteristic of negotiation duration, and three outcome characteristics: the attainment of the favorable agreements, the value of agreements reached, and the distribution of value among the parties.

Table 11. Distribution of data across initial condition and what the groups did with that initial condition.

| | Used an LCA | Did not use an LCA | Totals |
|---|---|---|---|
| Given LCA | 32 | 7 | 39 |
| Not Given LCA | 27 | 8 | 35 |
| Totals | 59 | 15 | 74 |

I analyze the data in three categories: those tables that used the LCA they were given, those that created an LCA during their negotiation, and those that did not use an LCA during the negotiation. The latter category comprises tables that did not use an LCA they were given and those that were not given an LCA and did not create one. Combining these categories is viable due to the focus of the research questions. Because I am interested in comparing tables that use a model with tables that do not use a model, exploring differences between tables that ignored a model and those simply did not co-create one is left for future research (see section 4.5).

### 4.4.2 Negotiation Outcomes

#### *4.4.2.1 Characteristics of Agreements Reached: Most Environmental and Value Maximum*

Here, I examine the subset of feasible agreements that include either the most environmental alternative or the value maximizing.

Because the LCA model excludes some alternatives on two of the five issues, the model reduces the number of issues on which the parties must use preferences to reach agreement. That is, the LCA model provides information to address the physical world issues that tables not using the LCA model must address with preference-based information.

Tables that created their own LCA outperformed the other two categories in terms of reaching the two, mutually exclusive, sets of most desirable agreements: the value maximizing agreement (set of one agreement) and the set of twelve agreements that maximize the environmental sustainability. The ratios of success for tables using the given model (0.25) and those that created a model (0.44) are significantly different from each other in a one-sided, 90% confidence test ($p = 0.0975$). See Figure 4. Other comparisons are not significant, though, notably, there are only four counts of success for tables not using a model.

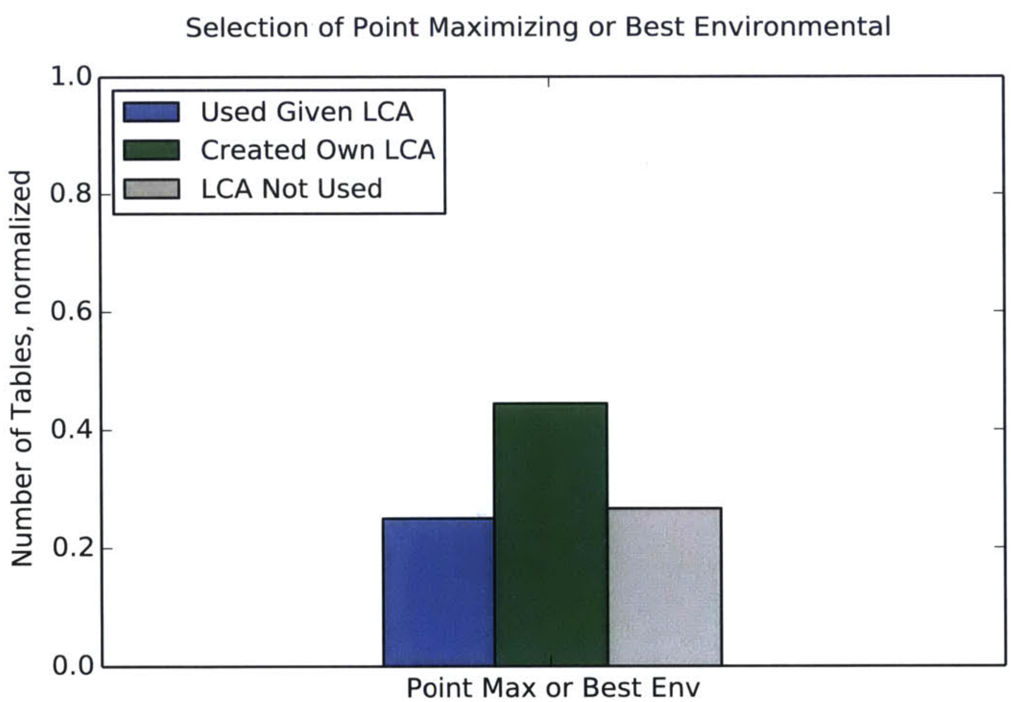


Figure 4. Favorable Agreements. Selection, by model-use category, of the mutually exclusive favorable agreements: the value maximizing agreement and any of the agreements that minimize the carbon dioxide emissions. The counts are normalized by the number of tables in each category.

The data show that half (50%) of the tables that did not use a model reached a unique final agreement (a final agreement not reached by any other table in that category), compared to 38% of tables that used the given model and 41% tables that created their own model, respectively. This spread of final agreements lends support to the finding that model-using tables were better able to target their final agreement to a favorable agreement because multiple tables were able to identify the most favorable agreements.

#### *4.4.2.2 Characteristics of Agreements Reached: Agreement Value*

The table score of the agreement is the sum of the parties' individual scores. All else being equal, it is better for the parties if they choose an agreement with a higher table score value. However, as discussed above, in the Cup Game design, the agreements that maximize emissions reduction have lower table values and those agreements that have higher table values offer less emissions reduction. Furthermore, note that the value maximizing agreement forms a ceiling for the table score data (765) and not reaching an agreement forms the floor (0).

Figure 5 shows the scores of tables that used the given LCA model, of tables creating their own LCA, and of those that did not use an LCA model. In this figure, the lowest outlier in the group that used the given LCA is an infeasible agreement. At this table, one party either miscalculated his/her score, or knowingly, possibly reluctantly, agreed to a score lower than his/her stated threshold. The only table not to reach agreement did not use a model; this table is not pictured in the figure. The median of all three categories is 720 points. Considering the dichotomous classification of using a model and not using a model, the difference in variance between these two categories is significant ($p = 2.2*10^{-6}$).

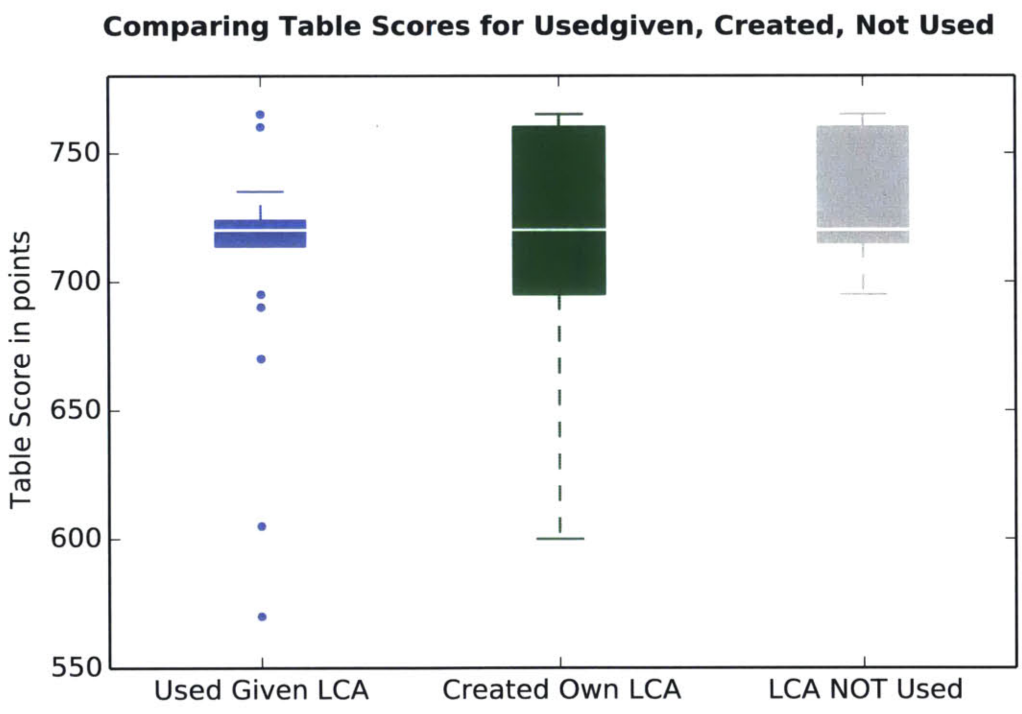


Figure 5. Box and whiskers plot of table scores displaying median, and 25th and 75Th percentiles by the categories Used Given LCA, Created Own LCA, and did NOT use LCA. The highest table scores possible is 765 points. Tables creating their own LCA had the largest variance.

Figure 6, Figure 7, and Figure 8 show the number of tables reaching each score for tables that used the given model, tables that co-created a model, and tables that did not use a model, respectively. Of the tables that used the given model, fifty percent reached agreements that earned a table score of 720 points (out of a maximum of 765 points); see Figure 6. Twenty-two percent of the tables that co-created their own model reached an agreement that earned them the maximum score of 765 points (see Figure 7). One table that did not use a model failed to reach agreement. As with the tables that used the given model, the tables that did not use a model most frequently reached agreements that yielded 720 points (see Figure 8).

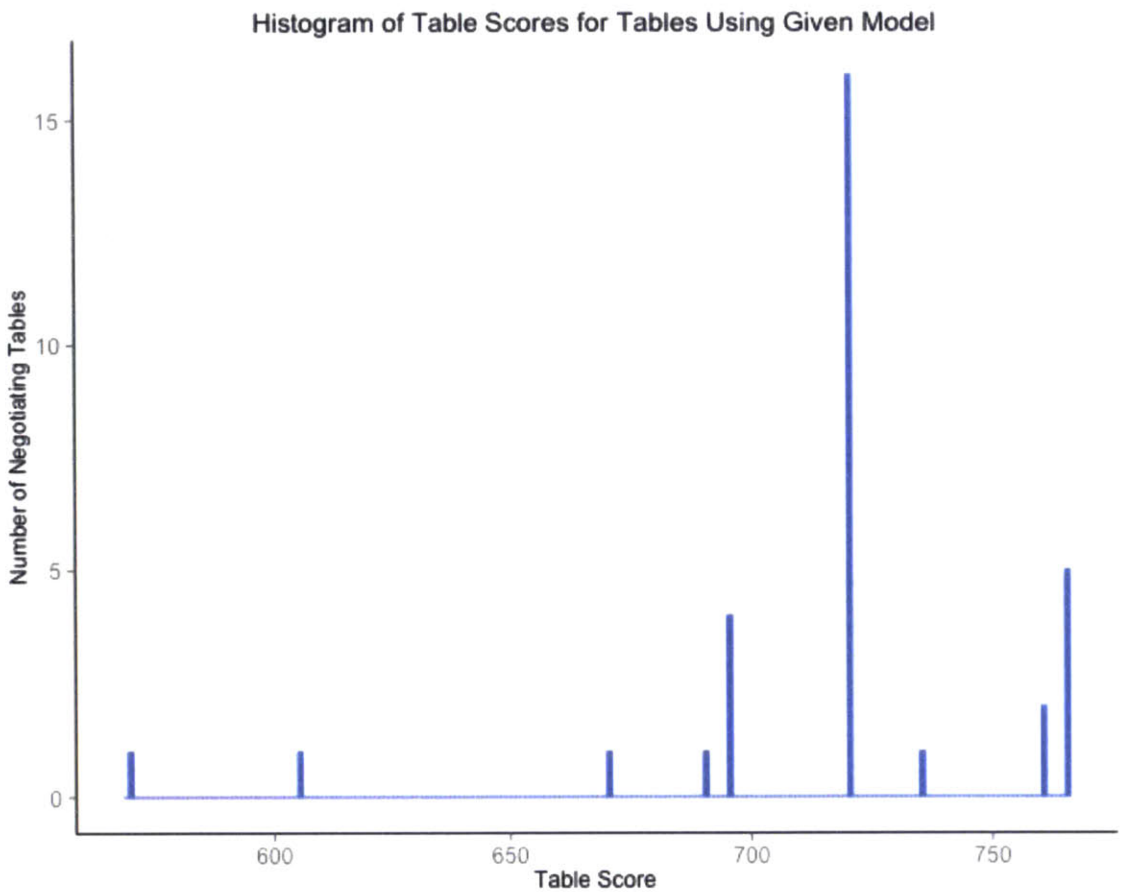


Figure 6. Tables Scores Reached by Negotiating Tables that Used the Given Model.

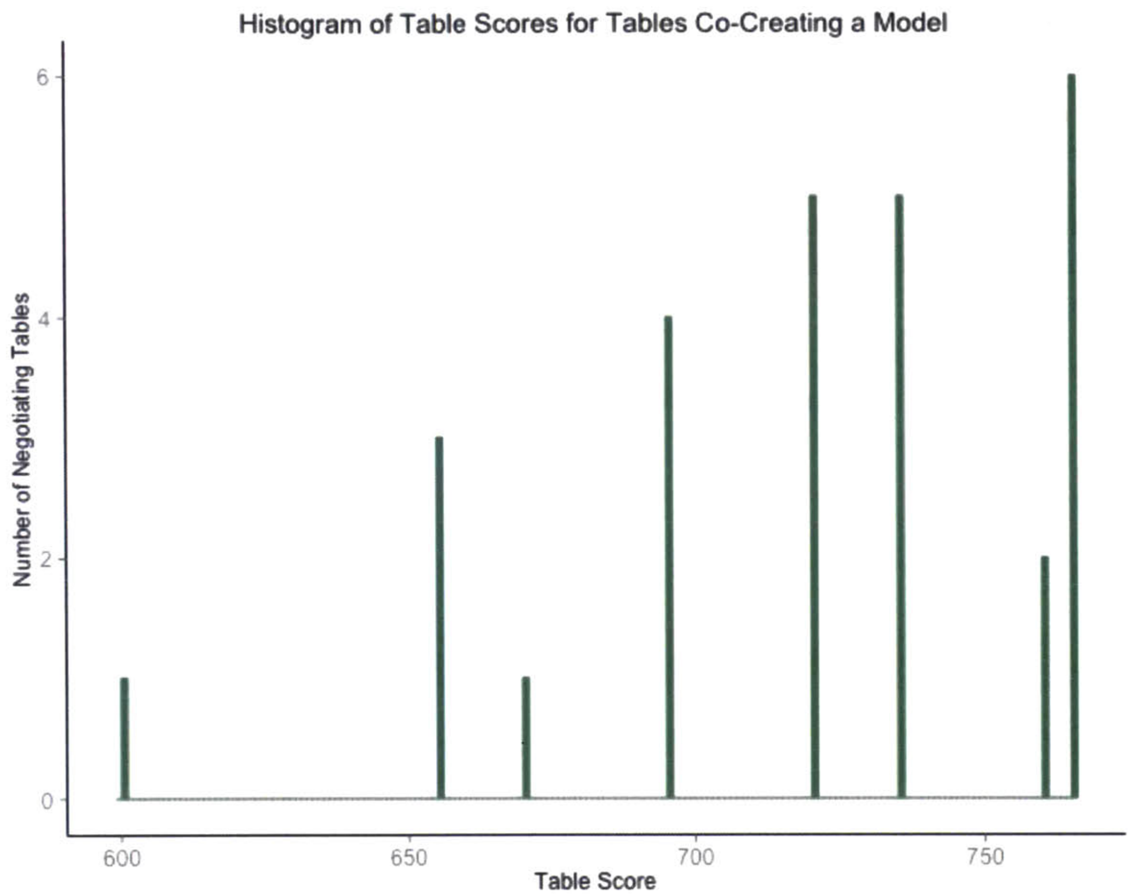


Figure 7. Table Scores Reached by Negotiating Tables that Co-Created a Model.

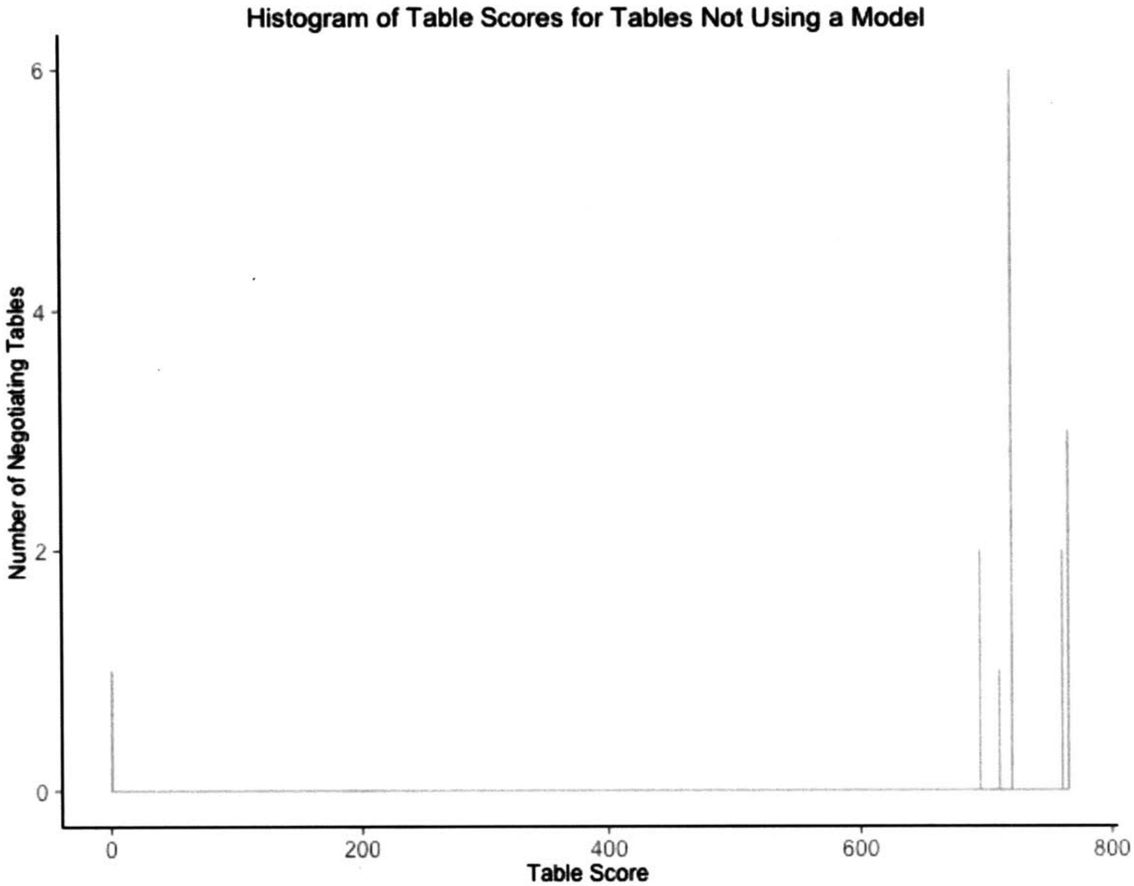


Figure 8. Table Scores Reached by Negotiating Tables that Did Not Use a Model.

#### 4.4.2.3 *Characteristics of Agreements Reached: Value distribution among Parties*

Using the LCA, whether using the given or creating one, compared with not using an LCA, did not vastly alter the value distribution among the parties. I measure this by looking at the score overage, which is the normalized number of points in excess of the minimum number a role must attain to enter into an agreement. The thresholds for joining an agreement differ by role.

Figure 9 shows that the roles' score overages, relative to each other, follow the same pattern regardless of whether the given model was used, a model was created, or no model was used. The Cup Maker and the Composter have the largest score overages, earning a median of two times the number of points they need to join an agreement. The score overages for the other three roles are similar to each other and do just slightly better than earning the number of points they need to join an agreement.

There are, however, some small differences for each role depending on whether the table used the given model, created a model, or did not use a model. The coffee retailer has the largest median score overage when the table creates a model. At the ninety percent level, the coffee retailer's median score at tables that created an LCA is statistically significantly different than at tables that used the given LCA (p = 0.06994) and than at tables that did not use a model (p = 0.04897). The variance is also larger in this case. The Cup Maker has a slightly lower (not statistically significant) median score overage when the table creates a model, and the variance is larger. The variance on the Cup Maker's score overage is the smallest when the table uses the given model. The Recycler has equal medians among the three cases and just a slight difference in variances. Note that the Recycler outlier under 1.0 is the individual who agreed to an agreement that was under his/her threshold for agreement. The Composter has a slightly higher (not statistically significant) median score overage when the table uses the given model and a slightly larger variance when the table creates its own model. The Hauler has the highest median overage when the table does not use a model and the lowest when the table creates its own model. These differences in the Hauler's score are not statistically significant.

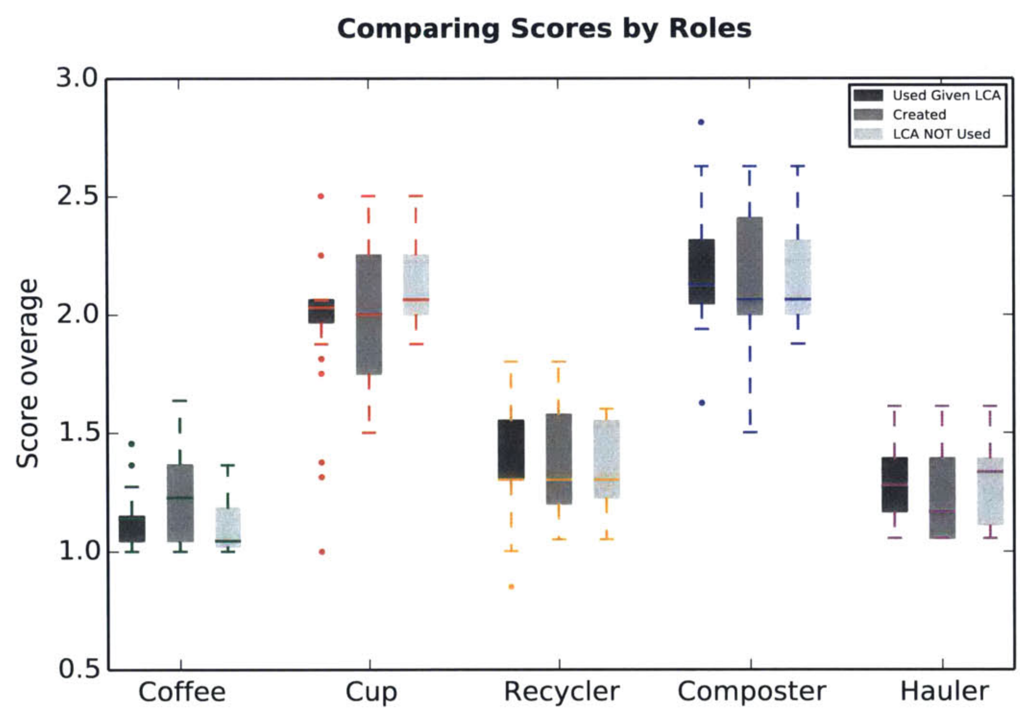


Figure 9. Role Score Overages by Used Given, Created, and Not Used LCA. A score overage value of 1.0 is the point threshold to join the agreement. Model use did not appreciably change the value distribution among the roles.

### 4.4.3 Negotiation Process

#### 4.4.3.1 Negotiation Duration

Use of the LCA impacted the duration of the negotiation. Tables using the LCA model, whether using the given model or creating their own, had a shorter median negotiation duration and mean negotiation duration than tables not using an LCA model. Tables using a model had a median negotiation duration of 45 minutes; the median negotiation duration of tables not using a model was 55 minutes. The mean duration for tables using a model was 46 minutes compared to 51 minutes for tables not using a model. Neither of these differences is statistically significant. The median and mean times for tables using the given model are 45 minutes and 46 minutes, respectively. Tables co-creating a model negotiated in median time of 45 minutes and a mean time of 47 minutes. Figure 10 also shows that the tables using an LCA have a smaller variance in their negotiation times. When those tables that used the given LCA and those tables that co-created an LCA are considered as a composite category, the variances for the tables using a model and those not using a model significantly differ ($p = 0.0016$). When considered individually, the variances of the tables using the given model and those creating a model are not significantly different from each other. However, the variance of each is statistically different from the variance of tables not using a model: tables using the given model and those not using a model have a significantly different variance ($p = 0.012$), and, the tables creating their own model and those not using a model have a significant difference in variance ($p = 0.0053$).

Of the tables that received the model, none of the participants had seen the model before the 20-minute negotiation preparation period (the time during which participants read the confidential instructions for their roles and the general instructions for all roles). Therefore, there was a learning curve associated with the LCA model itself. I found that model-using tables had a shorter negotiation time. Therefore, the reduction of the number of preference-based issues had a stronger impact than the addition of the learning curve, resulting in a comparatively shorter negotiation time for tables using the given LCA model than those not using the LCA model.

The tables that co-created the model had to do so while negotiating (the pre-negotiation preparation period was individual and participants at a table did not talk with each other). Even with this extra burden of creating a model, these tables still had shorter negotiation mean and median times compared to tables not using the model.

The tables using the given model had slightly shorter mean and median negotiation durations compared to the tables co-creating a model. This is expected, because the former had only to become familiar with a given model whereas the latter had to recognize the need for one and to develop it.

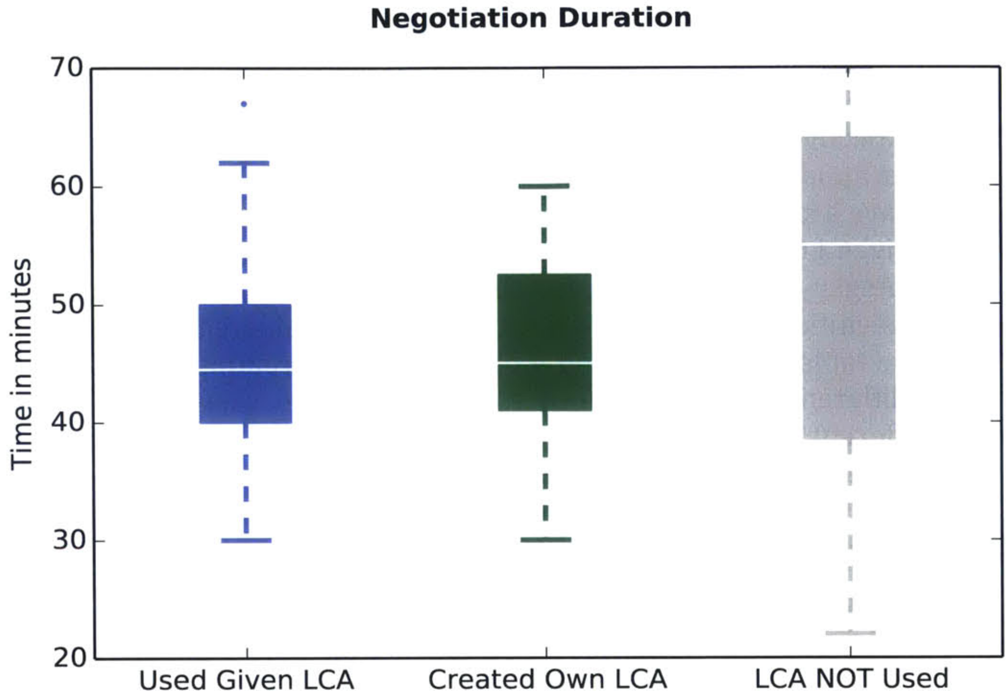


Figure 10. Negotiation Duration displaying median, and 25th and 75Th percentiles for the model use categories: Used Given LCA, Created Own LCA, and LCA Not Used. The tables not using an LCA had a longer median negotiation duration and a larger variance in negotiation duration than the other two model use categories.

#### 4.4.3.2 Different manners of using of the LCA

Through survey and interview data, I found that the tables that used the model, whether using the given model or creating one, used the model in different manners. At some tables the parties used the model collectively and at other tables, the Cup Maker used the model on his/her own. At tables where the Cup Maker role used the model individually, he/she had the possibility of using the model to maximize his/her own point value. The Cup Maker did this by collecting data from the other parties, plugging these data into the LCA model, and not sharing the results of the LCA model. However, this occurred only at a few tables.

Among collective model users, there were two different manners of model use: to test the emissions of alternatives in the process of developing an agreement and to verify the emissions of an agreement tentatively agreed upon. Below (Table 12), are interview quotes representative of each manner of LCA usage.

Table 12. Manners of Model Use. Tables of negotiators did used the model in different manners. The predominant two manners were to verify agreements and to test alternatives, though a third manner (self benefit of the party introducing the model) was also observed.

| | |
|---|---|
| Verify Agreement | "We looked at it to make sure we had the right decisions to trigger the incentive [bonus for reaching the $CO_2$ savings goal]." |
| Test Alternatives | "His [cup maker's] spreadsheet kinda became our fact checking or like a litmus test tool. ... [W]hen we started looking at different proposals, we started looking at the Cup Maker's spreadsheet to see [which were] above the threshold." |
| Self Benefit | "He [cup maker] just went around and asked us for numbers to estimate the $CO_2$ per ton that we would reduce.... So we thought maybe there was some sort of spreadsheet he was working with already. We don't know if he was calculating it separately or not...." |

The tables that used the LCA to test alternatives achieved table scores that skewed higher than the table scores of tables that used the LCA to verify an agreement. Note that the value maximizing forms a ceiling for the table Score data (765). The median values are similar for both of these groups. These differences are not statistically significant. Of the tables with an indication of how they used the model (26), the tables that used the model to test alternatives were the only tables to reach the value maximizing agreement.

The participants' quantitative comfort was not significantly different for those at tables given a model versus those at tables not given a model (p-value 0.2416); it also was not significantly different for tables that used a model versus those that did not use a model (p-value 0.9271). This demonstrates that participants did not self-select into model use by nature of their comfort with quantitative information, and demonstrates that the quantitative comfort is not an alternative explanation for the results found. Additionally, their assessments of trust of the parties and perceived commitment to sustainability were not significant—with the exception of trust for the composter—for the tables given versus not given a model nor for tables that used versus those that did not use a model (see Table 13 for a listing of p-values by role for trust ratings and Table 14 for a listing of p-values by for ratings of commitment to sustainability). Therefore, trust and perceived commitment to sustainability do not explain the results observed.

Table 13. P values of participant ratings of their trust of the information shared by each role. The composter trust in given versus not given is significant at a 90% level. (Significance codes: **** = 0; *** = 0.001; ** = 0.05; *= 0.1).

| | **Given versus Not Given** | **Used versus Not Used** |
|---|---|---|
| Trust of info Coffee shared | 0.1692 | 0.8619 |
| Trust of info Cup shared | 0.1667 | 0.4817 |
| Trust of info Recycler shared | 0.3696 | 0.7926 |
| Trust of info Composter shared | 0.09237* | 0.2443 |
| Trust of info Hauler shared | 0.2726 | 0.807 |

Table 14. P values of Participant ratings of role commitment to sustainability. None of the values is significant at better than 90% level. (Significance codes: **** = 0; *** = 0.001; ** = 0.05; *= 0.1).

| | Given versus Not Given | Used versus Not Used |
|---|---|---|
| Coffee Commitment to Sustainability | 0.2232 | 0.9226 |
| Cup Commitment to Sustainability | 0.605 | 0.6893 |
| Recycler Commitment to Sustainability | 0.1167 | 0.134 |
| Composter Commitment to Sustainability | 0.8568 | 0.4909 |
| Hauler Commitment to Sustainability | 0.7322 | 0.4459 |

## 4.5 Cup Game Discussion

This study complements existing studies of collaborative model use (such as those by Videira et al., 2004 and Beall and Zeoli, 2008) by utilizing a method that allows for repeated instances within the same context. In this study, there were 74 instances of the same context. These repeated instances enable me to add to the conversation about the ways models are used in sustainability negotiations, and how model-use impacts the negotiation duration and negotiation process.

In the role-play simulation, more tables used a model than did not, even if they had to create the model themselves. This suggests that the tables found a model helpful in their negotiation process and confirms the collaborative modeling research findings that model use can help sustainability decision makers (see for example Tidwell and van den Brink, 2008). Model users outperformed non-model users in negotiation duration and targeted agreement choice. Notably, model use perpetuated differences in value distribution, which could be interpreted as reinforcing, or at least not altering, the relative power among the parties.

Tables that used a model reached agreement faster than those not using a model. Even those tables that had to create a model while negotiating negotiated faster than tables that did not use a model. Shortening the time of negotiations eases a frequently stated reason for not using a negotiated approach. Quicker negotiations also increase the likelihood that the negotiation will reach a conclusion rather than being aborted due to a prolonged process. The duration of the negotiation could be considered a proxy for the ease of reaching agreement. Situations where some parties are better off if no agreement is reached notwithstanding, it is generally the case that an agreement must be reached for the group to take action towards improving sustainability. Indeed, I designed the Cup Game such that each party has a low barrier to agreement.

Neither using the model nor whether the model was co-created or expert-built vastly changed the value distribution among the parties. However, there were some smaller value shifts that depended on model use and model authorship (whether it was co-created or expert-built). The convening role (the Coffee Retailer) benefited from co-creating the model, whereas the hauler received lower scores when the model was co-created. The party introducing the model (the Cup Maker) and the convener received a narrower range of scores when the model was expert-built. The scores of the other two roles were not appreciably impacted by model use or model authorship.

Using models to test alternatives, rather than to verify a tentative agreement, will likely shorten negotiation durations and lead to more favorable outcomes. By exploring as they negotiate, the group can see more clearly the impact of each choice. This allows the table to identify which parties lose value in which choices and to find potential areas to give more value to those parties. Finding ways to convey more value is particularly pertinent if some parties lose value due to choices that protect the environment. Rather than stopping the entire negotiation process, parties that lose on environmental issues can gain value on other issues. Future studies can be designed to investigate this hypothesis that using the model to test alternatives will shorten the negotiation time and achieve higher valued favorable agreements.

One possibility as to why tables using a model to test alternatives reached higher table scores than tables using the model to verify an agreement is that the model served as a boundary object. A boundary object is an artifact (or an effort that leads to a product) that serves as focal point in the conversation, is specific to the situation at hand, and that can accommodate multiple perspectives (Star and Griesemer, 1989; Lynch, Tryhorn, and Abramson, 2008). In the context of negotiation research, a single text – one document that all parties are working with to craft agreement text – is a typically discussed boundary object (Susskind and Cruikshank, 1987).

Although there are some differences in the outcomes and durations of tables that used the given model and those that created a model, these differences are smaller than the differences found between the combined category of model users compared to tables that did not use a model. Tables that co-created a model performed slightly better than those that used a given model in measures of targeted agreement choice and negotiation duration. This supports the suggestion to involve the parties in the model development (Langsdale et al., 2009; Mustajoki et al., 2013; Pope et al., 2004; van den Belt et al., 2013). Though, unlike in these studies on collaborative modeling, no experts were involved in creating the model with the parties in this study; the parties themselves recognized the need for the model and created it amongst themselves. Given that model creation generally takes longer than using an already created model, it is surprising that tables creating a model negotiated faster than parties using a model given to them.

A higher ratio of the tables creating a model reached favorable agreements. However, some such tables sacrificed more value than they needed to in selecting the best environmental agreements (i.e. there were agreements that minimized emissions that had higher value that they could have selected). These tables spread out over the possible best environmental agreements, and in the process cost themselves some points, with the Coffee Retailer (the convener) and the Cup

Maker making the biggest point sacrifices. This may suggest that parties, especially the convening party, may seek to carefully explore the possible agreements before selecting an agreement. Future research should explore whether using their co-created model to test alternatives or using it to verify an agreement better helps the parties select a desirable agreement.

Model use can help to explore the implications of various alternatives within the negotiation. Furthermore, it provides a structure to the negotiation dialogue. Exploring the various alternatives in a structured manner can help tables explore the solution space of the negotiation and identify the most favorable agreements. Future research can determine whether model use impacts agreements considered en route to the final agreement. This experiment indicates that tables using a model were able to target their final agreement towards a favorable agreement, whereas tables not using a model had final agreements that were more spread out.

Being able to identify a favorable agreement among the total set of feasible agreements is one of the goals of negotiating. Solution space coverage (trying a variety of agreements before selecting the best among them) can help negotiators understand what their choices are. Because this experiment did not collect data about the agreements considered by each table (only data about the agreement finally reached), I cannot address the tables' trajectory through the solution space. However, these findings show that model-using tables reached a smaller set of agreements.

It is possible that there are other explanations beside model use and model authorship for the results observed here. I measured several variables to help rule out some of these possible explanations. For example, the participants' rated their comfort with quantitative information and numbers. I measured this to see if some collections of participants were more inclined to use or create a model than others and therefore might also be different enough from other participants to explain the process and outcome results described above.

Similarly, participants were asked to rate their perception of each party's commitment to sustainability and these ratings were not significant for tables given and tables not given a model nor for tables using and tables not using a model (see Table 14 for a listing of p-values by role). Therefore, I have evidence to suggest that comfort with quantitative information, trust among the parties, and perceived commitment to sustainability did not determine whether tables used a model or not and does not explain the other results detailed herein.

Based on the results of this study, I find qualified support that using a model in sustainability negotiations might help achieve more overall value and identify alternatives that are more protective of the environment. Model-use resulted larger variance in agreement value, without altering the distribution of agreement value among the parties. Along with other researchers ((Langsdale et al., 2013; van den Belt, 2004; Videira et al., 2004) among others), I further suggest that the way models are used and who creates them might be more important than just having a model. Tables co-creating their own model reached the highest ratio of favorable agreements (value maximizing or maximizing the environmental protection). Tables that used the model to test alternatives as they were negotiating reached higher scores than tables using the model to verify a tentative agreement. In aggregate, these results support the findings of previous collaborative modeling studies suggesting the importance of stakeholder involvement.

While this serious gaming approach allows me to test repeated instances of the same sustainability context, the role-play simulation constraints required that the physical world scenario be simplified. Further research could explore the influence a more realistic model has on negotiation duration, deliberate agreement choices, value distribution among the parties, and manner of model usage. Ideally, the model complexity should be on the level of those in case study and action research based collaborative modeling studies (van den Belt et al., 2013) (Tidwell and van den Brink, 2008). Additionally, future research could investigate further the different manners of model use, perhaps by providing instructions to role-play participants about the manner in which to use a model. Furthermore, such a study could also test whether model authorship reinforces the manner of model use in impacting the negotiation process and negotiated outcomes. In a multi-party negotiation, a sub-group of the negotiators could use the model actively while the others passively wait for the results; all parties could use the model on individual computers seeing the results for themselves; all parties could collect around one computer to use the model; one party could use the model and the results with the other parties; or one party could use the model secretly without sharing the results. Additionally, future studies could investigate why some tables do not use a model, including looking at why some tables ignore a given model and others do not co-create a model. Future research could compare the differing involvement of the parties. Additionally, future research can investigate why parties that co-create a model while negotiating still experience a shortened negotiation duration even though they are splitting their time between negotiating and co-creating the model.

# 5 Benefits of Using a Model in Sustainability Decisions and benefits of Co-creating that Model.

When considering the two studies of this thesis in concert with recent literature as described in section 2.1, they provide an analysis of the benefits of various components of often-suggested processes for collaborative decision making. Collaborative modeling studies often itemize suggested or observed steps for engaging in collaborative modeling. Many studies of collaborative modeling utilize a case study methodology. Although providing deep analysis of individual contexts, case studies do not allow the testing of alternative processes within repeated instances of the same context. This chapter interprets the results of the 3E Game (Chapter 3) and the Cup Game (Chapter 4) to explore the benefits of model use compared to the alternative processes explored in these two studies. From the 3E Game, this section discusses the benefits of using a model in a decision compared to three different types of movie presentations: of the model's logic, of general relevant information, and of irrelevant information. From the Cup Game, this section discusses the benefits of co-creating a model in a negotiation compared to using an expert model and compared to not using a model.

This chapter starts by describing more detail about the two collaborative processes discussed in sections 2.1.1 and 2.1.2 that are used in science-intensive decisions and disputes. Next, this chapter explores how the 3E Game and Cup Game findings inform the benefits of these processes.

## 5.1 Participatory Modeling: Collaborative Decision Making Processes that Use Models

Participatory Modeling has multiple names including Collaborative Modeling for Decision Support, Group Model Building, Mediated Modeling (trademarked by van den Belt (Voinov and Bousquet, 2010)), Companion Modeling, Shared Vision Planning, Computer Aided Negotiation, Participatory Simulation, among others (Langsdale et al., 2013; Voinov and Bousquet, 2010). Regardless of what it is called it has some common principles and steps. Although some researchers consider Mediated Modeling to be a variation of Joint Fact Finding, the founder of Mediated Modeling considers them to be different processes (van den Belt, 2004). They share many similarities, yet they differ in that Joint Fact Finding uses many other research methods while Mediated Modeling uses primarily (system dynamics) models. Therefore, Mediated Modeling is more tied to a specific method. In this thesis, I argue for Joint Fact Finding researchers and practitioners to consider using models of many kinds (not just system dynamics) in the JFF process.

Antunes et al. (2006) describe the basic structure of a group model building process as starting with agreement about the problem being addressed (Antunes et al., 2006) though they do not explain how this agreement is to be reached and what to do if the participants disagree on the problem. After agreement on the problem, the next step is to gather information from the participants, often individually, which can be done through interviews. Sometimes a preliminary model is modified for the purpose. Participants then select among differing formulations of the problem, structures for the model, and policy alternatives to structure the model. These processes are usually conducted in person in several facilitated workshops and involve soliciting the participants' perspectives (Antunes et al., 2006).

Mediated Modeling is a group model building process trademarked by van den Belt (2004) that is used mainly for environmental decisions (Voinov and Bousquet, 2010). It differs from the generic group model building process described above by Antunes et al. (2006) by including stakeholders broader than just the clients convening the process. It specifically highlights systems thinking and consensus building among the stakeholders and conveners (Antunes et al., 2006; van den Belt, 2004). Mediated Modeling uses system dynamics modeling.

Langsdale et al. (2013) use the term Collaborative Modeling for Decision Making as a category which contains the approaches various experts have developed in recent decades to include Mediated Modeling, Group Model Building, Participatory Modeling, etc. Langsdale et al. (2013) itemize the following as principles of collaborative modeling for decision support: 1) use collaborative modeling in complex, disputed decisions "where stakeholders are willing to work together;" 2) stakeholder representatives should be involved early and often so that their interests are considered; 3) ensure the model and the process are transparent and assessable to everyone participating; 4) building models collaboratively creates trust and mutual respect among participants; 5) use the model in the decision to simulate alternatives and incorporate new information; 6) the model must address the decision makers' and stakeholders' important questions; 7) before negotiating alternatives, participants clarify facts and share their interests; 8) "collaborative modeling requires both modeling and facilitation skills" (Langsdale et al., 2013). To realize these principles, these authors advise at least one best practice for each. These best practices include identifying whom to include in the process, making sure the process includes stakeholders' contributions, using easy to use and quick-simulating software, starting with a simple model that is expanded over time, asking participants who will use the model and how they will use it, etc.

Voinov et al. (2014) put forward "ten commandments for a socio-environmental modeling agenda" (Voinov et al., 2014). These commandments include 1) acknowledging that models and applied science contain the values of the modelers and scientists; 2) clearly documenting and discussing the assumptions and values; 3) maintaining clear separation between scientific facts and personal values; 4) acknowledging that science-based values change with new scientific information; 5) defining problems with stakeholders; 6) ensuring decision makers understand possible solutions and "using the modeling process to engage the public in debates about our future;" 7) handling modeling as the process that it is (don't expect definitive solutions); 8) following modeling best practices; 9) accepting the uncertainty inherent in complex systems; 10) communicating via all available means. Voinov et al. call for modelers to continually engage with stakeholders and decision makers in long term relationships and encourage scientists and modelers to combat climate skeptics via media outlets.

These two procedural lists but forward by Langsdale et al. (2013) and Voinov et al. (2014) highlight the similarities and differences among different flavors of participatory modeling. They share concern that the model address stakeholder concerns and interests, concern for stakeholder learning, and the understanding that models inherently contain assumptions and the need for stakeholders to understand these assumptions. They differ in that the Langsdale et al. list considers the broader context and process more than the Voinov et al. list does. The Voinov et al. list incorporates more advocacy science whereas the Langsdale et al. list describes an Honest Broker approach (Pielke, 2007).

## 5.2 Joint Fact Finding: an Approach to Making Science-Intensive Decisions in Environmental Disputes

Joint Fact Finding (JFF) is a facilitated process wherein decision makers and public stakeholders collaborate to resolve disputes in science-intensive decisions and conflicts (Adler, 2014; Adler et al., 2011; Andrews, 2002; Ehrmann, 1999; Karl et al., 2007b; McCreary et al., 2001). The facilitation team is comprised of facilitation process experts and science experts who are disinterested in the outcome of the decision or dispute. Such a team can handle the social challenges alongside the scientific challenges of multi-party sustainability negotiations. This external team, replete with its expert scientists, then serves in the role often envisioned for science: disinterested sense maker of the physical and social worlds (Pielke, 2007)- but unlike in typical societal visions of science, the sense making is happening collectively with the parties and experts together. This reinforces science's "cognitive authority" (Jasanoff, 2004), which relies on objectivity and detachment. It also has the external party playing the "Honest Broker of Policy Alternatives" role Pielke (2007) outlines for science to "expand the scope of choice available to decision-makers" by combining "scientific knowledge with stakeholder concerns in the form of alternative courses of action" (Pielke, 2007).

To be an external party, this party must not have a direct stake or interest in the negotiation; that is, the external party should be disinterested in the outcome. The word "Neutral" party is avoided because every individual has his/her own world believes and sets of experiences that influence how he/she interprets information and situations.

The JFF literature is a helpful source of suggestions for creating decision processes for multi-party sustainability negotiations (Adler, 2014; Karl et al., 2007b; McCreary et al., 2001). This literature consists of case studies analyzing instances of multi-party sustainability decisions that employed some form of collective inquiry into scientific components of the problem at hand. This literature has considered the application of Joint Fact Finding in very different physical situations—such as air pollution resulting from land zoning and water way damming (Nolon et al., 2013; Susskind et al., 2011)—but has not sufficiently investigated the use of models in the inquiry process.

Although the JFF process is adapted to the particular situations in which it is used, there are some common elements of JFF processes. JFF processes seek to address: what questions exist in the decision at hand; what information will address these questions, who should gather it, and how; and how will the data be used in the decision. Most JFF processes have the following characteristics: the key stakeholders are all represented at the table for the full duration of the process, including the scientific study; a professional disinterested team facilitates the process using consensus building techniques; and the JFF process has a clear connection to a decision to be made and the convening party commits to taking into account outcomes of the JFF process (Karl et al., 2007b).

The Joint Fact Finding framework does not suppose that science can tell what should be done but rather science, rationally analyzed by experts, would inform the agreements and decisions (Sarewitz, 2004). Such experts can include the parties themselves, who are experts on their own interests and may also have other technical expertise pertinent to the negotiation. This blurs the line between knowledge producers and knowledge users as each party becomes both and helps to answer the calls for closer and ongoing discussions between knowledge producers and knowledge users (Armitage et al., 2008; Innes and Booher, 2010; Susskind, 2010).

## 5.3 Assessing Model Co-Creation and Use within Collaborative Decision Processes

Joint Fact Finding (JFF) is an example of a participatory decision process that does not often use models, and Mediated Modeling is an example of a collaborative modeling process (see section 5.1 for a discussion about considering Mediated Modeling to be a variation of Joint Fact Finding).

Voinov and Bousquet (2010) point out there is a difference between involving stakeholders in creating a model and using a model in a participatory decision; that is, Voinov and Bousquet (2010) separate the model-creation process from the using of the model in a decision. That both the model creation and model using phases can be participatory does not make them the same. Furthermore, Voinov and Bousquet assert that sometimes, "the decision, in a way, becomes a by-product of this [collaborative modeling] process" (Voinov and Bousquet, 2010), criticizing situations in which the decision is subjugated to the model building. In this thesis, I maintain focus on the decision process; I examine model use, compare co-created with expert-made models, and examine an alternative (learning of the model's logic) for situations in which decision makers cannot use a model. Therefore, in this thesis, I argue that models can be included within participatory decisions such that both the model building and model using serve the decision making.

Joint Fact Finding could employ participatory model building in its science step and stakeholders could be involved in the building of the model, or they could be kept informed of the model building status and re-convene to exercise the model in making the decision. Where possible, involving the stakeholders in building the model is preferred, as supported by the Cup Game findings described above in Chapter 4. The choice to include the stakeholders in the modeling building alongside the expert model builders may be customized to the situation at hand, to include such considerations as the time and funding available to include the stakeholders, the stakeholders' interest in being involved in the model building, and the complexity of the model being built, among others. Alternatively, the JFF process could use or adapt existing models. Regardless of whether they are involved in the model building or not, the JFF process has the choice of using the resulting model to test alternatives during the discussion of possibilities, or to use the model only to verify a tentatively agreed to decision. The Cup Game results described above (Chapter 4) suggest that the model be used to test alternatives during the negotiation.

The Cup Game, as described in Chapter 4, demonstrates that tables of negotiators (called tables hereafter) that used a co-created model during the negotiation most accurately reached the most desirable set of agreements. In the case of the Cup Game, these were the agreements that either maximized table score value or minimized the carbon dioxide emissions. Tables using an expert model performed slightly worse than tables not using a model at reaching this same set of targeted agreements. Therefore, this thesis presents evidence to suggest that when the negotiation is trying to achieve a particular aim in the physical world, using a co-created model will be more likely to help participants achieve a set of desirable agreements than using an expert given model or not using a model.

However, using an expert-created model enabled tables to most precisely reach agreements (i.e. they had low dispersal of their agreements among the possible agreements). Using a co-created model led to lower precision than using the expert model, but to more precision than not using a model at all. The precision of agreements is relevant in situations wherein multiple instances of the same or similar negotiation is conducted. Additionally, the precision of agreements reached can aid a negotiator in predicting the likely outcome of an upcoming negotiation.

Furthermore, the Cup Game study results show that model use did not alter the balance of power among the parties, that model use shortened the negotiation time, and that using a model to test alternatives while developing an agreement led to higher agreement scores (compared to using the model to verify a traditionally negotiated agreement). This latter finding suggests that in addition to the authorship of the model, negotiators should consider how a model is used. Future research can directly compare both types of authorship with these two manners of use (testing alternatives while negotiating or verifying a traditionally negotiated agreement), but the Cup Game provides enough evidence to encourage using the model to test alternatives while developing agreement packages.

The 3E Game results show that model users, when compared to users of relevant information in a less interactive format and to users of less relevant information, reached the Pareto Frontier most readily. Furthermore, model users discovered the near win-win structure of one of the dimensions of sustainability whereas users of other types of information did not as readily. Not only did model users perform better, but they also rated the credibility, salience, and legitimacy of the model higher than participants who used other types of materials rated the credibility, salience, and legitimacy of those other materials. A user rates information high on credibility when she believes the information is believable and/or from a reliable source; she rates the information high in salience when she believes the information is pertinent to the current decision; and she rates the information high on legitimacy when she thinks it incorporates her perspective (Cash et al., 2003b). High credibility, salience, and legitimacy ratings are linked with the user's interpretation of the effectiveness of the materials and the information they produce (Cash et al., 2003a; Eckley, 2001). These results provide evidence to support the frequent calls other researchers ((Dowlatabadi, 1995; van den Belt, 2004) among others) have made for decision makers to use models.

The cost of having a decision maker learn of the model's logic and insights about a system (compared to having the decision maker use a model) include that the decision maker may not as readily create a policy whose outcome matches his/her stated priorities. Furthermore, the decision maker is less likely to create an optimal policy – a policy on the Pareto Frontier. The decision maker is less likely to rate the presentation of the lessons from the model to be as highly credible, salient, or legitimate as if he/she had used the model instead. Additionally, the decision maker is more likely to change his/her stated priorities and less likely to consider others' interests and allow others' interests to influence the decision.

That models helped negotiators target a more favorable agreement in the Cup Game implies that models can be useful in other sustainability negotiations, specifically when the negotiators co-create the model. Tables that created their own model outperformed tables using an expert-given model; this finding suggests that where possible, the negotiators should collaborate to produce the model they use. Furthermore, the Cup Game demonstrates that co-creating a model does not have to increase the duration of the negotiation (a possible reason for not co-creating a model is fear that it will take too long), and indeed can shorten it. Researchers who study collaborative modeling have encouraged the involvement of stakeholders in the model making process (McIntosh et al., 2008; Sanò et al., 2014) and the Cup Game finds support for this suggestion.

The Cup Game finds that an expert given model is also helpful; that negotiators need not co-create their own model to receive some of the benefits of model use. Collaborative modelers have focused on the process of creating new models and have not thoroughly investigated the use of existing expert-made models. Cup

Game tables that used the given model had a more predictable table score, which might be beneficial for organizations in planning their negotiation strategy, as they would be better able to anticipate the possible range of outcomes. Therefore, ideally the parties will co-create the model used, but where collaborative model building is not possible, using an expert-created model is encouraged.

An expert-given model, particularly one that is already created, might be helpful in particular settings where resources like time and money to pay to develop a model are scarce. However, before assuming that time is too short to create a model, would-be negotiators should recall that in the Cup Game, model users who created their own model had nearly identical median and mean negotiation durations to tables that used the given model. These similar durations demonstrate that creating a model does not necessarily prolong a negotiation. Both of these groups reached agreement faster than tables that did not use a model.

Additionally, the Cup Game results indicate that when using the Life Cycle Assess (LCA) model during the negotiation, tables of negotiators would likely benefit from using the LCA model to test alternatives as they are developing negotiation packages. For example, when considering what percentage of the used paper coffee cups to recycle and what percent to compost in the pilot study, negotiators should simulate the LCA with the different alternatives and compare the carbon dioxide emissions of the results. Tables that did so in the Cup Game had table scores that skewed higher than tables that negotiated normally and only used the model to verify a tentative agreement. Generalizing to situations beyond the Cup Game, negotiators could identify the issues that involve scientific information addressable by the model and simulate the model to determine the possible consequences. Negotiators can then create different agreement packages (possible agreements that contain an approach for each of the issues) using these consequences.

The tables using a model to test alternatives are likely employing the model as a boundary object – an artifact serving as a relevant focal point in a conversation and that is inclusive of multiple perspectives (Star and Griesemer, 1989; Lynch, Tryhorn, and Abramson, 2008). It is possible that this former group performed better than tables using the model to verify an agreement due to using the model as a boundary object. A model used to test alternatives might serve as a boundary object because it is a specific item that parties can interact with together. The parties may still each have different interpretations of the model and its output, but having the model in front of them gives them a common starting place to investigate their differing interpretations. A model might be a particularly useful boundary object because it can be used to test future possibilities, which a text document cannot. Negotiation researchers have not thoroughly investigated models as boundary objects. Future research can develop and test this line of reasoning.

The Cup Game finds that using the model did not alter the value distribution among the parties, which can be interpreted as the model not altering the balance of power among parties. Thus, there is evidence to suggest that model use does not become a strategic advantage for some parties over others, not even for the party that convened the negotiation or the party that introduced the model (at tables that were given a model). Therefore, parties should not be afraid of loosing advantage, nor expect to gain advantage, by using a model during the negotiation.

Even though model use did not alter the balance of power among the parties, having an external party facilitate the negotiation might be helpful in situations where there is an existing imbalance of power and/or the modeling to be done is complex.

# 6 Conclusions and Future Work

In this thesis I offer evidence to suggest that, in sustainability negotiations and decisions, models can help negotiators and decision makers reach better outcomes more readily and can improve the negotiation/decision making process. In two studies utilizing serious game role-play simulations, I show the impact model use had on individual decision makers' policy recommendations (the 3E Game discussed in Chapter 3) and on a multi-party negotiation (the Cup Game discussed in Chapter 4).

In the 3E Game, individual decision makers who used a model—compared to those who used other decision tools—most frequently recognized a win-win opportunity in the social equity dimension and most readily reached outcomes on the Pareto Frontier (the set of optimal agreements). However, by identifying the win-win, model users outperformed their social equity prioritization. Thus, they matched their policy outcomes to their stated priorities less well than did participants learning of the model's logic and participants learning general, relevant information. More model users (compared to participants in the other three decision tool categories) self-reported that they frequently considered others' interests as they made their policy recommendation, though they also reported that those others' interests were not as influential as their own role's interests. There was not evidence to suggest that model use prompted decision makers to change their stated priorities.

In the Cup Game, eighty percent of the tables of negotiators used a model in the multi-party sustainability negotiation. Nearly half of these co-created the model themselves. The tables of negotiators that co-created a model more readily reached an agreement in the set of favorable agreements—those agreements that either minimized the carbon dioxide emissions or mutually exclusively maximized the table point score. The tables co-creating a model also had table scores that skewed higher than the table scores of the other categories. Model use did not alter the value distribution among the parties, suggesting that model use did not impact the balance of power among the parties. Tables that used a model—even those that had to co-create the model before using it—reached agreement more quickly than tables that did not use a model. Co-creating a model did not take appreciably longer than using the expert-given model. Among the tables that used a model, they used the model in two dominant manners: using the model to test alternatives and using the model to verify an agreement. The former had table scores that skewed higher than the later.

By using a research method that enables the consideration of multiple instances and different decision processes in the same sustainability decision context, this thesis complements the body of literature that provides an in-depth analysis of specific cases of model use in sustainability negotiations and decisions (including (Adler et al., 2011; Karl et al., 2007a; Langsdale et al., 2013; van den Belt, 2006; van den Belt et al., 2013)). In both the individual decision making and multi-party negotiation settings, model users performed better than those who did not use a model in terms of achieving the set of favorable outcomes (the individual setting, those outcomes on the Pareto Frontier; and in the negotiation setting those agreements that minimized carbon dioxide emissions, or mutually exclusively, maximized the value earned). Therefore, the two studies described herein confirm the findings of previous research that encourage model use in sustainability negotiations and decisions (in addition to the above in this paragraph, see also (Bourget et al., 2013; Dowlatabadi, 1995; van Delden et al., 2011)).

However, contrary to Edwards et al. (2011) and McIntosh et al. (2010)—who note a lack of "uptake" of models— the Cup Game (Chapter 4) shows that most of the tables of negotiators chose to use a model in their negotiation, even going so far as to create a model if one was not given to them. Tables of negotiators that used a model—whether one they created or one given to them—had shorter negotiation times and better results, especially when the negotiators co-created the model. Therefore, the Cup Game demonstrates that negotiators will use a model, and benefit from doing so. As noted in section 4.5, the Cup Game uses a simple model. The 3E Game (Chapter 3) demonstrates that decision makers who used a (complex) model outperformed those who had other forms of decision support systems. Unlike in the Cup Game, the decision makers in the 3E Game who were randomly assigned to the model-using experimental condition had no alternative to using the model (apart from withdrawing from the experiment, which none did). Therefore, in the 3E Game, the model users were not electing to use the model in the face of alternative decision support systems. However, they rated the model higher than users of the other decision support systems rated those systems (see Table 10). Future research can directly investigate negotiator and decision makers' inclination to use complex models in sustainability decisions when they also have the choice of alternative decision support systems.

Whereas model users reported that they considered others' interests, they still reported that their own interests (in their role) were more influential in their policy recommendation. Future work can compare the results of this study with a multi-party role-play where a decision maker is interacting with real people rather than imagining them, which might better measure how influential others' interests are.

Using a model to explore alternatives as the negotiation progresses shows signs of being more effective than using a model to verify a traditionally negotiated agreement. Future work can quantify the differences in outcome and process afforded by using a model to test alternatives in an on-going manner. Specifically, future research can investigate whether there are other benefits, or any drawbacks, to using the model to test alternatives. Additionally future studies can investigate whether model authorship—whether the parties co-crated the model or it was expert-made—influences the manner in which negotiators use a model or the impact of using it in these two manners. Such studies might provide possible explanations as to why using the model to test alternatives resulted in table scores that skewed higher.

Similarly, future studies can trace the trajectory of agreements considered in the course of negotiating. This will enable the analysis of how thoroughly the negotiators covered the solution space (zone of potential agreement). Such analysis would illuminate whether model use correlates with persevering until an optimal agreement is reached—as compared to making do with the first agreement acceptable to all parties.

A future study should compare different types of models for their impact on a decision maker's ability to create a policy matching his/her stated priorities, ability to reach a favorable outcome, frequency of changing priorities, consideration of others' interests, and perception of the credibility, salience, and legitimacy of the decision materials.

Future research can also explore situations where there are multiple competing models. An example of such a study would be to modify the SIPS-G game used by Grogan (2014). SIPS-G is a multi-party game in which each of three intra-national negotiators controls one region of a fictional nation and the national infrastructure for one of water, energy, or agriculture and has access to a federated model (Grogan, 2014). By modifying the SIPS-G game such that the negotiators' models provide conflicting information and comparing results to the existing version, a future study could investigate how negotiations evolve when there are conflicting models.

The results of the studies comprising this thesis can be viewed as describing the benefits of model use or the cost of not using a model. In an individual decision, not using a model lowered the likelihood of discovering win-win components of the decision, lowered the likelihood of reaching Pareto Frontier outcomes, and lessened the consideration of others' interests (though the influence of the others' interests remained low regardless of model use). Of the participants not using a model, participants learning of the model's logic preformed best. They readily crafted policies that matched their priorities and were the only other experimental group to reach the Pareto Frontier. In a multi-party negotiation, not using a model lowered the likelihood of achieving favorable agreements and lengthened the negotiation duration.

In addition to model use (compared to not using a model), decision makers also must consider model authorship and the manner in which they use the model. In a multi-party negotiation, using an expert-given model rather than co-creating a model lowered the likelihood of achieving favorable agreements. Using a model to verify a tentatively accepted agreement resulted in table scores that skewed lower than the table scores of negotiators who used the model to test alternatives as they negotiated.

The findings in this thesis support the recommendation that collaborative decision processes like Joint Fact Finding consider using collectively built models—and use them to test alternatives—as a means to address the science-intensive components of the decision. Furthermore, these findings suggest that on-going decision processes that cannot involve stakeholders in the modeling building phase may still benefit from collectively using an expert-made model to address the decision at hand, especially if they use the model to test alternatives. Additionally, when a model is not available or the decision maker cannot use a model, teaching the decision maker about the insights and logic of a model of the system in which the decision takes place is preferable to providing relevant, but general information.

In this thesis, I use methods that test repeated instances of a given decision context, enabling the comparison of different decision processes. The results offer evidence to support the use of models in sustainability negotiations and decisions, and indicate that negotiators are willing to use models. Learning of the model's logic appears to be a tolerable alternative in situations where decision makers cannot use a model. Additionally, the results herein suggest that the authorship of the model and the manner in which the model is used are also important to consider. Involving the negotiators/decision makers in co-creating the model and using the model to test alternatives show the most promise.

# Appendix A 3E Game Role-Play Instructions

The following instructions were given to each participant in the 3E Game experiment. Each participant played the same role in an individual game. Participants received the instructions in an online survey delivery computer program. The only part of the experiment not delivered through this online survey program was the decision tool. The model users used the model within the Vensim Reader software (as described in Appendix B) and the participants in the other categories received links to online sites from which they streamed the movies comprising their decision tools.

## Appendix A.1 3E Game Role Instructions

You, the Minister of Sustainability, are preparing for a big meeting with the leader of your country in which you must present to him a recommendation for revamping the nation's infrastructure. Your country is so large that it can influence the global policy, therefore, you will provide a policy that is global in scope.

In preparation, you have been conducting meetings with the Directors of the Environment, the Economy, and the Society. As the Minister of Sustainability, you must balance gains in each of these three areas for this current generation and ensure that this generation doesn't detract from the ability future generations will have in providing for their own well being.

Each of the Directors makes a very strong case as to why his or her area (Environment, Economy, Social Equity) should be your highest priority in this infrastructure decision. The Director of the Environment strongly urges you to keep the average global temperature change in the year 2100 to within 2 degrees Celsius. The Director of the Economy wants you to grow the Gross World Product as high as possible. The Director of the Society wants you to give all people access to electricity.

You know you need to ensure the infrastructure includes benefits to each, but you must decide the proportional distribution among these three. You will measure benefit to the Environment by the change to global average temperature in the year 2100 compared to the average pre-industrial global temperature. You will measure benefit to the economy by Gross World Product (GWP) in the year 2100. You will measure Social Equity by the number of billions of people with access to electricity in the year 2050.

The experts in your office have created some materials for you to use to prepare for this decision. They have worked for you for years, and you trust their competence immensely. As they created these materials for you, they have conducted meetings with many groups of people to learn of these groups' opinions and experiences. Use these materials to determine your recommendation. You will be asked several questions both before you use the prepared materials and after. You will be asked to submit your recommendation twice, with feedback in between each submission.

The exercise today consists of the steps listed below, which you will be guided through via this website.

1. Prepare for the making the decision by systematically thinking about your priorities via the pre survey.

2. Use, for 20 minutes, the materials created by the experts in your office.

3. Submit a policy recommendation.

4. Receive feedback of how your policy impacts the temperature in 2100, the access to electricity in 2050, and the economy in 2100.

5. If you wish, make changes to the policy you recommend.

6. Receive feedback on how this 2nd version of your policy recommendation impacts the temperature in 2100, the access to electricity in 2050, and the economy in 2100.

7. Reflect on the policy you recommended via the post survey.

**Reminder of the Minister's Goals:**

Although your three Directors want you to reach these goals, it is up to you to make a recommendation that will include benefits from all 3 of these dimensions.

ENVIRONMENT

Measure Used: Change in average global surface temperature in the year 2100 compared to the pre-industrial average surface temperature.

Goal: The magnitude of the change in global temperature in the year 2100 at 2 degrees Celsius or less, (i.e., less than or equal to 2 degrees C).

ECONOMY

Measure Used: world economy (gross world product) in the year 2100.

Goal: The gross world product in the year 2100 as high as possible.

SOCIAL EQUITY

Measure Used: Number of billions of people with access to electricity in the year 2050.

Goal: As many people with access as possible.

# Appendix B – En-ROADS Model

The Energy – Rapid Overview and Decision-Support (En-ROADS) model was created and is maintained by Climateinteractive (www.climateinteractive.org); Ventana Systems (www.ventanasystems.com); the research team at ClimateWorks Foundation (www.climateworks.org); University of Massachusetts Lowell Climate Change Initiative (www.uml.edu/Research/Climate-Change/); and Prof. John Sterman of MIT. For more information and access to the model, contact Climateinteractive. En-ROADS is a system dynamics model designed to assist decision makers conducting "interactive scenario exploration." To enable the exploration of scenarios, it simulates quickly and runs on a laptop computer. It represents the world as one global region (rather than comprised of independent nations), which allows the model to ignore trading among nations (Siegel et al., 2015). Considering the world globally, including ignoring trade, compromises verisimilitude but enables rapid simulation.

Variables endogenous to the En-ROADS model include the energy source and carrier choices; the intensity of the energy; the energy variable and capital costs; the price, capacity, and utilization of extracted fuels; the price, capacity, and utilization of delivered fuels; the price of electricity from, capacity, and utilization of each source; the progression of learning by doing with energy technologies; the research and development of energy sources; the depletion of nonrenewable sources; the saturation of renewable sources; greenhouse gases and climate dynamics – including cumulative emissions and temperature change; population; and the global economy. Simulations of the En-ROADS model advance every month and a half (reported every quarter) from the year 1990 until 2100. In the 3E Game, participants could affect policy only from the current year (2015) on.

The user interface used in the 3E Game is the Sustainable Energy for All (SE4ALL) interface (see Figure 11). The SE4ALL interface is one of the many user interfaces in the En-ROADS model and was built for the United Nations – World Bank initiative Sustainable Energy for All (SE4ALL). Participants change input values in the model by sliding the sliders in the bottom third of the screen. As they change the model inputs, the graphs quickly update. Participants used the En-ROADS model in the Vensim Reader software (http://vensim.com/vensim-model-reader/).

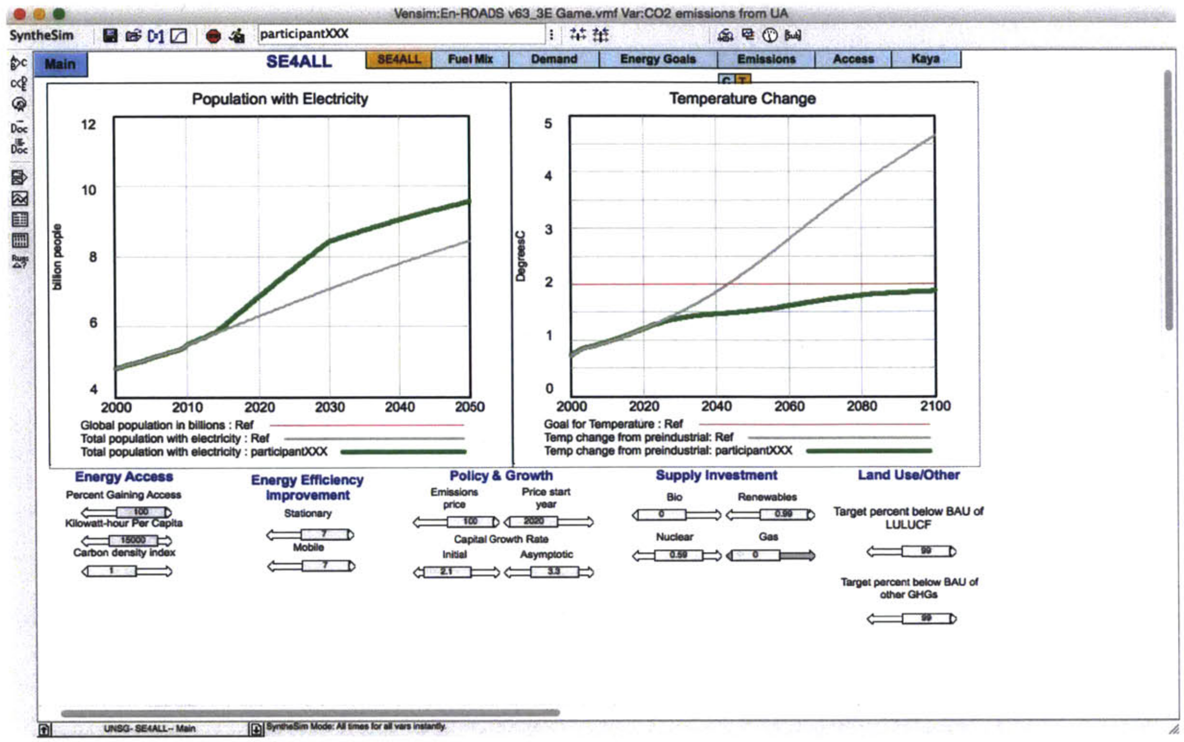


Figure 11. En-ROADS User Interface Used in 3E Game.

Because it is a system dynamics model, the En-ROADS model is comprised of causal loops, stocks, and flows; it is system of ordinary differential equations that are solved by Euler integration (Siegel et al., 2015). The En-ROADS model is large and detailed with many layers and sub-models. Figure 12, Figure 13, and Figure 14 depict the causal loop diagrams for the cumulative emissions, access to electricity, and global economy (called global GDP in the diagram).

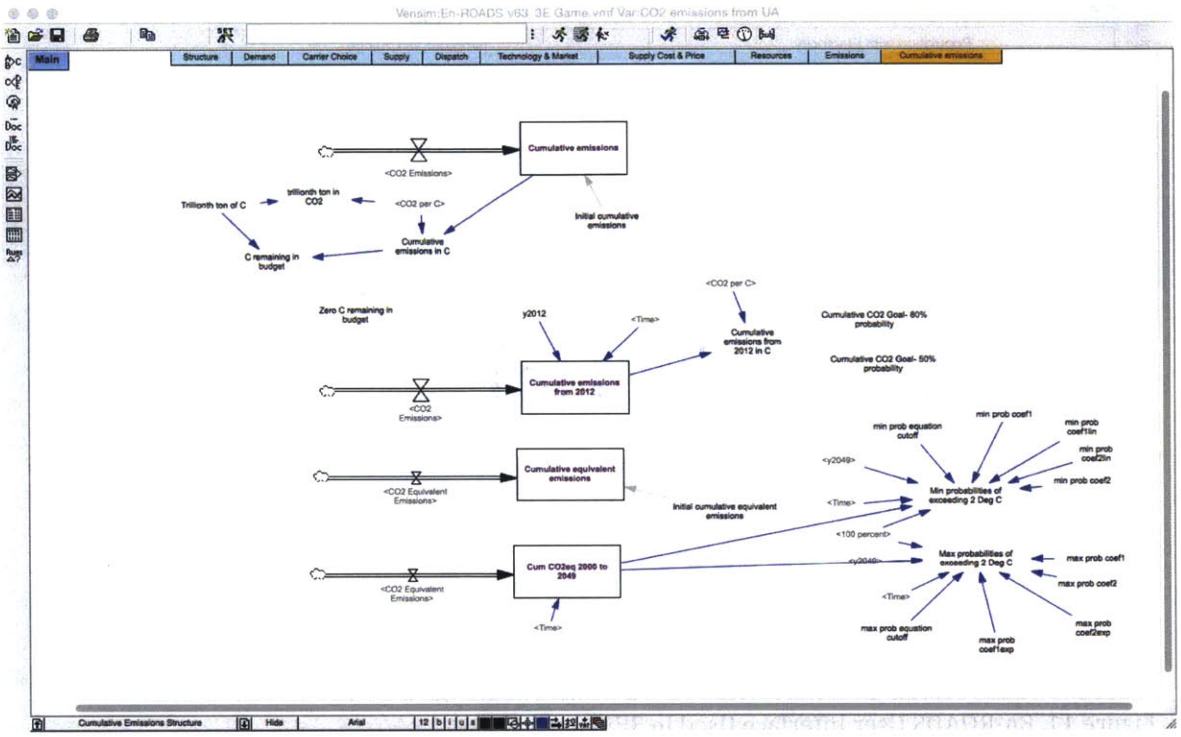


Figure 12. Causal Loop Diagram for Cumulative Emissions in En-ROADS.

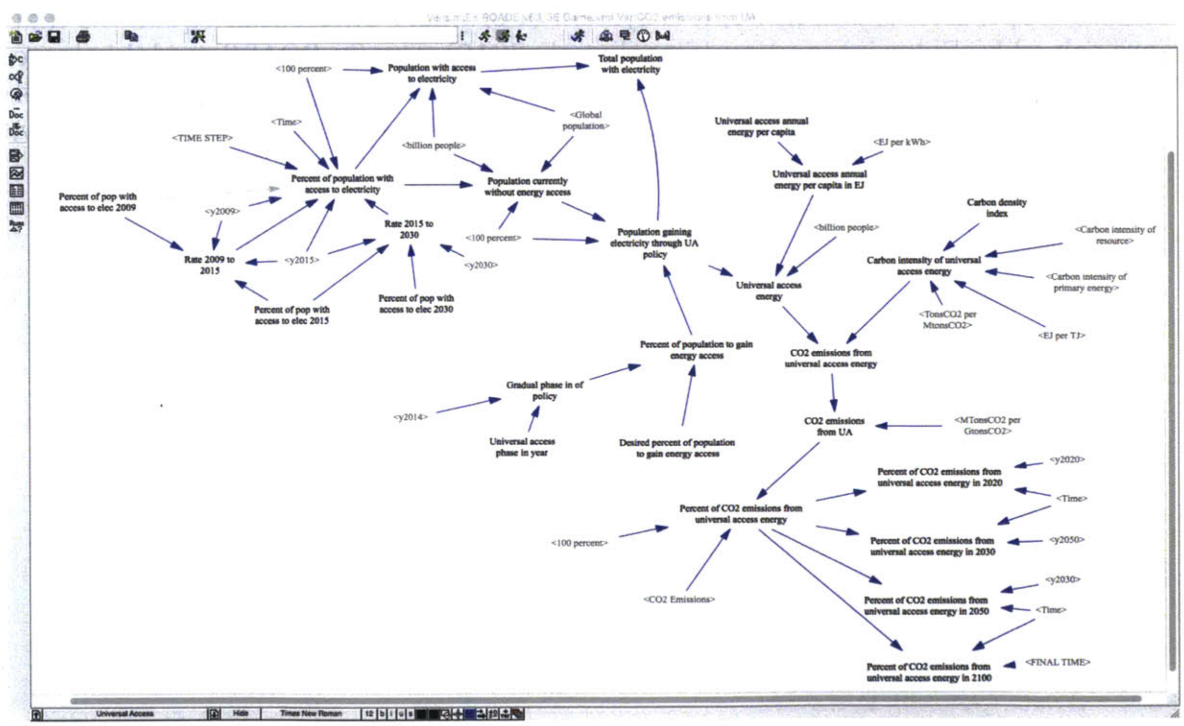


Figure 13. Causal Loop Diagram for Universal Access to Electricity in En-ROADS.

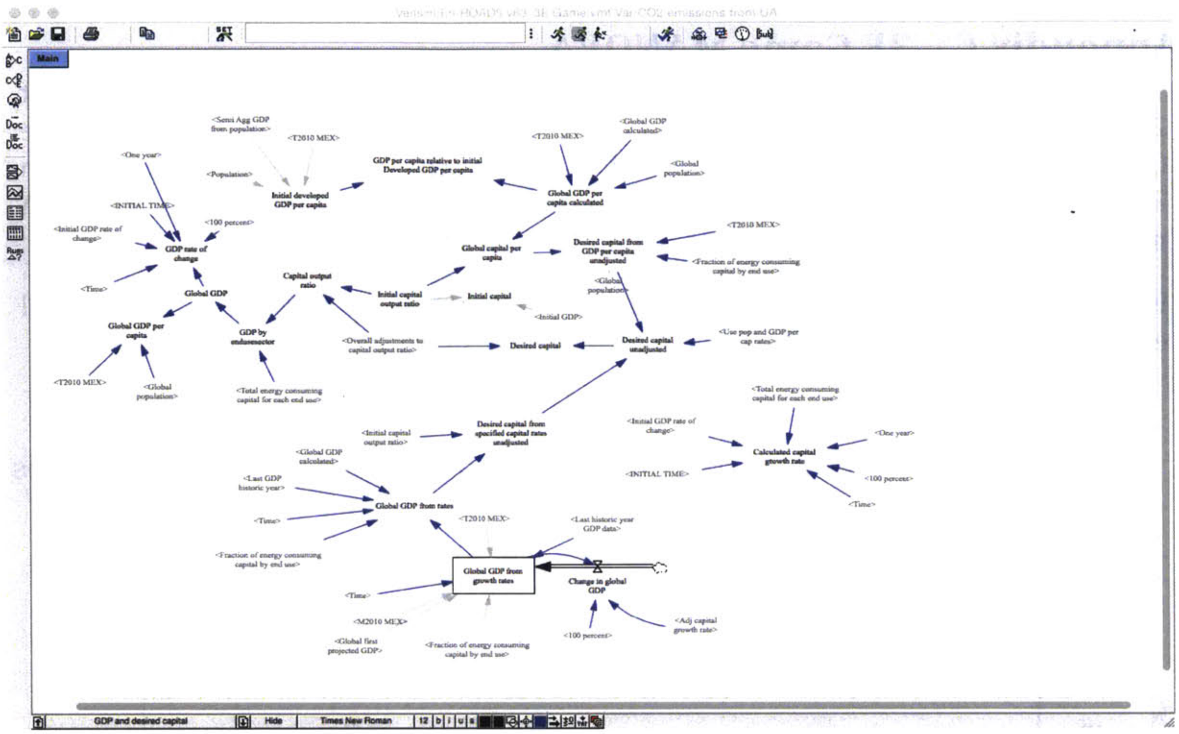

Figure 14. Causal Loop Diagram for Global Economy (called global GDP in diagram) in En-ROADS.

# Appendix C – 3E Game MANOVA

The Pillai test in MANOVA assumes multivariate normality for error terms (Everitt, 2005). Figures 15 and 19–22 use Everitt's (2005) R function "chisplot" to create Chi Square plots of the residuals for the models whose results are displayed in Tables 4 and 6. Figures 16–18 consider each of the variables in the MANOVA model independently as univariate dependent variables; see Table 5.

Figure 15 demonstrates that the residuals from the MANOVA model with all experimental conditions (see Table 4 for model results) are multivariate normal.

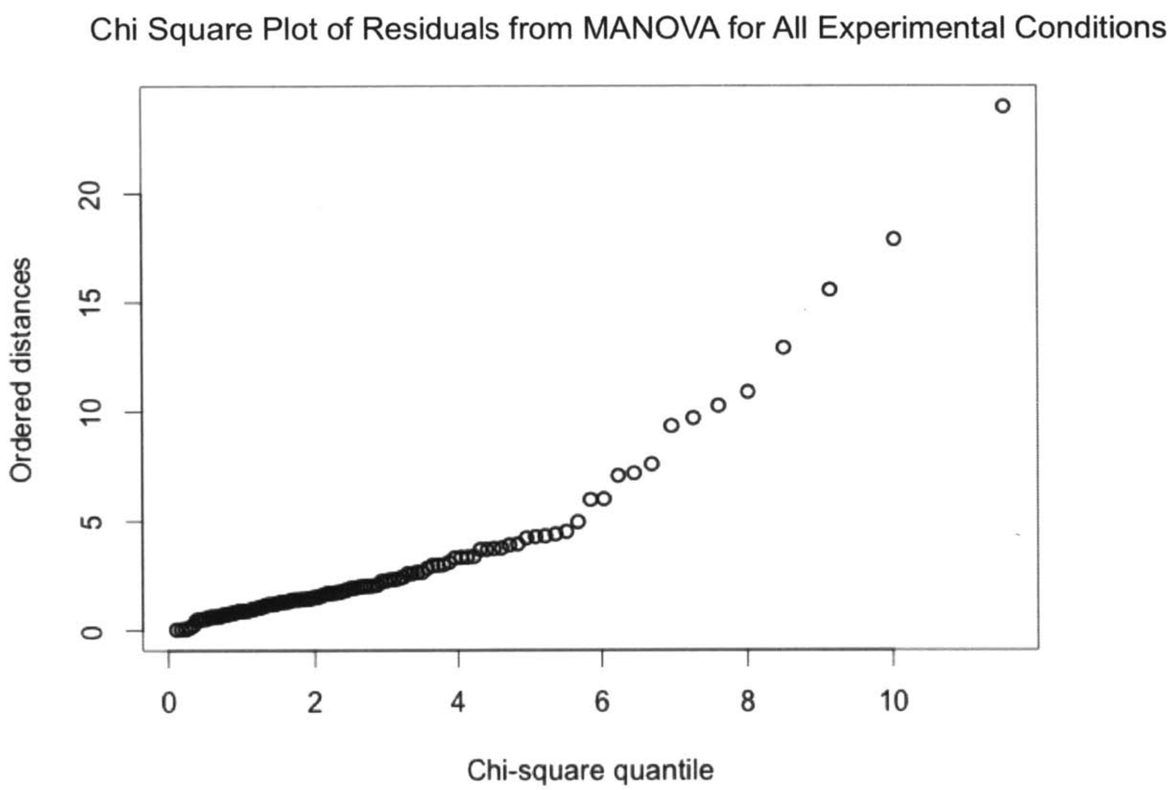


Figure 15. Chi Square Plot of Residuals from MANOVA for All Experimental Conditions.

In Figures 16–18, the residuals for the univariate multiple regression models are normally distributed. See Table 5 for the results of the regression models.

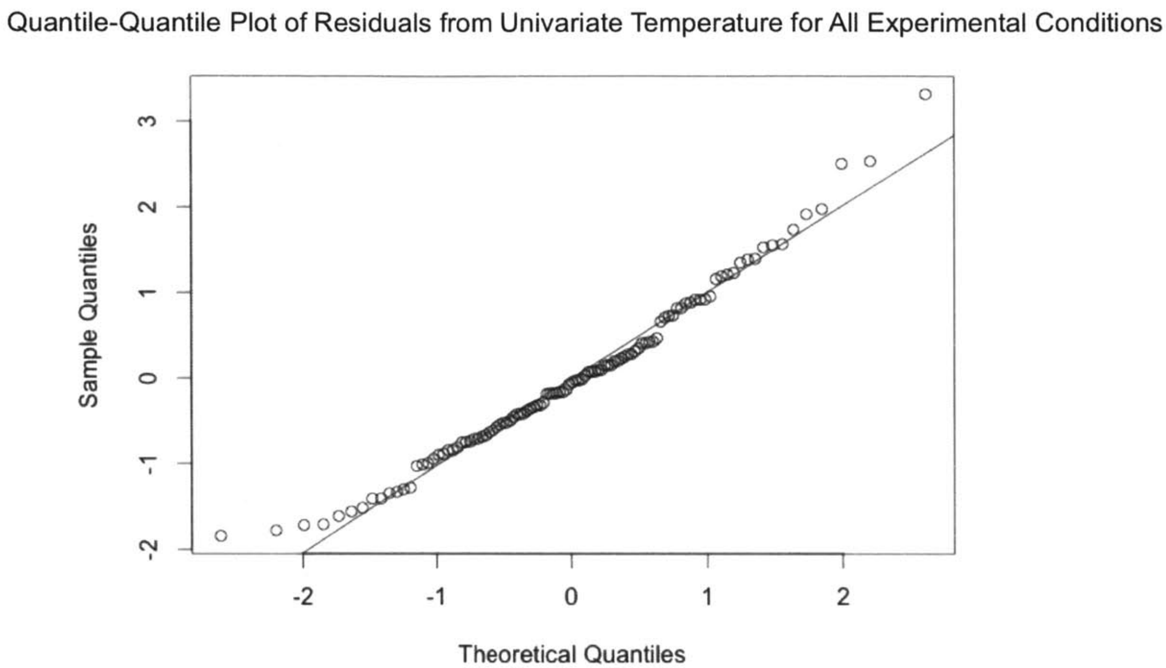


Figure 16. Quantile-Quantile Plot of Residuals from Univariate Temperature for All Experimental Conditions.

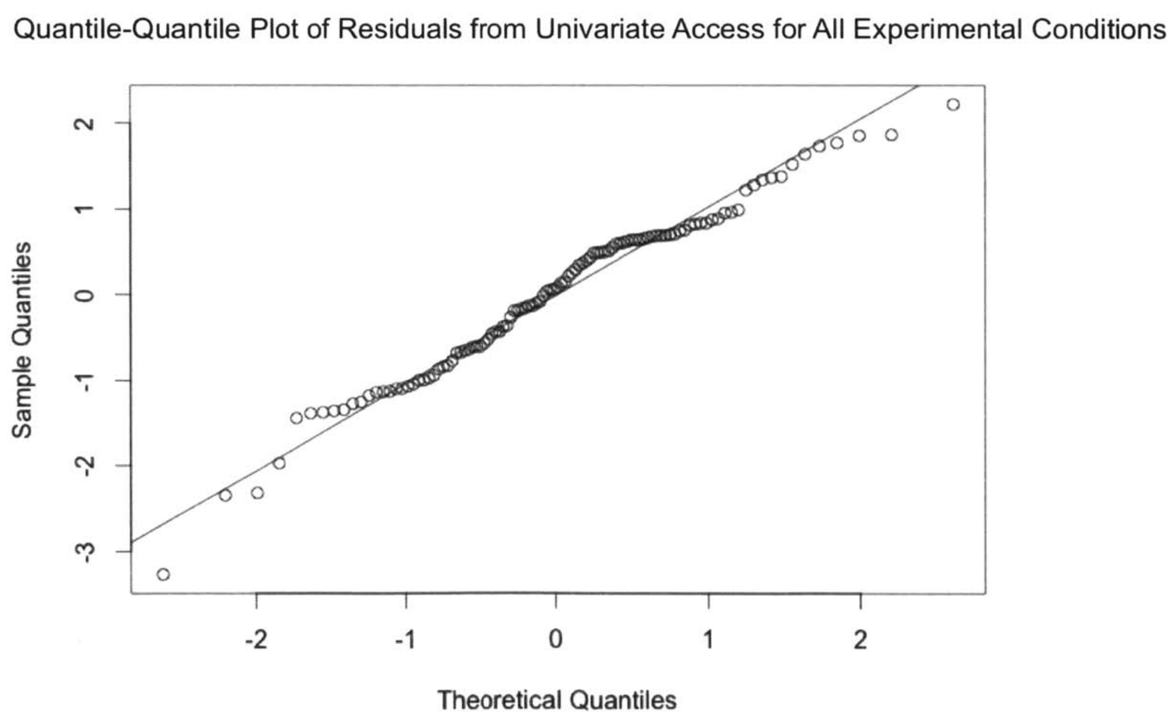


Figure 17. Quantile-Quantile Plot of Residuals from Univariate Access for All Experimental Conditions.

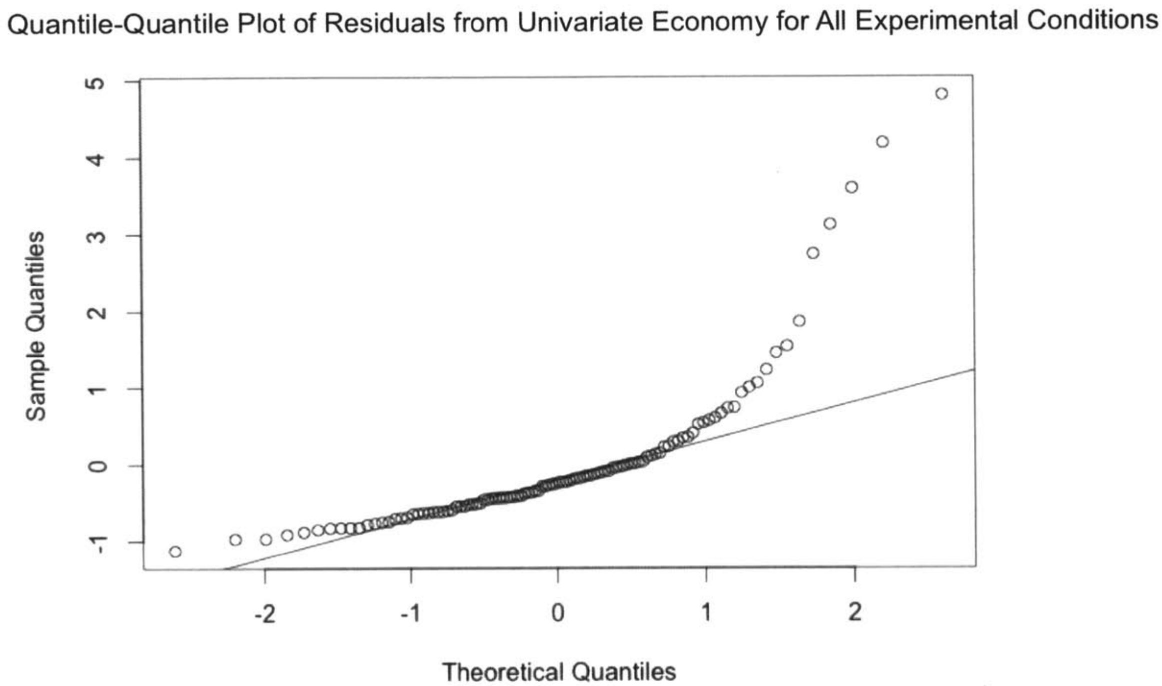


Figure 18. Quantile-Quantile Plot of Residuals from Univariate Economy for All Experimental Conditions.

Figures 19–22 demonstrate that the residuals from the MANOVA models for each experimental category, taken individually, are multivariate normal; see Table 6 for model results.

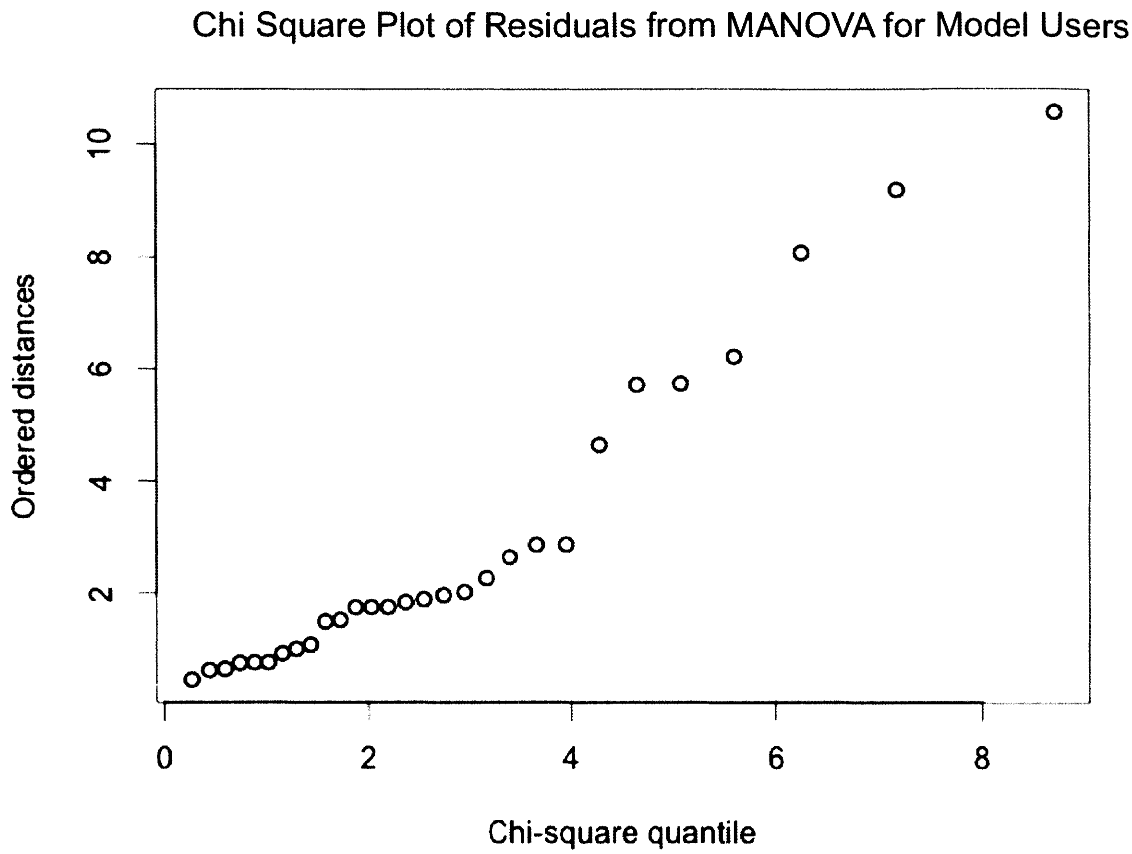


Figure 19. Chi Square Plot of Residuals from MANOVA for the Model Users Experimental Condition.

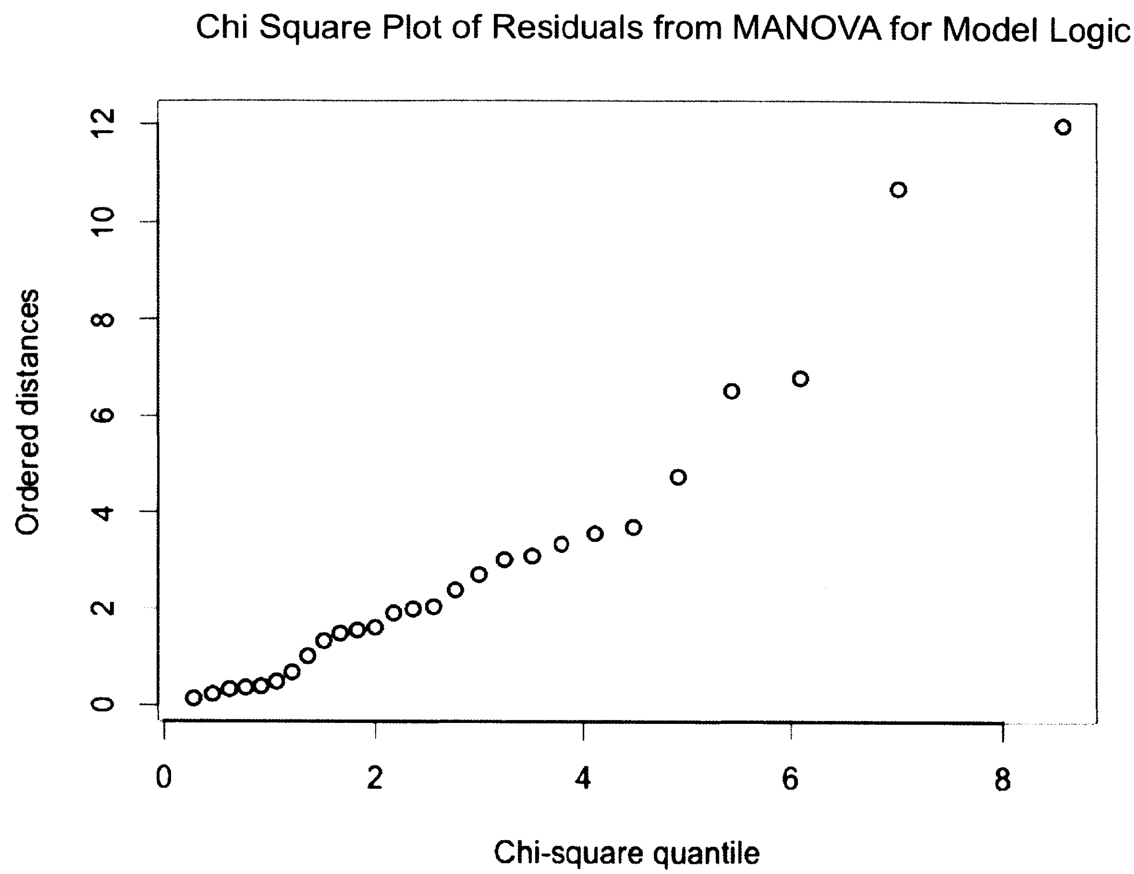


Figure 20. Chi Square Plot of Residuals from MANOVA for the Model Logic Experimental Condition.

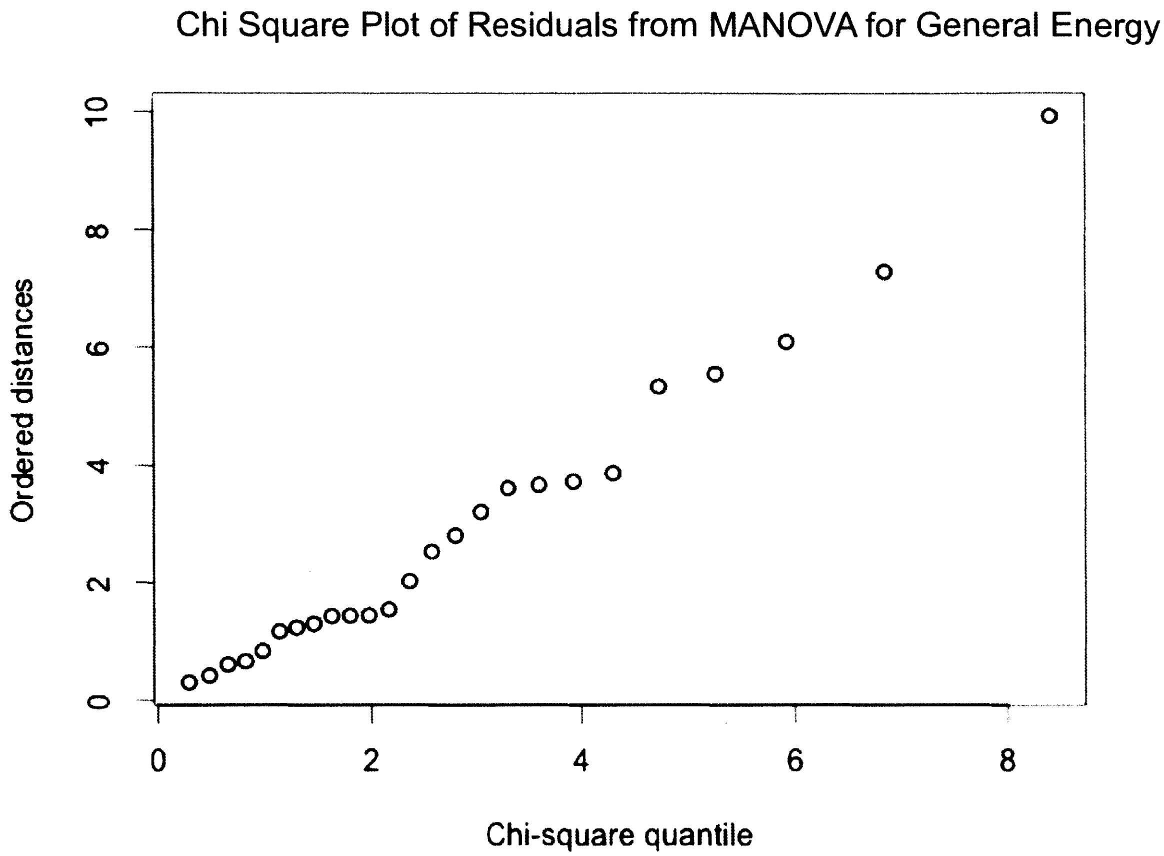


Figure 21. Chi Square Plot of Residuals from MANOVA for the General Energy Experimental Condition.

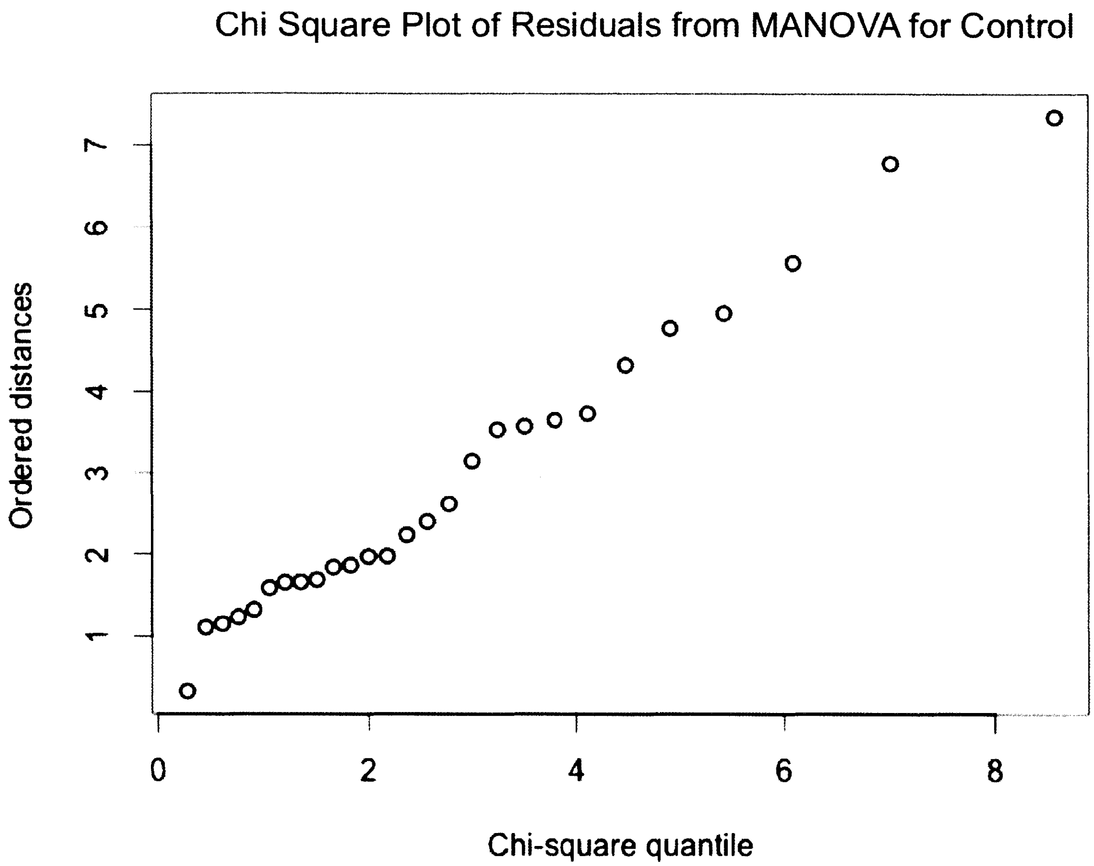


Figure 22. Chi Square Plot of Residuals from MANOVA for the Control Experimental Condition.

# Appendix D – Cup Game Participant Instructions

The Cup Game is a five-party role-play simulation I wrote for use in this research. Participants are randomly assigned a role and grouped into negotiating tables. Each participant receives a copy of the general instructions (identical for all participants) (see Appendix D.1) and specialized instructions for his/her role (see Appendices D.2 – D.7). The specialized role instructions for the coffee retailer, recycler, composter, and hauler are the same regardless of whether the table was given a model or not (Appendices D.2 – D.5). At tables given a model, the cup maker has the model in the role instructions and a memo with a link to an online spreadsheet containing the model (Appendix D.6). At tables not given the model, the cup maker's role instructions do not have the model equations or the memo (Appendix D.7).

Participants are asked not to share – writ large – the instructions specialized for the roles, though these instructions indicate which information in the instructions can be shared. The role-specific instructions contain a point structure for each role – participants are specifically asked not to share the number of points they receive on each issue alternative. They may, however, share their relative preferences among issues and among alternatives for issues.

## Appendix D.1 Cup Game General Information for All Participants

### Introduction

Earth's Coffee wants to avoid its hot beverage paper cups from being thrown into landfills. It is exploring ways to recycle and/or compost them.

Since Earth's Coffee neither makes the cups nor operates recycling or composting facilities, it has had to enroll the help of the paper cup supply chain (value chain) to help with this challenge. These five stakeholders are convening to negotiate the details of an upcoming test of a pilot system, and the resulting characteristics of the larger, long-term cup system.

The pilot test will use a specified number of tons of used paper cups to test the viability of composting and recycling these cups. The pilot will be in one municipal area, Greendale, an area particularly passionate about protecting the environment. Greendale's recycling and composting participation rates are above the national average. Greendale has both a composting facility and a paper mill nearby. Furthermore, the Greendale area Materials Reclamation Facility (MRF) is one of the best in the nation, allowing for sorting of recyclables by material, which enables single stream recycling. That means that consumers can place plastic, paper, aluminum, glass, and cardboard in one bin to be sorted at the MRF. After sorting these by material, the MRF creates bales of each material that it then sells. Buyers of these bales remake these materials into other products. The one exception to this is paper.

The company that owns the MRF has a paper mill at the same site as the MRF. Therefore, it has the option to sell the bales of to-be-recycled paper or to recycle these bales in its own paper mill. The company keeps information about how it makes this choice confidential, but external observers and analysts have determined that, on average, it sells 60% of the bales and recycles the other 40% in its own mills.

The pilot test in question in these negotiations is about the pulping (paper recycling) and composting processes. Therefore, the cups used will be collected specifically for the pilot, separate from the regular waste steam. For the pilot test, the cups will bypass the MRF, going directly to the UseAgain's paper mill. If this pilot shows that used paper coffee cups can be recycled, the MRF will need to determine how to separate these cups automatically. However, automatic MRF sorting is not a part of this pilot test.

In Greendale, the company that owns the paper mill, landfill, and MRF does not own hauling trucks. Therefore, a separate company has contracts with the city of Greendale for residential waste removal and with individual businesses for removal of their waste.

Recycling paper involves re-pulping it in a paper mill to make new paper. Composting involves allowing microorganisms to break down certain kinds of waste into soil. Neither of these is a straightforward approach for used coffee cups, unfortunately. The paper coffee cups are made of really strong paper fibers, which is good for recycling. However, these strong paper fibers are coated to prevent the hot coffee from seeping through the paper and burning customers. It is not clear whether this coating will cause problems in either or both of the re-pulping process and the composting process. Furthermore, most consumers put the cups into waste bins exactly as they last used them, which means there is a plastic lid on the cup, often an Old Corrugated Cardboard (OCC) heat sleeve around it, and coffee, sugar, milk, and other food residue inside the cup. The lids, OCC sleeves, and food residue could cause problems in the paper recycling process and thus may need to be separated from and cleaned out of the cups, respectively. The lids could cause problems for composting, unless they are made of a specific type of material.

Greendale is just the pilot test and first go-live site for the larger, long-term system. For the cups to have a truly productive end of life, this system must be national. This is also important for the cup maker and Earth's Coffee, as they are national businesses. Their supply chains cannot afford to have a unique approach for each city. However, each city has a different waste infrastructure. Therefore, the resulting system needs to be nationally consistent and locally customizable. The parties have been wrestling with this, bouncing back and forth between the larger national scale and the smaller scale of individual cities.

The group is interested in creating the most environmentally, economically, and socially sustainable outcome possible. In a previous integrative negotiation session, these five stakeholders explored the issues and generated a list of potential alternatives for each issue. The purpose of today's meeting is to decide among these alternatives. As such, the agreed upon agenda contains the following issues and alternatives for these issues:

1. **Issue 1: The Percent Composition of the Pilot Test.** Of the tons of cups collected in the pilot test, what percent will be tested for viability in a compost process and what percent will be tested for viability in the recycling process?
   a. Alternative A: 40% compost; 60% recycling.
   b. Alternative B: 60% compost; 40% recycling.
   c. Alternative C: 50% compost; 50% recycling.
2. **Issue 2: Timing of the Pilot Test.** The testing of the pilot system requires some preparation time for each of the components: collecting enough tons of cups, the recycling test and the composting test.
   a. Alternative A: Start in 6 months
   b. Alternative B: Start in 1 year
   c. Alternative C: Start in 18 months
3. **Issue 3: Composition of Larger, Long-term System.** The testing of the pilot system is occurring in Greendale. Greendale is also the first go-live site for the larger, long-term system. However, to be effective, it must be national. In this larger, long-term system, what is the percent allocation? Some of the parties want to lock in the percentages now and others want to set them after reviewing the results of the pilot test.
   a. Alternative A: 40% composting; 60% recycling
   b. Alternative B: 60% composting; 40% recycling
   c. Alternative C: 50% composting; 50% recycling
   d. Alternative D: 30% composting; 60% recycling; 10% landfill
   e. Alternative E: Set the percentages after analyzing the results of the pilot test
4. **Issue 4: Approach to Customer Education for the Pilot Test.** Given that the larger, long term system will require a change in customer behavior (to place the used cups in the special bins rather than in the trash and maybe to separate off the lids and sleeves), the parties are discussing including a customer education campaign in the testing of the pilot system. Not all agree it is necessary to include this in the pilot test.
   a. Alternative A: No customer education
   b. Alternative B: Coordinated customer education campaign funded equally by all parties (20% by each party).
   c. Alternative C: Coordinated customer education campaign funded by Earth's Coffee 50% and Disposaware 50%.
5. **Issue 5: Reporters and ENGOs at Pilot Test.** Inviting reporters and Environmental Non-Governmental Organizations (ENGOs) will make the tests public. Will reporters and ENGOs be invited or not?
   a. Alternative A: Yes, invite them.
   b. Alternative B: No, do not.

Also note: in the first round of negotiations, UseAgain and MakeSoil agreed not to charge WasteBeGone a tipping fee for the truckloads of used cups associated with the Pilot Test.

### The Negotiation Structure

The parties have agreed to a structure for their negotiation: they will vote on a proposal (of one alternative for each issue) after approximately an hour of negotiating. All 5 parties must vote in favor of a specific proposal to make it an agreement; fewer than 5 parties voting for the proposal nullifies the proposal and no agreement is reached.

### The Parties

**Earth's Coffee** is a global coffee retailer that operates coffee shops. Most of the customers elect to "take out" their coffee; therefore Earth's Coffee serves its coffee in paper cups. Customers who bring in a reusable mug receive a small discount on the price of the coffee. Earth's Coffee prides itself on its environmental and social responsibility. It has convened the cup supply chain to address the growing problem of used paper coffee cups in landfills.

**Disposaware** is a national maker of single-use food packaging, including coffee cups. Disposaware's parent company owns a series of paper mills, none of which are near Greendale, and only some of which are designed to take recycled paper. The ones that are designed for virgin-only are being phased out, as publicized in a new advertising campaign. Recently, Disposaware launched a compostable paper coffee cup.

**UseAgain** is a recycling company that operates a Materials Reclamation Facility (MRF), a paper mill, and a landfill near Greendale. The Greendale MRF has been recently updated and now utilizes the most up-to-date technology in material sorting.

**MakeSoil** is a composting company that operates a composting facility near Greendale. It employs composting technology that does not emit odor.

**WasteBeGone** is a hauling company that has a contract with the city of Greendale to haul their waste to the one of several nearby facilities: composting facility (MakeSoil's), paper mill (UseAgain's), MRF (UseAgain's), and landfill (UseAgain's). WasteBeGone's contract with the city of Greendale is for residential and government waste transporting. It has similar, individual contracts with some Greendale businesses.

## Appendix D.2 Cup Game Confidential Instructions for Earth's Coffee, Coffee Retailer

You are the representative of Earth's Coffee. When you took the position of Vice President, you were very excited to be able to lead initiatives important to you.

You are very passionate about protecting the environment and see that corporations that construct their businesses in environmentally and socially responsible ways can be leading figures in increasing sustainability. You believe that increasing sustainability can easily coincide with being profitable. You definitely want to see this initiative be successful and you know you need the support of these participants to make it work.

You expect some of the issues to be more contentious than others. Your two highest priorities are the composition of the pilot system to test the concept and the composition of the resulting, larger, long-term system. You expect there may be some disagreement, especially between MakeSoil and UseAgain when you discuss these issues.

You expect other issues, for example the customer education, to be more easily decided. After all, customer education is so vital a part of this project. There won't be a pilot if there aren't any used cups to test! Furthermore, for the larger, long-term system to be self-sustaining and efficient, customers will need to put their used cups in the appropriate waste bins.

You have worked with Earth's Coffee's marketing and customer education department to develop the estimate that **for each $1,000 spent on customer education, you can anticipate 1 ton of used cup waste collected in the pilot test**. You are not convinced the other groups will adhere to your standards of customer messaging, though you don't want them to know you don't trust them.

[total money spent on customer education]*[1ton / $1000] = [tons expected]

Furthermore, you suspect some of them may have more limited customer education budgets than you have. One of the alternatives on the table involves each party paying 20% of the overall customer education. You suspect some of the smaller companies will favor this alternative so they can be seen as equal partners with companies as well known as Earth's Coffee and Disposaware.

You respect the idea of equal contribution; you think it is noble. However, pragmatically speaking, if this alternative is chosen, the entire customer education budget, and therefore the number of tons of cups expected to be collected, will be constrained by these lower customer education budgets. Your analysts have estimated that that would limit customer education spending to $400,000 ($80,000 per party).

Earth's Coffee has budgeted to spend $250,000 on customer education. After all, Earth's Coffee gets marketing value out of it too and wants to control customer education in our own stores! You suspect that Disposaware can come close to matching that figure if not exactly matching it. Therefore, Earth's Coffee **prefers alternative C**, where the cup makers and you split the customer education budget. **If C is selected** and you have estimated Disposaware's budget correctly, then the customer education budget will be around $500,000, so **around 500 tons of used paper cups.**

This customer education budget, like all of Earth Coffee's finances is a closely kept company secret; **do not discuss costs, prices, or budgets**, or anything to do with Earth's Coffee's finances. However, **you are encouraged to discuss reasonable ranges for the anticipated number of tons of used cups**, as you suspect they will be looking to you for this information.

You have talked with various people in many departments of Earth's Coffee, and collectively, you have agreed upon the prioritization of the alternatives delineated in the following table. **You must achieve at least 110 points in the negotiated agreement** or the project won't be beneficial to Earth's Coffee. Earth's Coffee 10-year company strategy depends on you getting agreement at this negotiating table (no pressure!). Environmental improvement is the goal of the entire project. Therefore, **if the agreement reached saves at least 110,000 pounds of carbon dioxide in the pilot test (issue 1), you will receive a 100-point bonus added to your points scored in the negotiation.** Therefore, if the agreement saves at least 110,000 pounds of carbon dioxide in the pilot, you will get a minimum of 210 points.

Table 15. Cup Game: Coffee Retailer's Point Structure

| Earth's Coffee Priority among Alternatives | Points Earned | Reasoning |
|---|---|---|
| **Issue 1: % compost & recycling in pilot test** | | |
| A: 40% compost; 60% recycling | 60 | Recycling re-uses the strong paper fibers, saving trees from being cut. When the fibers are no longer suitable for recycling, then, they can be composted and used to grow new trees. Furthermore, paying more for compostable cups would have a huge impact on your business viability. |
| B: 60% compost; 40% recycling | 20 | |
| C: 50% compost; 50% recycling | 40 | This is your second choice because it keeps everyone at the table. You are afraid that the composters and recyclers will fight. In some cities (in the larger, long-term system), composting may be the only viable alternative to landfilling, so you need both composting and recycling tests to be conducted. |
| **Issue 2: timing of pilot test** | | |
| A: Start in 6 months | 20 | You don't want to wait. Your customers are pushing for you to address how many of your cups appear in landfills. |
| B: start in 1 year | 10 | |
| C: start in 18 months | 5 | |
| **Issue 3: larger, long-term system composition** | | |
| A: 40% compost; 60% recycling | 35 | If forced to preset the percentages, you want the most recycling possible. |
| B: 60% compost; 40% recycling | 20 | |

| | | |
|---|---|---|
| C: 50% compost; 50% recycling | 25 | |
| D: 30% compost; 60% recycling; 10% landfill | 0 | Having any % landfill is your absolute last choice. |
| E: set after pilot results | 60 | You want to see the results of the pilot before deciding; that's good science. Furthermore, you expect the pilot will justify allocating a higher percentage to recycling than to composting. |
| **Issue 4: Approach to customer education for pilot test** | | |
| A: no customer education | 0 | You don't want to be constrained by this agreement into no customer education. Customer education directly relates to the number of tons of used cups collected and you need enough tons of used cups to make the pilot test worthwhile. **Note, if this alternative is chosen, you can estimate the number of expected tons of used cups as 0 tons.** |
| B: coordinated campaign funded equally by all participants (20% each) | 15 | You are prohibited from sharing budget information and can't expect others to be able to pay as much as Earth's Coffee wants to. However, this alternative is better than no customer education. Based on your analysts' estimates this limits total customer spending and**, therefore limits the number of tons expected to 400 tons of used cups.** |
| C: coordinated campaign funded 50% by Earth's Coffee and 50% by Disposaware | 20 | Customer education is directly linked to the number of tons of cups the pilot can expect to collect. You want autonomy to spend your full $250,000 budget and to have control over customer education in your stores. You estimate that this alternative **will lead to an expected 500 tons of used cups for the pilot.** |
| **Issue 5: reporters and ENGOs at pilot test** | | |
| A: yes | 20 | You prefer this alternative because these third parties will provide legitimacy for the pilot test. They also will provide publicity. |
| B: no | 0 | |

## Appendix D.5 Cup Game Confidential Instructions for UseAgain, Recycler

You are the President of the recycling company UseAgain, which is headquartered in Greendale. UseAgain operates a paper mill, a Materials Reclamation Facility (MRF), and a landfill in the Greendale area. It has a few MRFs and landfills in other locations; the Greendale paper mill is its only mill. UseAgain is passionate about the environment and sees its service as vital for the health and wellbeing of the residents of Greendale and nearby towns. Sanitation is not clean work, and is often thankless, but UseAgain employees pride themselves on doing their part to help the environment and the residents.

Of the cups that are to be recycled, there are two approaches: blend them with an exiting paper grade or treat the used cups as a new material type. If it is proven not to disrupt the pulping of established paper grades, it can be baled with those grades. If there is a market for used cup material, it will be worth your while to collect it, separate it, and bale it as a new material type.

However, there are technical challenges with each of these approaches. If you bale used cups with existing paper grades, you will have to be assured it will not jeopardize the bale quality of these other paper grades. UseAgain is extremely protective of the purity of its bales because the purity influences the price at which bales are sold. UseAgain cannot afford to have the price of its paper bales plummet. To make bales of used cup material as its own material type, you will have to sort it from other materials and funnel it into its own bales. It is not yet clear how to automate this process, and it will be expensive to hire humans to take the lids and sleeves off the cups and wash out the food residue. Therefore, although you do not want to miss a business opportunity, you have some questions about the viability either approach: including them in existing paper grades or separating out the cups.

The pilot test being planned in these negotiations will test the first approach: including used paper coffee cups in the pulping process with other existing paper grades. To explore the viability of the second approach, UseAgain is planning its own small test at the MRF to see if it can develop a mechanical means of separating used paper coffee cups from the waste stream. Simultaneously, UseAgain the business team is looking for potential buyers for the bales of used cups. Overall, the second approach has higher hurdles than the first.

Your scientists have estimated that **for every ton of paper material recycled in a paper mill, 310 pounds of carbon dioxide ($CO_2$) are "saved" from being released into the atmosphere**. This net value accounts for the carbon dioxide released during the pulping process itself (e.g. $CO_2$ released creating electricity running the pulping machines), and it includes carbon dioxide saved from the reuse of the paper fibers and the carbon dioxide trapped by the trees left standing (those not needed because using recycled material spares virgin trees). However, your scientists stressed that this is just an estimate, as there are no reliable data on recycling paper cups specifically. Therefore, to estimate the amount of carbon dioxide saved in each alternative of issue 1, your scientists gave you this equation:

**[Tons of material to recycle]*310 = [pounds of $CO_2$ saved by recycling these tons]**

UseAgain compares this to zero carbon saved in landfilling. Actually, landfilling emits carbon, but for this negotiation, UseAgain has decided to ignore that because most of the alternatives do not involve landfilling.

You know there is a link between the amount spent on customer education and the amount of used cup material that can be collected for this test. However, you are not sure how to quantify it. Unfortunately, UseAgain's marketing budget is already overspent and therefore it cannot contribute to a customer education fund for this test of the pilot system. Anyway, given your doubts about the technical viability of this project, a financial investment is too risky. Furthermore, you also suspect that Earth's Coffee and Disposaware have already been collecting used cup material, or that they can get enough for the test without involving the customers. For these reasons, you **strongly prefer alternative C on issue 4**, which has Earth's Coffee and Disposaware splitting the customer education costs between themselves; if they think they need it, they can pay for it. Your second choice is not to have any customer education because you estimate that there are already enough used cup reserves for the test or that enough cups can be easily gotten without involving the customers. You really want to avoid being asked to pay 20% of the customer education for the test. You just don't have the money for it!

**You must get at least 100 points in the negotiated agreement for the project to be worthwhile to UseAgain.** Otherwise, UseAgain is better off walking away (voting "NO"), which will stop the project. However, if you can negotiate an agreement that is beneficial to UseAgain and the project reaches its environmental goal, UseAgain will benefit. Therefore, **if the agreement reached saves at least 110,000 pounds of carbon dioxide in the pilot test (issue 1), you will receive a 100-point bonus added to your points scored in the negotiation.** Therefore, if the agreement saves at least 110,000 pounds of carbon dioxide in the pilot, you will get a minimum of 200 points.

The UseAgain priorities among the alternatives for the 5 agenda items are below in the table.

Table 16. Cup Game: Recycler's Point Structure.

| **UseAgain Priority among Alternatives** | **Points Earned** | **Reasoning** |
|---|---|---|
| **Issue 1: % compost & recycling in pilot test** | | |
| A: 40% compost; 60% recycling | 30 | If the ratio isn't going to be even, you want it to favor recycling. |
| B: 60% compost; 40% recycling | 15 | |
| C: 50% compost; 50% recycling | 40 | This alternative balances two competing risks: of ending up with cups you cannot use (if recycling cups does not work) and of missing a business opportunity (if recycling cups works). |
| **Issue 2: timing of pilot test** | | |
| A: Start in 6 months | 0 | |
| B: start in 1 year | 30 | |
| C: start in 18 months | 55 | You need time to prepare your mill schedule to meet all current commitments (this pilot will require stopping your normal work). Also, strategically, you want to test both approaches to |

| | | |
|---|---|---|
| | | recycling used cups: re-pulping with existing paper grades and creating a new material type for used cups. This pilot test explores the first approach. You're investigating the second on your own. It requires: other markets and buyers for the used cup material, automated MRF sorting technology to facilitate larger scale operations, and ways to keep the food residue from fouling the bale purity. With all these upcoming tests, you really need more time. |
| **Issue 3: larger, long-term system composition** | | |
| A: 40% compost; 60% recycling | 45 | If you can't get D or E, your third choice is to get commitment now to lock in high percentages of recycling. You don't want the composter to get commitment for greater % of composting and for you to miss the business opportunity. By the time the longer-term system starts up, you expect you can make recycling work. Though, this choice carries some risk. |
| B: 60% compost; 40% recycling | 5 | |
| C: 50% compost; 50% recycling | 20 | |
| D: 30% compost; 60% recycling; 10% landfill | 60 | Including landfill is beneficial for 2 reasons: you own a landfill (so you'd get revenue from tipping fees) and you expect that eventually, you would be able to reallocate the 10% from landfill to recycling, if recycling is feasible. It might take another negotiation, but since 70% of the material would already be going to your facilities, you have a strong argument. So you gain certain business for your landfill and the possibility of reallocating from landfill to recycling to bring recycling up to 70%. It is politically risky to reveal this preference and logic. |
| E: set after pilot results | 50 | This is your second choice alternative because it buys you time, but it is not as financially attractive to you as D, which uses the landfill as a current revenue stream and source of future flexibility. |
| **Issue 4: Approach to customer education** | | |
| A: no customer education | 20 | Contrary to what they said at the last meeting, you suspect Earth's Coffee and Disposaware already have enough tons of used paper cups to conduct the test, or can get enough without running a large customer education campaign. You don't really want to push them on this, but you don't see the big deal. |

| | | |
|---|---|---|
| B: coordinated campaign funded equally by all participants (20% each) | 0 | Your budget is already overspent. |
| C: coordinated campaign funded 50% by Earth's Coffee and 50% by Disposaware | 40 | Customer education is a form of publicity, and you'd like publicity. But, this pilot test may not work. If it doesn't work, the publicity might be negative. So, it is a risky investment. If they think customer education is so important at the pilot stage, they can pay for it. Even if you had money to spend (your marketing budget is already spent), you'd rather bow out of this round of customer education and contribute to the customer education for the larger, long-term system when it will be less risky and more beneficial. |
| **Issue 5: reporters and ENGOs at pilot test** | | |
| A: yes | 0 | |
| B: no | 40 | You think the mill test will work will but there is some uncertainty. If it fails, UseAgain, and maybe recycling in general, would get bad publicity. You want to wait until you have proven that it works before involving the press and other outsiders. Why take the risk? |

## Appendix D.4 Cup Game Confidential Instructions for MakeSoil, Composter

You are the Founder and President of MakeSoil, a small composting facility near Greendale, the site for the cup pilot test. Over the years, you've build up MakeSoil from your own personal composting, to a neighborhood project, and now to a viable community-wide company! You have put a lot of hard work into MakeSoil, first while also holding down a full time office job. You have no doubt MakeSoil's recent success is due to your quitting your office job to focus on MakeSoil full time.

MakeSoil is passionate about the environment and sees its service as vital for the health and wellbeing of the residents of Greendale and nearby towns. Composting is not clean work, and is often thankless. You consider it a point of pride that your employees (both of them) pride themselves on doing their part to help the environment and the local residents. You are happy to be spreading that dedication!

You are really hoping to grow your business by demonstrating that the used coffee cups work with your compost "recipe." However, you have a little internal tension within MakeSoil. Your chief of operations is not certain that you will actually be able to handle the number of tons of coffee cups that is likely to come from this venture when it is operating full scale. However, he has been testing out some ideas for tweaking the "recipe" to accommodate large numbers of used cups. So far the results are hard to interpret. It looks like you might have to enter into this negotiation without as much confidence as you'd like to have. However, if MakeSoil can include these cups then MakeSoil can expand its operations. MakeSoil has just recently purchased the land surrounding its facility for this very purpose.

You know that Earth's Coffee favors recycling over composting so you feel it is your job to convince them of the benefits of composting. Although there aren't data yet on composting used coffee cups, your scientist has been working on estimating the benefit of composting different materials. From these studies, **your scientist has estimated that for every ton of cup material composted, a net 200 pounds of carbon dioxide are "saved" from being released into the atmosphere.** This net value accounts for the carbon dioxide released during the composting process itself. Therefore, to estimate the amount of carbon saved in each alternative of issue 1, your scientist gave you this equation:

**[Tons of material to compost]*200 = [pounds of $CO_2$ saved by composting these tons]**

You expect there to be lots of talk about the approach to customer education (issue 4). You will likely get more publicity if you contribute directly. More importantly, MakeSoil values equal partnership: self-confidence comes from contributing. Therefore, your **first choice is equal funding (alternative B)**. You feel very proud of how you've build up MakeSoil from nothing and would take pride in partnering with companies as large as Earth's Coffee and Disposaware; your business is making it!

Unfortunately, you still have a limited budget and there is some risk that the pilot test won't work and you would lose this investment. If you can save your money now, you will likely be able to contribute to customer education in the larger, long-term system. Therefore, if it is not going to be an EQUAL partnership, you'd rather have Earth's Coffee and Disposaware split the customer education cost between themselves. You know how needed customer education is, so you don't see alternative A (no customer education) as viable.

**You must earn at least 80 points in the negotiated agreement for the project to be worthwhile to MakeSoil.** If the final agreement is worth less than 80, then MakeSoil is giving up too much and is better off stopping the project (by voting "NO"). You have met with your employees and the three of you agreed upon the prioritization that is delineated in the table below. There will be a huge publicity benefit from partnering with well-known companies on a successful environmental project, if it succeeds. **Therefore, if the agreement reached saves at least 110,000 pounds of carbon dioxide in the pilot test (issue 1), you will receive a 100-point bonus added to your points scored in the negotiation.** Therefore, if the agreement saves at least 110,000 pounds of carbon dioxide in the pilot, you will get a minimum of 180 points.

Table 17. Cup Game: Composter's Point Structure

| MakeSoil Priority among Alternatives | Points Earned | Reasoning |
|---|---|---|
| **Issue 1: % compost & recycling in pilot test** | | |
| A: 40% compost; 60% recycling | 0 | |
| B: 60% compost; 40% recycling | 60 | You have a strong indication that you will be able compost used paper coffee cups and you want to be seen as the food packaging solution. After all, it has food waste in it! |
| C: 50% compost; 50% recycling | 45 | |
| **Issue 2: timing of pilot test** | | |
| A: Start in 6 months | 50 | You can be ready to go in 6 months and you see this as a competitive advantage over the recyclers. |
| B: start in 1 year | 10 | |
| C: start in 18 months | 0 | |
| **Issue 3: larger, long-term system composition** | | |
| A: 40% compost; 60% recycling | 30 | |
| B: 60% compost; 40% recycling | 75 | You want to lock in this % now because you are afraid the paper mill tests will work and will erode the amount of used cups available to compost. |
| C: 50% compost; 50% recycling | 50 | |
| D: 30% compost; 60% recycling; 10% landfill | 0 | Landfilled cups are a waste of compost base material! |
| E: set after pilot results | 25 | You really want to lock in the % now to beat UseAgain to these used cups. |
| **Issue 4: Approach to customer education** | | |
| A: no customer education | 0 | Customer education is such an important part of this project. Customer behavior change, brought about through customer education, will sustain the larger, long-term system. |
| B: coordinated campaign funded equally by all participants (20% each) | 50 | MakeSoil values equal partnership. And, although it is a risk, contributing as an equal player would feel great. It would be a sign your business is making it! You also will likely get more publicity if you contribute directly. |
| C: coordinated campaign funded 50% by Earth's Coffee and 50% by Disposaware | 35 | As great as it would feel to contribute, you also are aware that this is still a risky investment. If it is not an equal split, then you prefer that Earth's Coffee and Disposaware cover it themselves. This buys you time to |

| | | |
|---|---|---|
| | | save and allows you to invest only if the pilot test succeeds. |
| **Issue 5: reporters and ENGOs at pilot test** | | |
| A: yes | 45 | You strongly prefer this alternative because you think the composting will work. Therefore, this is a great publicity/Public Relations opportunity for MakeSoil. |
| B: no | 0 | |

## Appendix D.5 Cup Game Confidential Instructions for WasteBeGone, A Hauling Company

You are the president of a hauling company that operates in Greendale. Your company has contracts with the city for residential and government facility waste pick-up and individual contracts with companies for commercial waste removal. WasteBeGone operates a fleet of identical trucks (identical to keep the maintenance and repair costs down).

WasteBeGone is passionate about the environment and sees its service as vital for the health and wellbeing of the citizens of Greendale. Sanitation is not clean work, and is often thankless, but WasteBeGone employees pride themselves on doing their part to help the environment and the residents. WasteBeGone has corporate policies regarding percentages that it can take to landfills, composting centers, and MRFs. WasteBeGone does not have a MRF, landfill, or composting center. In fact, it must pay a tipping fee each time it empties a truckload of waste into a landfill, composting center, or MRF.

The goal of the pilot test and of the larger, long-term system is to have a net carbon dioxide reduction. To calculate the net carbon dioxide reduction, the amount of carbon dioxide *released* by executing the process must be subtracted from the carbon dioxide *saved*. The exhaust from WasteBeGone's trucks represents a carbon dioxide "cost" to this system. You suspect that the recyclers and composters will try to highlight that they are the part of the process that saves carbon. However, their processes also emit carbon dioxide, even if indirectly through the generation of electricity to power their machines. You are afraid that in an attempt to make themselves look good, they will point out that hauling provides no carbon dioxide savings, but is entirely a cost. You are prepared to remind them that hauling is an important part of the process: without it they would not have cups on-hand to compost or recycle!

During this pilot test, WasteBeGone will have to keep these testing cups separate from other waste. This will require dedicated trucking routes covering the same areas it already covers in normal routes, which is more carbon dioxide emitted and more expense for WasteBeGone. However, using dedicated truck routes for this pilot test does make the calculation of emitted carbon dioxide easier.

**WasteBeGone's trucks can haul 13 tons per truckload.** The amount of carbon dioxide emitted per material depends on the number of truckloads. That can be calculated according to the following formulas:

For composting:

**[Tons of material compost]/ [13 tons per truckload] = truckloads to compost**

For recycling:

**[Tons of material recycle]/ [13 tons per truckload] = truckloads to recycle**

UseAgain and MakeSoil's facilities are not near each other. **UseAgain's facility is 120 miles due east** of WasteBeGone's central point and **MakeSoil's is 100 miles due west**. Therefore, the trucks will have to head off in opposite directions on round trip journeys.

Table 18. Cup Game: Hauler's Driving Distances.

| Destination | Average Driving distance (round trip) |
|---|---|
| MakeSoil's Composting Facility | 100 miles |
| UseAgain's MRF & paper mill | 120 miles |

WasteBeGone tracks its carbon dioxide output from its driving activities, using the average of **4 pounds of carbon dioxide emitted per mile** driven. Therefore, the driving emissions "spent" on driving each type of material, can be calculated according to the following equations:

For composting:

**[truckloads compost]*100*4 = pounds carbon dioxide emitted driving to compost**

For recycling:

**[truckloads recycle]*120*4 = pounds carbon dioxide emitted driving to recycle**

WasteBeGone, is philosophically in favor of providing a productive end-of-life to used coffee cups. However, it fears that unless the larger, long-term system is designed right, WasteBeGone's costs will increase prohibitively. WasteBeGone does not want this agreement to require it to purchase and maintain new equipment; to add additional routes; and/or result in an increase in the tipping fees.

If its costs can be kept the same, participation in the larger, long-term system will likely increase WasteBeGone's profits. WasteBeGone operates in contracts. Its more stable (long-term) contracts are the municipal ones and its more lucrative contracts are the commercial contracts. You are hoping this test of the pilot system is successful and that **the larger, long-term project will be structured as a long-term contract**.

WasteBeGone resents when others criticize it for being too cost focused: it must remain a viable business to be able to provide this service to the city. If the larger, long-term system is not viable for haulers to exist, then waste will accumulate and not be reused as appropriate, and humans and the environment will suffer.

Based on your research, you expect issue 4 about customer education will be a little contentious. Earth's Coffee seems really enthusiastic about customer education. You disagree with their approach and messaging. Therefore, **your first choice on issue 4 is not to have any customer education (alternative A).** You also don't have any room in your budget and cannot contribute to customer education for this pilot test. Therefore, if the others are insistent that there be some type of customer education, your 2$^{nd}$ choice is alternative C, Earth's Coffee and Disposaware splitting the cost between themselves.

You are happy WasteBeGone was asked to participate in these talks about this project because you think the waste-and-reuse industry needs to develop long term alternatives for improving reuse of waste. However, you cannot support a system that will drive up current or future costs.

**You must earn at least 90 points in the negotiated agreement for the project to be worthwhile to WasteBeGone.** If you get less than 90, then WasteBeGone is giving up too much and is better off stopping the project (by voting "NO"). You met with your board and you agreed upon the prioritization scheme that is delineated in the table below. You and the board agreed that the success of this pilot is good for the waste-and-reuse industry. **Therefore, if the agreement reached saves at least 110,000 pounds of carbon dioxide in the pilot test (issue 1), you will receive a 100-point bonus added to your points scored in the negotiation.** Therefore, if the agreement saves at least 110,000 pounds of carbon dioxide in the pilot, you will get a minimum of 190 points.

The official WasteBeGone priorities on the 5 agenda issues alternatives are in the following table.

Table 19. Cup Game: Hauler's Point Structure.

| WasteBeGone Priority among Alternatives | Points Earned | Reasoning |
|---|---|---|
| **Issue 1: % compost & recycling in pilot test** | | |
| A: 40% compost; 60% recycling | 10 | WasteBeGone calculated its cost of participating in the pilot test using labor, driving, & |

| | | |
|---|---|---|
| | | maintenance costs. During the first round of negotiations, UseAgain and MakeSoil agreed not to charge tipping fees for the pilot test. This alternative is the most expensive of the pilot test alternatives. |
| B: 60% compost; 40% recycling | 30 | WasteBeGone calculated this based on its labor, driving, & maintenance costs. The pilot test is above and beyond WasteBeGone's normal operating budget. This alternative minimizes the cost of participating in the pilot. However, you are worried that the pilot will be a precedent for the larger, long-term system (see issue 3), in which you also have to consider tipping fees. |
| C: 50% compost; 50% recycling | 20 | WasteBeGone will be OK, cost-wise, with this alternative. |
| **Issue 2: timing of pilot test** | | |
| A: Start in 6 months | 40 | To participate in the pilot test, WasteBeGone will have to shift its trucking schedules by estimated tons. Since this is a temporary change with advanced notice, WasteBeGone can be ready to start in 6 months. Starting the pilot quickly might help counteract some negative publicity WasteBeGone recently received from a so-called-environmental group. |
| B: start in 1 year | 30 | |
| C: start in 18 months | 10 | |
| **Issue 3: larger, long-term system composition** | | |
| A: 40% compost; 60% recycling | 20 | This is 4th least costly alternative (it is the most expensive alternative). |
| B: 60% compost; 40% recycling | 50 | Your business is mostly in long-term contracts. You want to set the percent composition of the larger, long-term system upfront so you can do your business planning. Regarding what the percentage mix is set to: you want WasteBeGone to incur the least costs possible. The cost analysis of the hauling business is quite involved, and due to anti-trust concerns you do not want to go into details in this negotiation. For the larger, long-term system, tipping fees are again a factor. Given tipping fees, labor costs, driving costs, maintenance costs, etc. this alternative is the 2nd least costly. |
| C: 50% compost; 50% recycling | 30 | This is the 3rd least costly alternative. |
| D: 30% compost; 60% recycling; 10% landfill | 75 | Most of your business is in long-term contracts. Therefore, you would like to establish the plan for the larger, long-term system *now* so that you can manage your budget better. Setting the |

| | | |
|---|---|---|
| | | percentage mix to minimize WasteBeGone's costs is critical. Experts at WasteBeGone compared these Issue 3 alternatives by estimating the expected costs. This alternative is the least costly. The cost calculations are very involved, including tipping fees (which are in force in the larger, long-term system), labor costs (which factor in union regulations, government safety standards on driving limits, etc.), driving costs (e.g. fuel, tolls, etc.), and maintenance costs. Due to anti-trust concerns, you do not want to discuss the details of your cost structure during this negotiation. **This percentage mix minimizes WasteBeGone's cost.** This stance might be controversial and probably misunderstood (because it includes landfill), but WasteBeGone is comfortable with its commitment to the environment. In fact, WasteBeGone feels it needs to stay in business to be able to benefit the environment. |
| E: set after pilot results | 0 | Given your long-term contracts with the city, WasteBeGone plans its budget in 10-year increments. You would like the plan for the larger, long-term system now so you can start planning. |
| **Issue 4: Approach to customer education** | | |
| A: no customer education | 40 | You don't want to set a precedent wherein WasteBeGone pays for customer education about this larger, long-term project. You don't have money for customer education now and do not expect to have much more in the future. Besides, if you had extra money, you'd pass it through to your workers. You also are particular about the message that gets released to the public, and you disagree with Earth's Coffee's approach; you would rather see no message than a bad one. |
| B: coordinated campaign funded equally by all participants (20% each) | 0 | You don't have the money; your money goes to maintaining trucks, paying workers, and other business expenses like tipping fees. If you had extra, you'd give your workers a pay increase. |
| C: coordinated campaign funded: 50% by Earth's Coffee and 50% by Disposaware | 15 | If there is going to be customer education, then you can at least meet one of your objectives (not paying for it) through this alternative. You realize that if this alternative is selected, you will have to put up with Earth's Coffee's approach. Although this is not ideal, you just don't have the money to "buy" a voice in the customer education piece. |
| **Issue 5: reporters and ENGOs at pilot test** | | |
| A: yes | 30 | You want to get ENGOs off WasteBeGone's back. |

| | | |
|---|---|---|
| | | Having the (free) publicity of participating in this study will help, regardless of the outcome of the pilot test. By participating, you are demonstrating your commitment to the environment. |
| B: no | 0 | |

## Appendix D.6 Cup Game Confidential Instructions for Disposaware, Cup Manufacturer at Negotiating Tables Given the Model

You are the representative for Disposaware. You have risen through the ranks at Disposaware, having started in a food-container paper products manufacturing plant. Now as a Vice President, you are very knowledgeable about the paper industry, though you have always focused on food-use paper products. Disposaware makes all sorts of single-use food packaging items. It is a branch of a larger paper company that owns many acres of forestland and several paper mills, but none near Greendale. Historically speaking, this larger paper company was a pioneer in paper recycling. Disposaware employees are proud of this heritage.

There is a bit of internal struggle regarding this cup project. If recycling is favored and shown viable, the company itself could benefit from this increase in sales in one of its businesses and from the cost reduction of using fewer tons of virgin materials for some of its paper products. However, it is not clear that these cups won't foul the mills with their mixed materials and food waste. Also, Disposaware sells a compostable cup, which would be vulnerable to an approach to this system that heavily favors recycling. You take a higher-level view: Disposaware's many business lines make it more robust, despite the uncertainty in recycling used paper cups. Therefore, Disposaware is relatively well positioned to succeed regardless of the results of the mill tests in this pilot project.

You and your boss see this cup project as an opportunity for Disposaware to lead the greening of the food packaging industry. Participation in the cup pilot test demonstrates Disposaware's responsiveness to consumers' demands for increased environmental stewardship from businesses. It also highlights Disposaware's innovative side and helps address some recent negative press. A non-profit organization recently attacked Disposaware for being a commodities business relying on bulk sales of unsustainable products. Simply speaking, Disposaware does make more profit the more disposable food packing items it sells. But that is not the full story: Disposaware has environmental ethos as part of its ancestral DNA and has been brainstorming ways to improve its environmental impact (hence the compostable cups). This non-profit didn't mention Disposaware's positive environmental steps like the compostable cup. Participating in this pilot test will highlight Disposaware's good work.

Disposaware sells to larger corporations that vend food and drink, and sells to grocery stores that sell to picnic-goers. Earth's Coffee is a high visibility customer for you because of the Earth's Coffee brand value, but they are not your largest customer in terms of sales figures. Furthermore, they buy only one type of product that Disposaware sells. Your boss hopes that Disposaware's participation in this pilot will entice Earth's Coffee to buy your compostable cup for geographic areas that have compost but no recycling, when the full system rolls out nationwide.

To help you in the negotiation, your mill engineers have run some calculations based on the size of UseAgain's paper mill. They have determined that the testing of the pilot system will not be a viable test unless there are **at least 160 tons of used cups to test in the paper mills** (this does not include the tons of cups composted). You expect this minimum threshold to be relevant to the discussion about issue 1, the percent composition of the pilot test, and to issue 4, the approach to customer education. Since both recycling and composting are to be tested in this pilot (issue 1), there will need to be enough cups. In the previous meeting with Earth's Coffee, you gathered they consider a total of 400 tons of used cups to be a minimum threshold. **The table below shows that, with the 400ton total, the Issue 1 alternatives being discussed in the negotiation will result in enough tons of cups for the paper mill (at least 160 tons for the paper mill).** This gives you some options to work with at the negotiating table.

Table 20. Cup Game: Recycling Tons for Tables Given a Model (Identical to Recycling Tons at Tables Not Given a Model).

| **% recycling in Issue 1: composition of the pilot test** | **400 tons total. Below are tons of recycling for each alternative in issue 1.** |
|---|---|
| Alternative A: 60% recycling | 240 tons recycling |
| Alternative B: 40 % recycling | 160 tons recycling |
| Alternative C: 50% recycling | 200 tons recycling |

Your engineers suspect that there is a relationship between the amount of money spent on customer education and the number of tons of used cups collected. They just aren't sure how to estimate it. Therefore, your boss has encouraged you to **commit to matching what Earth's Coffee spends on customer education**. Your research indicates that this will be around $250,000 and, that the recycling, composting, and hauling companies will not be able to spend this much on customer education. You see this as an opportunity to demonstrate to Earth's Coffee that Disposaware is committed to sustainability, in general, and a better end of life for used coffee cups, in particular. Furthermore, by splitting it with Earth's Coffee, your two companies will be able to control the content and style of the messaging. Therefore, you **prefer alternative C on issue 4**, where you and Earth's Coffee split the customer education budget 50-50.

Your boss has instructed you to keep Earth's Coffee happy so that Disposaware can keep the Earth's Coffee contract and grow it when the full system launches nationwide. Your boss, herself a forward-thinking visionary, sees great years ahead if Disposaware leads in the greening trend.

Your boss' forethought led her to have one of the Disposaware scientists create the following model of the situation. **She STRONGLY encourages you to share it with the other parties to determine the amount of carbon dioxide saved with different alternatives for issue1.** Disposaware doesn't have many of the inputs, but suspects the other parties will have reliable data to input into the model. The model outlines 9 such needed values. It uses these values to calculate other values that will be helpful during the negotiation. To enable considering these values in the negotiation, she recommends that you **use the spreadsheet provided or set up this model in a spreadsheet or on paper prior to the negotiation, leaving blank spaces for the values you have to find out from the other parties.** ***A Google spreadsheet version is available at the link indicated on the attached memo.***

1. Tons composted
    a. [Tons of used cups collected]*[%compost in issue1] = [tons composted]
2. $CO_2$ emitted in trucking to compost facility
    a. Estimated truckloads to compost
        i. [Tons composted]/[tons per truckload] = [truckloads compost]
    b. [distance to compost facility]*[truckloads compost]*[carbon cost per mile]=[$CO_2$ emitted trucking to compost]
3. $CO_2$ saved composting
    a. [tons composted]*[$CO_2$ saved per ton composting] = [$CO_2$ saved in composting]
4. $CO_2$ net composting
    a. [$CO_2$ saved in composting]-[$CO_2$ emitted trucking to compost] = [$CO_2$ net composting]
5. Tons recycled
    a. [Tons of used cups collected]*[%recycled in issue1] = [tons recycled]
6. $CO_2$ emitted in trucking to recycling facility
    a. Estimated truckloads to recycle
        i. [Tons recycled]/[tons per truckload] = [truckloads recycling]
    b. [distance to recycling facility]*[truckloads recycle]*[carbon cost per mile]=[$CO_2$ emitted trucking to recycling]
7. $CO_2$ saved recycling

a. [tons recycling]*[$CO_2$ saved per ton recycling] = [$CO_2$ saved in recycling]

8. $CO_2$ net recycling

   a. [$CO_2$ saved in recycling]-[$CO_2$ emitted trucking to recycling] = [$CO_2$ net recycling]

9. $CO_2$ net on pilot

10. [$CO_2$ net composting] + [$CO_2$ net recycling] = [$CO_2$ net on pilot]

In addition to talking with your boss, you have talked with various people in many departments of Disposaware. Collectively, you have agreed upon the prioritization of the alternatives presented in the table below. **You must achieve at least 80 points in the negotiated agreement** or the project won't be beneficial to Disposaware. **Additionally, if the agreement reached saves at least 110,000 pounds of carbon dioxide in the pilot test (issue 1), you will receive a 100-point bonus added to your points scored in the negotiation.** Therefore, if the agreement saves at least 110,000 pounds of carbon dioxide in the pilot, you will get a minimum of 180 points.

Table 21. Cup Game: Cup Maker's Point Structure at Tables Given a Model (Identical to Cup Maker's Point Structure at Tables Not Given a Model).

| Disposaware Priority among Alternatives | Points Earned | Reasoning |
|---|---|---|
| **Issue 1: % compost & recycling in pilot test** | | |
| A: 40% compost; 60% recycling | 30 | |
| B: 60% compost; 40% recycling | 40 | |
| C: 50% compost; 50% recycling | 50 | You have compostable cups for sale now, but you believe the mill test will work, eventually. This alternative demonstrates your faith in the success of the mill test. Your boss thinks this alternative minimizes the risk of missing out on recycling revenue and minimizes the risk of cannibalizing your own compostable cup product. **Remember that you need at least 160 tons of cups for the recycling part of the pilot test and that you are at these talks to shape them in a way favorable to Disposaware's future strategy** (which includes avoiding unnecessary risks). ***You are encouraged to share the LCA model Disposaware scientists created.*** |
| **Issue 2: timing of pilot test** | | |
| A: Start in 6 months | 0 | |
| B: start in 1 year | 60 | You need some time to prepare your mills so that you can do some (secret) testing on your own. And, you don't want to be seen as delaying - so this alternative balances those two interests. Remember, Disposaware mills aren't being used in this test; you are here to shape these talks in ways useful to your future strategy. |
| C: start in 18 months | 45 | You need some time to prepare your mills so that you can do some (secret) testing on your own. |

**Issue 3: larger, long-term system composition**

| | | |
|---|---|---|
| A: 40% compost; 60% recycling | 20 | |
| B: 60% compost; 40% recycling | 40 | If you are pressed to lock in the percentages before the pilot results are available, then this is the least risky alternative because your compostable cup is already on the market. Disposaware is risk adverse so prioritizes the known (compostable cup) over the unknown (recycling regular cups). The downside of this alternative is that you might lose out on future sales if recycling proves to be successful (so you prefer alternative E). |
| C: 50% compost; 50% recycling | 25 | |
| D: 30% compost; 60% recycling; 10% landfill | 0 | Having any % landfill is your last choice. |
| E: set after pilot results | 60 | You want to see the results of the pilot before committing to any percentages. Using the results of the pilot to determine larger system percentages is advantageous for you strategically. It allows you to asses the risk of recycling paper cups and allows you to collect sales results for the compostable cup. This is the alternative best aligned with Disposaware's future strategy. |

**Issue 4: Approach to customer education for pilot test**

| | | |
|---|---|---|
| A: no customer education | 0 | If there is no customer education, there will not be enough cups to conduct the mill test component of the pilot system (there must be at least 160 tons). Besides, customer education is a form of marketing and you want to get the word out that Disposaware is sustainable! |
| B: coordinated campaign funded equally by all participants (20% each) | 25 | There should be customer education for three reasons.<br>1) If you all are going to do this test, you want it to be done well: the pilot test must have enough cups (160 tons) for the mill component of the pilot test. 2) Customer education is a form of marketing and Disposaware needs to repair the damage to its image done by a non-profit that didn't tell the full story. 3) Besides, to make the larger, long-term system viable, customers will need to be involved so we might as well get going in training them. |
| C: coordinated campaign funded 50% by Earth's Coffee and 50% by Disposaware | 30 | There are several reasons why you want to split the cost with Earth's Coffee. By splitting the customer education cost with Earth's Coffee, Disposaware demonstrates its interest in this project and in sustainability. This demonstration of interest might result in more future business with Earth's Coffee and will be useful in restoring Disposaware's image after that damaging article by the non-profit. Furthermore, paying for half of it gives you more control over the content and styling of the message. You don't want to share these reasons, however, because they might be taken the wrong way. **Disposaware commits to match Earth's Coffee on customer education spending for the pilot**, which you estimate will be around $250,000.<br>The three reasons you want customer education, even if it is paid for by all five, are delineated above with alternative B. |

| Issue 5: reporters and ENGOs at pilot test | | |
|---|---|---|
| A: yes | 0 | |
| B: no | 25 | There is some uncertainty as to whether the pilot tests will work. Disposaware likes to experiment and be innovative but doesn't like to go public until the experiments are successful. Negative press is a particularly touchy subject right now because of the damaging article by the non-profit (even though that article didn't tell the full story). Your boss prefers to play this safe until recycling is shown to work. |

## Appendix D.6.1 Memo for Disposaware at Tables Given a Model

The following link will direct you to the model Disposaware scientists have created. It is a Google spreadsheet containing the calculations itemized in your confidential instructions.

You are **encouraged** to share this model, and/or its output, with the other parties.

**https://tinyurl.com/CupGameTable38**

## Appendix D.7 Cup Game Confidential Instructions for Disposaware, Cup Manufacturer at Tables Not Given a Model.

You are the representative for Disposaware. You have risen through the ranks at Disposaware, having started in a food-container paper products manufacturing plant. Now as a Vice President, you are very knowledgeable about the paper industry, though you have always focused on food-use paper products. Disposaware makes all sorts of single-use food packaging items. It is a branch of a larger paper company that owns many acres of forestland and several paper mills, but none near Greendale. Historically speaking, this larger paper company was a pioneer in paper recycling. Disposaware employees are proud of this heritage.

There is a bit of internal struggle regarding this cup project. If recycling is favored and shown viable, the company itself could benefit from this increase in sales in one of its businesses and from the cost reduction of using fewer tons of virgin materials for some of its paper products. However, it is not clear that these cups won't foul the mills with their mixed materials and food waste. Also, Disposaware sells a compostable cup, which would be vulnerable to an approach to this system that heavily favors recycling. You take a higher-level view: Disposaware's many business lines make it more robust, despite the uncertainty in recycling used paper cups. Therefore, Disposaware is relatively well positioned to succeed regardless of the results of the mill tests in this pilot project.

You and your boss see this cup project as an opportunity for Disposaware to lead the greening of the food packaging industry. Participation in the cup pilot test demonstrates Disposaware's responsiveness to consumers' demands for increased environmental stewardship from businesses. It also highlights Disposaware's innovative side and helps address some recent negative press. A non-profit organization recently attacked Disposaware for being a commodities business relying on bulk sales of unsustainable products. Simply speaking, Disposaware does make more profit the more disposable food packing items it sells. But that is not the full story: Disposaware has environmental ethos as part of its ancestral DNA and has been brainstorming ways to improve its environmental impact (hence the compostable cups). This non-profit didn't mention Disposaware's positive environmental steps like the compostable cup. Participating in this pilot test will highlight Disposaware's good work.

Disposaware sells to larger corporations that vend food and drink and sells to grocery stores that sell to picnic-goers. Earth's Coffee is a high visibility customer for you because of the Earth's Coffee brand value, but they are not your largest customer in terms of sales figures. Furthermore, they buy only one type of product that Disposaware sells. Your boss hopes that Disposaware's participation in this pilot will entice Earth's Coffee to buy your compostable cup for geographic areas that have compost but no recycling, when the full system rolls out nationwide.

To help you in the negotiation, your mill engineers have run some calculations based on the size of UseAgain's paper mill. They have determined that the testing of the pilot system will not be a viable test unless there are **at least 160 tons of used cups to test in the paper mills** (this does not include the tons of cups composted). You expect this minimum threshold to be relevant to the discussion about issue 1, the percent composition of the pilot test, and to issue 4, the approach to customer education. Since both recycling and composting are to be tested in this pilot (issue 1), there will need to be enough cups. In the previous meeting with Earth's Coffee, you gathered they consider a total of 400 tons of used cups to be a minimum threshold. **The table below shows that, with the 400ton total, the Issue 1 alternatives being discussed in the negotiation will result in enough tons of cups for the paper mill (at least 160 tons for the paper mill).** This gives you some options to work with at the negotiating table.

Table 22. Cup Game: Recycling Tons for Tables Not Given a Model (Identical to Recycling Tons at Tables Given a Model).

| **% recycling in Issue 1: composition of the pilot test** | **400 tons total. Below are tons of recycling for each alternative in issue 1.** |
|---|---|
| Alternative A: 60% recycling | 240 tons recycling |
| Alternative B: 40 % recycling | 160 tons recycling |
| Alternative C: 50% recycling | 200 tons recycling |

Your engineers suspect that there is a relationship between the amount of money spent on customer education and the number of tons of used cups collected. They just aren't sure how to estimate it. Therefore, your boss has encouraged you to **commit to matching what Earth's Coffee spends on customer education.** Your research indicates that this will be around $250,000 and, that the recycling, composting, and hauling companies will not be able to spend this much on customer education. You see this as an opportunity to demonstrate to Earth's Coffee that Disposaware is committed to sustainability, in general, and a better end of life for used coffee cups, in particular. Furthermore, by splitting it with Earth's Coffee, your two companies will be able to control the content and style of the messaging. Therefore, you **prefer alternative C on issue 4**, where you and Earth's Coffee split the customer education budget 50-50.

Your boss has instructed you to keep Earth's Coffee happy so that Disposaware can keep the Earth's Coffee contract and grow it when the full system launches nationwide. Your boss, herself a forward-thinking visionary, sees great years ahead if Disposaware leads in the greening trend.

In addition to talking with your boss, you have talked with various people in many departments of Disposaware. Collectively, you have agreed upon the prioritization of the alternatives presented in the table below. **You must achieve at least 80 points in the negotiated agreement** or the project won't be beneficial to Disposaware. **Additionally, if the agreement reached saves at least 110,000 pounds of carbon dioxide in the pilot test (issue 1), you will receive a 100-point bonus added to your points scored in the negotiation.** Therefore, if the agreement saves at least 110,000 pounds of carbon dioxide in the pilot, you will get a minimum of 180 points.

Table 23. Cup Game: Cup Maker's Point Structure at Tables Not Given a Model (Identical to Cup Maker's Point Structure at Tables Given a Model).

| Disposaware Priority among Alternatives | Points Earned | Reasoning |
|---|---|---|
| **Issue 1: % compost & recycling in pilot test** | | |
| A: 40% compost; 60% recycling | 30 | |
| B: 60% compost; 40% recycling | 40 | |
| C: 50% compost; 50% recycling | 50 | You have compostable cups for sale now, but you believe the mill test will work, eventually. This alternative demonstrates your faith in the success of the mill test. Your boss thinks this alternative minimizes the risk of missing out on recycling revenue and minimizes the risk of cannibalizing your own compostable cup product. **Remember that you need at least 160 tons of cups for the recycling part of the pilot test and that you are at these talks to shape them in a way favorable to** |

| | | |
|---|---|---|
| | | **Disposaware's future strategy** (which includes avoiding unnecessary risks). |
| **Issue 2: timing of pilot test** | | |
| A: Start in 6 months | 0 | |
| B: start in 1 year | 60 | You need some time to prepare your mills so that you can do some (secret) testing on your own. And, you don't want to be seen as delaying – so this alternative balances those two interests. Remember, Disposaware mills aren't being used in this test; you are here to shape these talks in ways useful to your future strategy. |
| C: start in 18 months | 45 | You need some time to prepare your mills so that you can do some (secret) testing on your own. |
| **Issue 3: larger, long-term system composition** | | |
| A: 40% compost; 60% recycling | 20 | |
| B: 60% compost; 40% recycling | 40 | If you are pressed to lock in the percentages before the pilot results are available, then this is the least risky alternative because your compostable cup is already on the market. Disposaware is risk adverse so prioritizes the known (compostable cup) over the unknown (recycling regular cups). The downside of this alternative is that you might lose out on future sales if recycling proves to be successful (so you prefer alternative E). |
| C: 50% compost; 50% recycling | 25 | |
| D: 30% compost; 60% recycling; 10% landfill | 0 | Having any % landfill is your last choice. |
| E: set after pilot results | 60 | You want to see the results of the pilot before committing to any percentages. Using the results of the pilot to determine larger system percentages is advantageous for you strategically. It allows you to asses the risk of recycling paper cups and allows you to collect sales results for the compostable cup. This is the alternative best aligned with Disposaware's future strategy. |
| **Issue 4: Approach to customer education for pilot test** | | |
| A: no customer education | 0 | If there is no customer education, there will not be enough cups to conduct the mill test component of the pilot system (there must be at least 160 tons). Besides, customer education is a form of marketing and you want to get the word out that Disposaware is sustainable! |

| | | |
|---|---|---|
| B: coordinated campaign funded equally by all participants (20% each) | 25 | There should be customer education for three reasons.<br>1) If you all are going to do this test, you want it to be done well: the pilot test must have enough cups (160 tons) for the mill component of the pilot test. 2) Customer education is a form of marketing and Disposaware needs to repair the damage to its image done by a non-profit that didn't tell the full story. 3) Besides, to make the larger, long-term system viable, customers will need to be involved so we might as well get going in training them. |
| C: coordinated campaign funded 50% by Earth's Coffee and 50% by Disposaware | 30 | There are several reasons why you want to split the cost with Earth's Coffee. By splitting the customer education cost with Earth's Coffee, Disposaware demonstrates its interest in this project and in sustainability. This demonstration of interest might result in more future business with Earth's Coffee and will be useful in restoring Disposaware's image after that damaging article by the non-profit. Furthermore, paying for half of it gives you more control over the content and styling of the message. You don't want to share these reasons, however, because they might be taken the wrong way. **Disposaware commits to match Earth's Coffee on customer education spending for the pilot**, which you estimate will be around $250,000.<br>The three reasons you want customer education, even if it is paid for by all five, are delineated above with alternative B. |

**Issue 5: reporters and ENGOs at pilot test**

| | | |
|---|---|---|
| A: yes | 0 | |
| B: no | 25 | There is some uncertainty as to whether the pilot tests will work. Disposaware likes to experiment and be innovative but doesn't like to go public until the experiments are successful. Negative press is a particularly touchy subject right now because of the damaging article by the non-profit (even though that article didn't tell the full story). Your boss prefers to play this safe until recycling is shown to work. |

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