Aligning Wind Energy Development with National Cultural Dimensions

Leigh Allison

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Reading Committee:

Jessica Kaminsky, Chair

Timothy Larson

Joe Mahoney

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Abstract

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Leigh Allison

Chair of the Supervisory Committee:
Jessica Kaminsky
Department of Civil and Environmental Engineering

This dissertation studied how wind development operates in different national cultural environments in order to answer the overarching question: *How does culture impact wind energy development?* Situated within cross-cultural comparison and social acceptance research, the three studies in this dissertation offer tools for understanding and comparing the cultural context of different nations with respect to wind energy innovation. Fundamental to this research was the development of a new quantitative model for cross-cultural comparisons. Based on the World Values Survey, an inductive big data approach discovered five national cultural dimensions using multidimensional item response theory (MIRT). They are (1) Religiosity, (2) Neutrality, (3) Fairness, (4) Skepticism, and (5) Uncertainty Tolerance. While a deeply simplified representation of culture and the diversity within a nation, each dimension offers a useful tool for modelling cross-

cultural differences and can be used to help us understand the impacts of culture on different political, economic, and development variables. This new cultural framework was applied to the development of wind energy in two studies.

First, Fairness and Uncertainty Tolerance significantly correlated with installed wind capacity of 42 nations around the globe using a multivariate linear regression. Based on diffusion theory, these findings suggest that countries with high scores for Uncertainty Tolerance and Fairness may be more accepting of wind development. We suggest that Fairness supports wind development through developing opportunities for new technology to enter the energy market as well as through support for equitable impacts (e.g. positive externalities). Similarly, countries with high levels of Uncertainty Tolerance may be more likely to adopt wind energy despite the variability in electricity production. Lastly, Religiosity indirectly relates to the proportion of installed wind capacity. While the relationship is an order of magnitude smaller, the relationship suggest that nations with less connections to religion tend to have more installed wind energy.

In the final study of this dissertation, wind developers from Sweden and the United States provided insight into how Uncertainty Tolerance and Fairness influence the social acceptance of wind development. In Sweden, high Uncertainty Tolerance was visible through the planning policies, such as the municipal veto and in the siting process through less systematic stakeholder engagement strategies. In the United States, lower Uncertainty Tolerance was observed through distributed decision-making and comprehensive, targeted stakeholder engagement strategies. The United States and Sweden have similar Fairness scores, which were visible through the inclusion of public participation and compromises with stakeholders.

The findings of this dissertation can be used in several practical ways. First, in future research the national cultural dimensions can be used in conjunction with or as a replacement for other national

cultural values to deepen the understanding of cross-cultural differences. Second, understanding how Religiosity, Uncertainty Tolerance and Fairness drive energy innovations allows international renewable energy companies to adapt their development practices such that they are more successful. Finally, this dissertation contributes to the nexus of social and technical knowledge for planners, developers, and engineers so that they may make informed choices about the societies that they impact.

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ACKNOWLEDGEMENTS

Over my five years at the University of Washington, I have had been fortunate to have support and encouragement from many different folks. Specifically, I would like to thank my excellent advisor, Jessica Kaminsky. Guiding me from topic development to quantitative and qualitative data analysis, I could not have asked for a better mentor. She offered regular encouragement and patience that I am immensely grateful for. I would also like to thank Kamal Ahmed for taking a chance with me and giving the opportunity to teach. Kamal is an incredible instructor and mentor, and I aspire to teach a class as he does one day.

I am very grateful for the funding provided through the Valle Scholarship and Scandinavian Exchange Program at the University of Washington. I was able to travel to Sweden, collect data, and learn from the Technology, Management and Economics Group, particularly Anna Bergek and Ingrid Mignon at Chalmers University. Joe Mahoney and Tim Larson have been both mentors and excellent committee members. I am thankful for all of their support over the years.

In 2014, I was lucky enough to be join five other PhD students Julian, James, Heta, Kine, and Yanbo in a shared workspace. We encouraged and learned from each other, and I truly appreciate all the time we spent together. Finally, I would never have been able to make it here without the support of my family and friends, especially, Ty, my best friend and biggest supporter.

DEDICATION

To Cedar

Chapter 1. INTRODUCTION

The world's energy infrastructure must dramatically change over the next generation if it is to both continue supplying electricity and fight climate change. Renewable energy technologies, such as wind and solar, are well-established systems and feasible solutions to this problem. However, even with the reduced cost of technology and construction, renewable electricity remains underutilized in high resource settings. Most of the existing literature focuses on identifying the development challenges associated with renewable electricity projects, such as: public and/or market support, institutional knowledge, and regulatory structures. However, fewer studies investigate why these challenges exist in some countries but not others. This dissertation incorporates cultural values into the understanding of wind energy development by investigating how national culture (as measured by the World Values Survey) affects the development of wind energy projects across the global and within nations.

1.1 DISSERTATION SUMMARY

This dissertation addresses three research problems through separate publications. First, a quantitative cultural model was created using an exploratory factor analysis, which reduces the 250 variables from the World Values Survey into five latent cultural dimensions (Chapter 2) as seen in Figure 1.1. Next, in a quantitative statistical analysis, the five national cultural dimensions were used as covariates in a linear regression with wind energy capacity at the national level (Chapter 3). Finally, wind developers in Sweden and the United Sates (U.S.) were interviewed to determine how these values manifest in wind project development (Chapter 4). The primary hypothesis confirmed throughout this dissertation is that an understanding of culture is useful for the development of wind energy projects. The various quantitative and qualitative methods employed to investigate these questions are explained in more detail in the following sections as well as the specific results. Ultimately, this dissertation contributes to the understanding of how renewable energy development, primarily wind development, is influenced by culture, providing a nexus of social and technical knowledge to improve the diffusion of sustainable energy infrastructure. Figure 1.1 visually summarizes the work done in this dissertation.

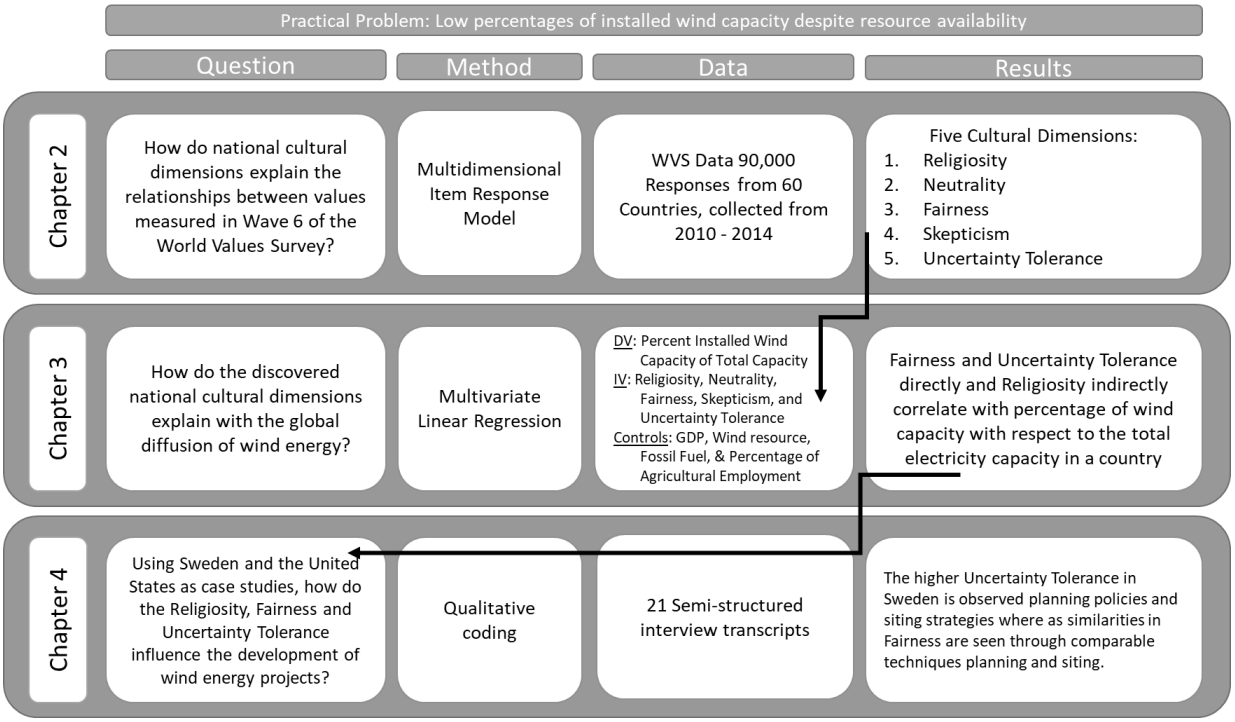

Figure 1.1. Research Design

1.2 RESEARCH CONTEXT

This dissertation brings together social science and engineering, so it worth noting the context which brought me to study aspects of both fields. First, fundamental to this research is how culture has been previously modelled. Existing quantitative cultural models are based on limited samples, predisposed questions, and non-repeatable methodologies. Nevertheless, these models are used extensively. For example, Hofstede's cultural model is by far the most common model use for culture in engineering literature; yet it was derived from survey responses of IBM employees in the 1970s (Hofstede 2001; Taras et al. 2009). Advances in high performance computing and statistical modelling allows for new types of analyses with larger data sets. With inspiration from big data analyses, it is possible to perform an inductive analysis of nationally representative survey data. Therefore, this study allowed cultural values to emerge from comprehensive set of questions administered in World Values Survey (WVS Association 2019a).

Second, research in diffusion of innovation and technological innovation systems has established the importance of actors and their values in renewable energy transitions

(Kaminsky 2016; Mignon and Bergek 2016; Rogers 2003). However, the majority of the literature has studied particularly within a country or across a few cultures (Bergek and Mignon 2016; Mayfield and Mayfield 2012; Toke et al. 2008). With one notable one exception (Kaminsky 2016), quantitative studies have been unable to operationalize norms, values, or policies to explain the global diffusion of renewable energy (Gosens et al. 2017). Therefore, this study builds on Kaminsky's work by replacing Hofstede's model with a new cultural model. In Chapter 3, a regression analysis compares the installed wind capacity of 34 countries with our newly established cultural dimensions.

Finally, to explore the implications of the quantitative model, the third study uses interviews with wind development professionals. Using a social acceptance frameworks allows us to explore not only the broader impacts of policies and markets, but also specific issues that arise during siting (Wolsink 2018; Wüstenhagen et al. 2007). However, there are very few studies which compare social acceptance across countries, the notable exception being a comparison six European countries (Toke et al. 2008). Thus, the study in Chapter 4 incorporates the findings from Chapter 3 into the social acceptance framework using the United States and Sweden as case studies.

1.3 Dissertation Format

This dissertation follows a publication-based approach, addressing each question through separate publications. Chapters 2, 3, and 4 are written as independent studies and will be submitted to journals as such. I request that if you would like to reference this work please reference the published journal article, rather than this document. In this document, there are additional resources, including several preparatory investigations and the R code that was used to conduct all of the statistical analyses in Chapters 2 and 3. Appendix A contains full results of the national cultural model from Chapter 2. Appendix B includes the preparatory alternative approaches explored and ultimately rejected for the analysis presented in Chapter 2. Appendix C includes the R code for final creation of the model, not including data cleaning, which can also be found at https://github.com/Laalliso/CrossCulturalDimensions. Finally, the coding dictionary, IRB exemption status forms, and interview templates are in Appendix D.

Chapter 2. AN INDUCTIVE ANALYSIS OF THE WORLD VALUES SURVEY

Leigh Allison*[1], Chun Wang[2] and Jessica Kaminsky[3]

Quantitative models of cultural difference have not only made major contributions to the fields of cross-cultural anthropology, psychology and sociology, but also have allowed for interdisciplinary studies that bring together engineering, life sciences, and social sciences. Building on the past work, the authors used an inductive big data approach to discover a new set of quantitative cultural dimensions based on the World Values Survey, a nationally representative survey covering 60 countries and 90,000 individuals. Five national cultural dimensions were discovered using multidimensional item response theory (MIRT). This approach is fundamentally different from previous quantitative cultural models because it accounts for response variability within a country for binary, nominal, and ordinal survey questions. This approach is possible due to recent advancements in computing power and programming. Five latent factors emerged from the MIRT model. They are (1) Religiosity, (2) Neutrality, (3) Fairness, (4) Skepticism, and (5) Uncertainty Tolerance. Each cultural dimension is defined by a set of questions that most strongly correlate with the dimension. Like all quantitative cross-cultural models, this model is a deeply simplified representation of cultural difference. However, it is a useful tool for modelling cross-cultural differences that can be used to help us understand the impacts of culture on different political, economic, and development variables.

KEYWORDS: factor analysis, cultural dimensions, multidimensional item response theory

[*1] PhD, University of Washington, Seattle, Washington, USA, laalliso@gmail.com

[2] Assistant Professor, College of Education, University of Washington, Seattle, Washington, USA

[3] Assistant Professor, Department of Civil and Environmental Engineering, University of Washington, Seattle, Washington, USA

2.1 INTRODUCTION

In this study, a new and methodologically distinct quantitative cultural model for countries is created. It differs from previous models in five ways. First, this model uses nationally representative data from the World Values Survey (WVS). The WVS has been distributed in seven waves over the last 37 years to nationally representative populations worldwide (WVS Association 2016). Second, the questions used to create the model were not preselected based on existing cultural theories; instead multivariate statistical modelling allowed questions cultural dimensions to emerge from the dataset. Third, this model is computationally reproducible. The analysis code is written in R, a free statistical programming software, and is available for download as a supplement to this article. Fourth, this model can be applied to different WVS data sets meaning it may be updated in the future. All waves of the WVS data are publicly available for download; however, since the WVS questions change with each wave, data cleaning would be required before applying the analysis code published with this study. Fifth, and finally, this model accounts for the distribution of responses within a country rather than relying on country means.

2.2 A COUNTRY'S CULTURE: DEFINING CULTURE AT THE COUNTRY LEVEL

In 1952, Kroeber and Kluckhohn traced the word *culture* back to its introduction into the English language from German as a derivative of the words *civilization* and *cultivation*. While theorists expanded the definition of culture to include understandings of a people's customs and social structures, the defining element of culture remains that it is shared by a group of people (Hofstede et al. 2010; Kroeber and Kluckhohn 1952). In a recent review of cultural studies, 121 unique instruments were identified that quantitatively measure culture. The majority of researchers developed their own instrument to measure specific cultural aspects that are related to their research objective (Taras et al. 2009). Most common across a variety of fields are instruments measuring culture at the country level. Examples of country level instruments were developed by Hofstede (1980), Trompenaars (1993), Schwartz (1994), Inglehart (1997), and House (2004).

Since culture is a set of concepts shared by a group, all definitions of culture should include the assumption of who is included in the group. Some studies argue that demographic

information such as occupation, education, generation, and socio-economic status are acceptable grouping parameters (Taras et al. 2016). In contrast, many ethnographers would argue that ethnicities are a more appropriate unit of analysis (Baskerville 2003). Still, the unit of analysis in the majority of global studies are countries. Country boundaries provide a useful and reproducible method by which to divide people into groups because within each country there are common institutions, such as the government or economy. Using countries to define cultural groups does not deny the existence of subcultures. It instead presents the characteristics of culture that are apparent across countries and assumes that countries vary more between countries rather than within the country (Smith et al. 2013). For example, Hofstede and collaborators demonstrated that even though national cultural parameters mask unique traits of regional (sub) cultures, these subcultures tend to cluster as a nation. Thus, cultural indices can indicate general trends and shared interpretation within a country; however, they note that the indices should be used to compare countries rather than examine the specific values of a particular country (Minkov and Hofstede 2012).

2.3 Existing Country Cultural Models

There are several major cultural models that have been developed and used in multiple peer-reviewed studies. Table 2.1shows five models which were developed with more than 20 countries, which measure two or more different values, and which have subsequently been applied in other academic studies. For a more comprehensive list of existing cultural studies, please refer to Minkov (2013).

In all of these studies, individuals complete the questionnaires and results are averaged to create a citizen mean. Citizen means are country-level data points, but they cannot be used to make conclusions about individuals. This type of data is often classified as an ecological measurement because the level of analysis changes from individuals to countries (Hofstede 2001; Leung and Bond 1989). With this type of analysis, non-ordered questions are often represented as a series of dummy variables that are percentages of respondents choosing that response, creating a series of variables, which are dependent on the other categories. All currently available country cultural models with the exception of the Global Leadership and Organizational Behavior Effectiveness (GLOBE) model use this approach to develop and

validate models (Dyer et al. 2005; Hofstede 2001; Minkov 2013; Wyer et al. 2009). This assumption limits available models because they not only lose details about response patterns and the spread of the responses within a country, but also may create variables with spurious correlations. The result is a deterministic model that cannot account for the variability within a country. The model described in this paper addresses this limitation by using MIRT to include response patterns in the model.

Table 2.1. Existing Cultural Models

Model		Number of Dimensions	Approach	Sample		Nationally Representative
Author	Year			# of Countries	# of Respondents	
Hofstede	1980[a]	4	Deductive	30	362	No
	2001[b]	6	Deductive	50	117,000	No
Trompenaars	1993[c]	7	Deductive	43	8,841	No
	2012[d]	7	Deductive	100	100,000+	Unknown
Schwartz	1994[e]	7	Deductive	38	12,900+	No
	2009[f]	7	Deductive	72	55,022	No
Inglehart	1997[g]	2	Inductive	43	60,000	Yes
	2000[h]	2	Inductive	65	165,594	Yes
House	2004[i]	9	Deductive	59	17,370	No

a - (Hofstede 1980), b - (Hofstede 2001), c - (Trompenaars 1993), d - (Trompenaars 2012), e - (Schwartz 1994), f- (Wyer et al. 2009), g-(Inglehart 1997), h - (Inglehart and Baker 2000), i - (House et al. 2004) **A summary of all the studies can be found in (Minkov 2013)**.

In the majority of past studies, cultural values were measured using theoretical constructed questionnaires. This deductive approach is indicated in Table 1 as appropriate. For example, Schwartz originally proposed ten values that he believed all people hold in varying levels of importance. He developed a questionnaire which measured those orientations and distributed it to school teachers and high education students around the world (Schwartz, 1992, 1994). Schwartz and collaborators tested these values among individuals in many different cultures, but determined that only seven of the values are useful in measuring cultural differences in countries (Bilsky, Janik, & Schwartz, 2011; Schwartz & Klaus Boehnke, 2004; Schwartz et al., 2001). More recently, he repeated his study with a much wider sample of teachers and students and added additional clarification on the creation of the country scores (Schwartz, 2008; Vinken, Soeters, & Ester, 2004; Wyer et al., 2009). Similarly, in 1993, Trompenaars proposed that there were seven cultural dimensions relevant to the business world. Theoretically, these dimensions were borrowed from previous scholars and were well received

in the business world. However, in 1996, a study measured three of seven dimensions but was unsuccessful in recreating the dimensions that Trompenaars originally proposed (Smith et al. 1996). Trompenaars' work remains popular among business and management professionals; however, to date there have been no further academic attempts to replicate the data (Minkov 2013).

In contrast to Schwartz and Trompenaars, Hofstede choose a combination of theory and data mining to create his indices. Using data from a completed IBM employee attitude survey, Hofstede developed the Power Distance Index (PDI) based the primary question of how frequently employees were afraid to express disagreement with their managers. Similarly, he developed the Uncertainty Avoidance Index (UAI) based on how often the employee felt nervous or tense at work. Theory guided him towards the primary questions and data mining identified which other questions in the survey had correlations with those primary questions. To create the Masculinity index and the Individualism index, he studied 14 work goal questions that were included in both versions of the IBM survey. He used a factor analysis to extract two latent dimensions. The first factor is referred to as the Individualism Index (IDV), and the second factor was identified as the Masculinity Index (MAS), based on a separate analysis on the effects of gender on work goals (Hofstede 2001).

The GLOBE study aimed to understand leadership and organizational behavior by building on the dimensions that Hofstede identified in his study. A major difference between these studies was the addition of new concepts and how the questions were phrased. Each of the nine proposed dimensions was measured using two approaches. The first asked a respondent about their values as they existed, whereas the second asked a respondent what their values should be. The difference in phrasing allowed researchers to separate a respondents personal values from the norms of the society (House et al. 2004; McCrae et al. 2008; Minkov 2013). To select the items to measure each of the cultural dimensions, a factor analysis was performed on each set of questions thought to be related to a specific factor. The items which most highly correlated with the factor were retained for use in the final questionnaire. The research team confirmed the model structure using a multilevel confirmatory factor analysis, which allowed them to account for the variability that exists within a country. Finally, the GLOBE country scales are averages of the dimension's items, likely due to limitations in the methodologies and

computing abilities at the time (Dyer et al. 2005; Hanges and Dickson 2006; House et al. 2004; Minkov 2013).

Inglehart took a different approach in 1997. Working with the second wave of the World Values Survey (WVS Association 2019a), Inglehart first constrained his analysis to questions which focused on modernist and postmodernist values. Using averages and other aggregate values of questions, he performed a principle component analysis resulting in two dimensions. He repeated analysis with the first (1980) and second (1990) waves of the WVS to confirm the factor structure with the 23 variables included in both surveys and that countries scored similarly over time (Inglehart 1997). Starting in 2000 and in following publications of WVS data, the values are recreated using only ten variables. The two dimensions remain the (1) Traditionalism vs. Secular-Rational Authority and (2) Survival vs. Well-Being (Gelfand et al. 2018; Inglehart and Baker 2000; Inglehart and Welzel 2005). In 2005, Inglehart and Welzel teamed up to create their influential cultural maps for which parts of the methodology and indexes were released to the public in 2019 (Inglehart and Welzel 2005; WVS Association 2019b). In 2010, Welzel performed his own analysis which continued the work of Inglehart and hypothesized his own five dimensions related to self-expression based on the WVS data (Welzel 2010).

2.4 CRITIQUES

Over time, these models have been criticized, particularly with respect to the statistical analyses used to obtain these relationships. For example, Hofstede's book *Culture's Consequences* describes how all of his cultural dimensions were created; however, not enough detail is provided to replicate exactly what Hofstede did (McSweeney 2002). Furthermore, many researchers question the generalizability of the model he created since the survey data is from primarily male, highly-educated employees of IBM in the 1970s (Baskerville 2003). Others question the measurement validity since the questionnaire was developed not to study culture but to study employees' opinion of a company (Smith 2002). In the years since the first and second publications of *Culture's Consequence*, Hofstede and collaborators have continued to compare his four dimensions to other data sets collected in ways that are more representative of a nation's population. They argue that while the original model may have

been based on less than ideal data, their dimensions of uncertainty avoidance, power distance, independence, and masculinity are distinguishable (Minkov and Hofstede 2014).

To date, studies attempting to replicate the Inglehart-Welzel dimensions have been unsuccessful, resulting in some researchers questioning whether questions are truly measuring the same values across countries. In addition, neither the original scores from 1997 nor the updated scores from 2000 were ever published (Alemán and Woods 2016; Chen 2008; Minkov 2013). While the majority of researchers accept the values that Schwartz has identified, there remains criticism of the broad definition of his values (Minkov 2013) and doubt in the assumption that the Likert data from his survey can be used as interval data (Lee and Soutar 2010). Trompenaars' values have never been published in academic journals and instead have largely been adopted by business professionals looking to improve their success in the global market. Unfortunately, it has never been reproduced (Minkov 2013), and the primary academic publication that attempts to do so presents evidence that they cannot be reproduced (Smith et al. 1996).

Finally, the GLOBE study provides valuable insight into the difference between personal preferences and cultural norms; however, the primary criticism relates to the ability of respondents to answer questions related to how the values *should be*. Some researchers argue that *should be* questions ask the respondents to stereotype their community, which may or may not be reasonable (McCrae et al. 2008). Finally, a criticism of all the models except for Inglehart's is that the samples are not nationally representative, yet they generalize to the country level.

2.5 Current Study

The current study produces a new set of cultural dimensions for 56 countries. The model differs from and addresses the limitations of previous work by (1) starting with a nationally representative data set, (2) allowing the cultural factors to emerge from the data, (3) providing a computationally reproducible and fully documented methodology, (4) accounting for variation among the responses of a country, and (5) including the ability to be updated with future WVS data sets. The study began with the primary goal of creating a model which was more representative and reproducible than the current models available. Due to advancements

in statistical programming and computing power (Chalmers 2012), our second goal was to account for the distribution of responses within a country using a multidimensional item response model. We do not believe that nations are culturally homogeneous; however, for this study, nations are a common and reproducible unit of analysis and offer a platform for understanding global trends. By using a probabilistic approach that studies response patterns, we hope to more accurately account for countries' diversity. Under the assumption that cultural values can be measured at the country level to provide a useful model in understanding cultural differences between countries, we expected that there would be between four and seven cultural dimensions. Moreover, we did not expect this study would uncover cultural values that had never been measured or proposed before; instead we aimed to create a model which builds on previous models by offering transparency and reproducibility using a big data approach.

2.6 METHOD

Similar to other big data approaches, this study uses an inductive exploratory statistical analysis to discover national cultural dimensions embedded in the values measured by the WVS. Big data is a relatively new resource for researchers, and it requires a new set of analysis skills that the academic world is just beginning to understand (Bail 2014). This study contains information collected from 90,000 people from around the world. Our analysis of the WVS data is similar to other big data approaches in that results are found through exploratory analysis and not through a deductive theoretical approach (Kitchin 2014). Furthermore, our approach differs from previous analyses of the WVS, which tend to use pre-selected questions to measure previously-defined theoretical constructs. Therefore, our analysis identified statistical relationships within the data which can be used to understand some of the cultural differences between countries.

2.6.1 *Data*

This study uses data from Wave 6 of the World Values Survey. As downloaded, there are 339 coded questions from 60 countries (accessible at www.worldvaluessurvey.org). The questions are a combination of ordinal (interval), nominal (unordered), and metrical responses.

The data had a significant number of missing values that had to be dealt with prior to data analysis. Four countries were removed from the analysis due to large amounts (over 50%) of missing values for more than 20 questions, and 42 questions were removed from the analysis due to large amounts (over 50%) of missing values for 15 countries. We chose not to remove all responses with any missing values because over half of the data would be eliminated from the data set. All questions related to sociodemographics were also removed from the dataset because these questions do not represent values. All questions which had open ended responses such political affiliation or religious group were also removed. Finally, we removed questions asking about the respondent's environment; the responses to these questions are not choices that the respondents can make based on their values. For example, the question "how frequently do robberies occur in your neighborhood" was removed because response depends on the respondents' living environment not values. The resulting dataset contains 56 countries (85,264 individual respondents) and 198 question variables. The final step of data cleaning involved transforming responses to particular questions into smaller numbers of categories in order to reduce the computational requirements. For example, questions answered on a scale from one to ten were reduced to a scale of one to five. The link to R code for cleaning the data can found in the supplementary information of this article

2.6.2 *Analysis*

To reduce the data set into a series of latent dimensions, several exploratory multidimensional item response models were created. Unlike manifest variables (e.g. age), latent dimensions (e.g. happiness or the cultural dimensions of interest in this study) cannot be directly measured. Therefore, latent dimensions are typically measured through a combination of manifest variables and are fundamentally based on the manifest variables that are included in the analysis. These latent dimensions are new continuous variables (Bartholomew et al. 2008). A multidimensional item response model is similar to an exploratory factor analysis, but it differs in a few key aspects. Exploratory factor analysis is a model-based technique that aims to explain the correlations between continuous variables. In contrast, an item response model uses a function to model the probability of a response being in a response category, often called the item response function (Bartholomew et al. 2008). In both cases, the output is a continuous latent dimension. For exploratory factor analysis, the input variables must be

continuous while for item response functions, the input variables may be binary, ordered, categorical, and/or nominal. For example, the item response function for binary data can be thought of as the logit function that is used in logistic regression to link binary data to a continuous probability. The questions in the WVS are binary, ordered, or nominal; therefore, we use item response functions to model the probability of answering in a category for a question (Bartholomew et al. 2008; Simpson 1995).

2.6.3 *Item response functions.*

The probability of a certain response for the variable, *i*, given the latent dimensions is denoted as $\pi_i(f)$ as seen in Equation 2.1 below. Note that Equation 2.1 was developed for the dichotomous case; additional functions must be added when there are more than two categories, as explained below (Bartholomew et al. 2008).

$$\pi_i(f) = \frac{1}{1+\exp\left(-\left(\alpha_{i0}+\sum_{j=1}^{q}\alpha_{ij}f_i\right)\right)} \tag{2.1}$$

The intercept (α_{i0}) is also called the easiness parameter because as it increases the probability of the latent factor. The discrimination parameters $\left(\alpha_{i1} \ldots \alpha_{iq}\right)$ alter the steepness of the curve, altering the relationship between the factor values and the likelihood of a response for the observed variable. This model is called the two-parameter logistic model (2PL) due to the two parameters describing the response function. We use this model for questions with only two responses (i.e dichotomous variables) (Baker and Kim 2004; Bartholomew et al. 2008).

When there are multiple categories, we use a cumulative approach for the ordered responses, and the nominal approach for the unordered responses. The cumulative approach estimates the probabilities of a particular response based on the difference between two adjacent cumulative response probabilities. In item response theory, the graded response model (GRM) is a widely used cumulative method. The graded response model replaces the category response function $\pi_i(f)$ with the cumulative response function $\gamma_{i(s)}(f)$. The probability of a response being in a particular category is calculated as the difference between the probability of a response being in a category greater than or equal to the category of interest and the probability of a response being in the category greater than or equal to the response

category above of the category interest (Bartholomew et al. 2008; Chalmers 2018; Samejima 1997). Equation 2.2 applies given a certain latent ability (θ) and a set of parameters (ψ) applied to both k and k+1. Probability is estimated using the equation for $\pi_i(f)$ shown above (Chalmers 2018).

$$P(x = k \mid \theta, \psi) = P(x \geq k \mid \theta, \psi) - P(x \geq k + 1 \mid \theta, \psi) \qquad (2.2)$$

The nominal response model (NRM) is used for responses that are nominal. This model is a generalized version of the general partial credit model (Penfield 2014; Thissen and Steinberg 1986). Instead of comparing the cumulative probability of one response to the one adjacent to it, this model compares the probability a single category against a reference category using a multinomial logistic function (Baker and Kim 2004; Bock 1972). The NRM has two parameters explaining how the latent dimension(s) relate to the probability of a certain response as seen in Equation 2.3 below. However, since there are now unordered categories the discrimination factor is divided into two different coefficients, one for the entire item or question and another representing the specific response. These are called the scoring coefficients (ak_i), and they represent the probabilistic ordering of the categories and aid with interpretation of the model (Chalmers, 2018).

$$P(x = k \Big| \theta, \psi) = \frac{\exp\left(ak_{k-1} * (a_1 * \theta_1 + a_2 * \theta_2 + \cdots + a_q * \theta_q) + d_{k-1}\right)}{\sum_1^k \exp\left(ak_{k-1} * (a_1 * \theta_1 + a_2 * \theta_2 + \cdots + a_q * \theta_q) + d_{k-1}\right)} \qquad (2.3)$$

The statistical program R was used to model this relationship. Specifically, we used version 1.29 of the *mirt* package (Chalmers 2012). The *mirt* function uses marginal maximum likelihood estimation with the expectation-maximization (EM) algorithm to estimate the item response function parameters as well as the correlations between the proposed latent dimensions (Bartholomew et al. 2008; Chalmers 2012). With the *mirt* function we specified 2PL for questions which had only two response categories or where only two response categories were used, GRM for questions with ordered responses, and the NRM for questions with unordered responses. The expectation-maximization algorithm is an iterative process where an initial set of parameters are randomly chosen, and expected distributions for different response patterns are created based on the values of the latent dimension (Bock et al. 1988).

New parameters are selected to maximize the marginal likelihood that the parameters create the observed response patterns. The process iterates until the model parameters converges for all parameters (Bartholomew et al. 2008; Bock and Aitkin 1981; Do and Batzoglou 2008; Robins et al. 2007)

To avoid indeterminacy in the metric and unit of the latent dimensions, the distribution of the latent dimension in this analysis is normally distributed (Bartholomew et al. 2008; Reise et al. 1993). Our final constraints on the analysis are (1) grouping the responses by country and (2) constraining the model parameter values (slope and intercepts) to be equal across the different countries. The factor means are freely estimated for different countries, while the covariance is held at one. This grouped analysis of the responses takes the spread and skew of each country into consideration when selecting the best parameters for item response functions. While we could have analyzed all the responses together, an analysis of that type would ignore country membership. Since culture for this study is defined by the country, it is an essential parameter in the analysis. In technical terms, this model assumes that the WVS survey questions are invariant across countries, and the effect of group membership, also called an impact, can be shown by differences in the latent dimensions. Impact studies are focused on the true group differences rather than inconsistencies within the survey items (Millsap 2011). Unlike measurement invariance or bias, the goal of impact studies is to understand the differences between groups. Thus, the model is constrained to look for aspects of culture that are similar across countries but that also vary between countries. The item parameters are translated into factor loadings. Factor loadings are interpreted as correlations between the latent dimension and the variables (Bock and Aitkin 1981; Wirth and Edwards 2007). The model becomes multidimensional when more than one latent factor is modelled. In our analysis, we tested item response models ranging from one to six factors.

2.6.4 *Exploration: Exploratory factor analysis.*

Any exploratory technique looks for relationships within data without prior assumptions about relationships. Similarly, an exploratory factor analysis (EFA) does not require a model structure containing the pattern of potential associations between the manifest variables and the latent dimensions, which are also called latent factors. In this way, an EFA searches for the best model structure between the manifest variables and one or multiple latent dimensions.

Since item response functions are being used to model the latent abilities, the analysis determines a set of parameters that is most likely to predict the outcome of a particular question based on a latent dimension. For example, if the latent dimension is fairness and the question asks whether a respondent if stealing is justifiable on a scale of one (always justifiable) to five (never justifiable), the item response function is looking for parameters, which based on a certain level of fairness are able to best estimate the probability of being in a certain response category, such as "never justifiable". Only one difficultly parameter is estimated per question and applied to all categories, but there are different intercepts for each category. The parameters for each item are converted into traditional factor loadings. This approach has also been called an item factor analysis (Wirth and Edwards 2007). EFAs do require the number of latent dimensions to be estimated. For our analysis, three, four, five, and six factor models were created. Based on the Akaike information criterion (AIC) and the Bayesian information criterion (BIC), the five-factor model was selected as the final cultural model. Both AIC and BIC are model selection tools based on penalized criteria. The model fit is penalized as the number of parameters increase. AIC assumes that a true model does not exist and instead focuses on how well the model predicts future data while BIC looks for models with the highest probability of being the true model. However, the best model minimizes both values (Burnham and Anderson 2004; Kuha 2004). The results of an EFA are a series of component loadings, which represent the relationship between the manifest variables and latent dimensions. In an EFA, the factor loadings can then be rotated in order to clarify interpretation. Rotations are often used to clarify interpretations (Bartholomew et al. 2008). Rotating the latent factors does not change the model but allows new perspective on the same latent factors by allowing the latent factors to be correlated or uncorrelated.

2.6.5 *Validation: Confirmatory factor analysis.*

Unlike an EFA, a confirmatory factor analysis (CFA) has a predefined model structure, meaning that the relationship (correlated or uncorrelated) between the manifest variables and latent dimension are identified before the analysis starts. The model can no longer be rotated because the relationship is defined in the model structure. A CFA confirms the structure of the latent dimensions, and allows for the calculation of a series of global fit parameters that demonstrate if the CFA model is a good fit of the original data (Agresti and Finlay 1997;

Bartholomew et al. 2008). To measure how well the data fits into the model, several global fit parameters could be used. Root mean square error of approximation (RMSEA) estimates the ability of the model to exactly estimate the sample rather than approximately. Values under 0.05 are considered a good fit; while 0.1 is considered a poor fit. The Comparative Fit Index (CFI) and the Tucker Lewis Index compare the fitted CFA model with a null model where the variables are not correlated. CFI and TLI values closer to 1 indicate improved fit (Bartholomew et al. 2008; Miles and Shevlin 2007).

Using the relationships that had previously emerged in the EFA, we defined a CFA model containing 55 manifest variables all of which had loadings of 0.3 or higher onto at least one of the five latent dimensions from the oblimin rotation. We choose the oblimin rotation because we believe that the latent cultural dimensions do covary. We tested CFA models with correlated and uncorrelated latent factors, and we selected the final CFA model based on the global fit data. Unfortunately, we were unable to estimate a CFA model with correlated factors. Since we subdivided our data into 56 country groups, each sample becomes relatively small for the number of parameters that we are estimating. Therefore, the latent dimension variance matrix becomes non-positive, and the estimation fails. Nevertheless, the estimation is successful when the latent dimensions do not account for the covariation between the latent dimensions' defining variables. Previous studies maintain that latent cultural dimensions should remain uncorrelated (Hofstede 2001; Inglehart and Baker 2000; Leung and Bond 1989). By eliminating the manifest variable from the EFA, which had weak correlations with the five latent factors in our model, we are able to create a simplified model containing 55 variables.

2.6.6 *Factor Scores*

The final step is to name the latent factors and estimate the factor scores. Factor scores are estimated using maximum a posteriori (MAP) which selects the factor score based on the maximum posterior density for the given response pattern (Embretson and Reise 2013). To estimate the factors scores for each respondent, the latent dimensions were evaluated between negative six and six. Since we are interested in a country score, we calculated a weighted average of all the factor scores within a country to create a country score for each latent dimension. In the WVS, each individual respondent is given a weight so that each sample can be adjusted to accurately represent a country population and each country sample is similar

size. This ensures that no single country dominates the data just because it contains more responses. Each country was allowed to choose how the sample should be weighted to represent their country; the majority of countries relied on gender, age, education, and socioeconomics to adjust samples (Medrano 2019). All the factor scores were multiplied by 10 so that each individual score ranges from -60 to 60. The average country scores range from -40 to 40; however, no dimension takes up the entire ranged as seen in Figure 2.1.

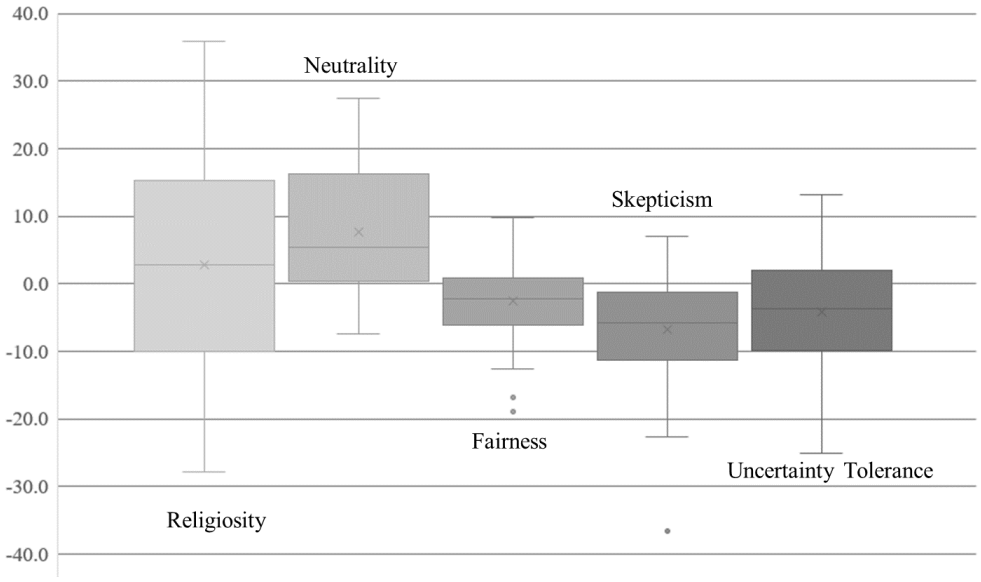

Figure 2.1. Distribution of Country Scores on Cultural Dimensions

2.7 RESULTS

Six EFA models were created using the *mirt* package (v1.29) in R (Chalmers, 2018). Each model had a different number of exploratory factors, ranging from one to six factors. Each model had 56 groups, one for each country. Every group was constrained to have equal item parameters. The five-factor model had the lowest AIC and BIC of all the models created and so was selected for discussion. We utilized high performance computing in order to run these models. Models above four factors were exceptionally large (over 250GB); the size of the model was reasonable considering that it contains 56 groups and 198 items with a series of responses that must be modelled independently as item response curves (Chalmers, 2012). The outputs of these models are a series of coefficients that have been converted into factor loadings (Wirth and Edwards 2007). Analyzing the factor loadings allowed us to label the newly created factors. Loadings represent how the question (often called an item in IRT literature) relates to

Table 2.2. Confirmatory Factor Analysis (CFA): Question Loadings on Latent Factors

Factor	QUESTION	Loading
CD1	Religion is very important in your life	-0.61
	Believe in God	-0.61
	Strongly agree that whenever science and religion conflict, religion is always right	-0.51
	You pray several times a day	-0.47
	Religious faith was mentioned as a quality that children can be encouraged to learn at home.	-0.44
CD2	Not members of an environmental organization	-0.76
	Not members of a consumer organization	-0.76
	Not members of a humanitarian or charitable organization	-0.74
	Not members of a professional organization	-0.72
	Not members of a self-help or mutual aid group	-0.76
CD3	Stealing property is never justifiable	-0.77
	Someone accepting a bribe in the course of their duties is never justifiable	-0.74
	Cheating on taxes if you have a chance is never justifiable	-0.70
	Violence against others is never justifiable	-0.63
	A man to beat his wife is never justifiable	-0.58
CD4	You have no confidence at all in Parliament	-0.77
	You have no confidence at all in the government in your nation's capital	-0.74
	You have no confidence at all in the civil service	-0.70
	You have no confidence at all in political parties	-0.63
	You have no confidence at all in the courts	-0.58
CD5	Not at all worried about a civil war	0.82
	Not at all worried about a terrorist attack	0.80
	Not at all worried about a war involving your country	0.80
	Not at all worried about not being able to give your children a good education	0.49
	Not at all worried about government wire-tapping or reading my mail or email	0.47

the factors and range from -1 to 1. Appendix A shows the loading structure of all 55 variables on each of the factors. These five factors were the latent cultural dimensions that emerged from the data. As we started with a broad scope of questions in our EFA and grouped by country, the latent factors that emerged are cultural dimensions at the country level; however, as with all factor analyses the greatest challenge was in interpreting what the factors represent based on the variable loading patterns. From here forward, we refer to five factors modelled as cultural dimensions and in the discussion section, we provide an analysis of the value that each dimension represents.

Table 2.2 shows the results of the CFA with 55 manifest variables and no correlations between the latent dimensions. In this table, we list only to top five questions that loaded most strongly onto each factor. We repeated the CFA several times to determine the stability of the model under repeated estimations. As expected the results numerically varied slightly (Yavuz

and Hambleton 2017); however, the countries latent values relative to each other (i.e. rank) remained consistent across the different simulation techniques. The numeric results presented in this paper are from the CFA model with the best global fit values. They were estimated using the traditional EM method described in the methods section. Our CFA models converged when the max change in the parameters was less than 0.0005.

Table 2.3 below shows the global fit for CFA model. There is not enough data available to calculate the fit of each model within each country; therefore, these fit values were calculated with all the data (global level). As described in the methods section, RMSEA values should be less than 0.05 while CFA and TLI should 0.95 for good fit. We believe our slightly higher values for RMSEA and slightly lower CFI and TLI values are due global data analysis.

Table 2.3. Global Fit values for CFA Model

	N	DF	RMSEA	TLI	CFI
CFA_Global_Data	85264	1337	0.0661	0.884	0.889

The final output of model was a set of factor scores. Factor scores estimate a respondent's ability along the newly formed latent factors. The term *ability* is used because item response theory was developed as a tool for educational psychologists aiming to understand intellectual abilities. However, a factor or ability score simply ranks all the respondents within the new latent dimensions. The factor scores were calculated using the loadings from CFA as it provides a simpler structure and improves the correlation accuracy of the factor scores (Grice 2001). The factor scores were useful in understanding how our new latent dimensions relate to existing cultural dimensions.

2.8 DISCUSSION

The model presented above was created from an exploratory analysis and then confirmed with a confirmatory factor analysis. Both models are dependent on multidimensional item response theory and result in the same five cultural dimensions. In this discussion, we name each of the five factors and then present a comparison with previously published cultural models. We estimate each country's position along the cultural dimensions using factor scores. It is important to note that lower scores do not indicate poor results; instead, they represent a different cultural view than countries with higher scores. Similarly, countries with high scores

are in no way superior to those with lower scores; the countries simply are at the opposite end of the scale for that cultural dimension.

2.8.1 *Five Discovered Factors*

The first cultural dimension (CD1) contains questions related to belief in God and support of religious customs as seen in the first five rows of Table 2. We have labeled this first cultural dimension as **Religiosity** because it represents a strong dedication to God and religious customs, but not any particular religious faith. This dimension focuses on foundational moral values that historically have been held by religious leaders and texts (Koleva et al. 2012). Examples of the WVS questions include disapproval of divorce and homosexuality, opposition to abortion, the belief that religion is always right, the belief that religious leaders should be a part of the government, as well as confidence, membership and attendance in religious groups. The Religiosity dimension means that people in countries with high scores such as Jordan, Pakistan, and Libya tend to be more traditional in following religious customs and beliefs while people in countries with low scores such as China, Netherlands, and Sweden tend to be more accepting of secular and alternative lifestyle choices.

The second cultural dimension (CD2) represents **Neutrality,** represented by questions related to membership (or lack thereof) in various types of organizations as well as participation in political activities. Neutrality represents low engagement with both civic engagement groups as well as individual need or interest groups. Questions which load on to the factor include non-membership in environmental organizations, self-help groups, political parties and sports organizations. Neutrality also includes a lack of motivation to become involved in civic or political issues with the questions about participation in boycotts, sticks, and petitions. The countries with the highest scores (i.e. Azerbaijan, Armenia, and Tunisia) are countries where over 95% of the population are not in social organizations such as environmental organizations, humanitarian or charitable organizations. Neutrality therefore represents a lack of engagement and relevance of such activities (Dahlgren 2006). Countries with low Neutrality scores (i.e. South Africa and New Zealand) have more participation and therefore voluntary organizations have more relevance in these cultures. Still, it is important to note that even low-scoring countries have just half to one-third of its citizens in these social groups.

The third cultural dimension (CD3) represents **Fairness**. As seen in Table 2, the questions that load on to this factor ask if actions such as stealing, bribery, and violence are ever justifiable, despite the fact that these are illegal in the majority of justice systems. Theoretically, fairness is associated with a judgement of a social situation that creates cooperative behaviors; it can be used both proactively to create cooperative behaviors or reflectively to judge previous actions (Brockner and Wiesenfeld 1996; Greenberg 2002). This dimension does not define what constitutes stealing, bribery, or violent actions; however, it does identify the importance a society places on avoiding such behaviors as such are locally defined. The countries with high scores for Fairness such as Turkey, Georgia, and Japan have more than 85% of the population stating that it is never justifiable to do these things. Countries like South Africa, Philippines, and Algeria, have lower scores for Fairness, meaning approximately 50% of the population believe that it is never justifiable to do things like stealing, bribery, or violence.

The fourth cultural dimension (CD4) represents **Skepticism**. This cultural dimension measures the lack of confidence in large organizations and institutions (Scott 2007). Skepticism specifically identifies an unwillingness to give organizations (political or civic) the benefit of the doubt (Cook and Gronke 2005). Skepticism is considered a vital part of a democracy because it ensures that people continue to stay in involved with elections and decisions made by the government. Skepticism hold organizations accountable by other organizations as well as court systems (Cleary and Stokes 2006). Peru, Yemen, and Tunisia have high Skepticism scores, implying that large proportions of the population (30% or more) tend to have relatively less confidence in their major institutions such as government groups, labor unions, press, and major corporations. On the other hand, Uzbekistan, China, and Singapore have much lower Skepticism scores, with over 70% of the population having relatively more confidence in institutions.

The fifth and final cultural dimension (CD5) represents **Uncertainty Tolerance**. This dimension measures a lack of worry about, or an acceptance of ambiguities and risk that threaten societies (war, terrorism, etc). It is worth noting that despite the similarities of name, this dimension is different than (and is uncorrelated with) Hofstede's Uncertainty Avoidance. Instead, the questions that load on this dimension relate to respondents' worries (or lack there

of - see Table 2.2). Worrying is a symptom of anxiety due to uncertainty (Boehnke et al. 1998; Freeston et al. 1994). Some worries are associated with risks that may be out of respondent's control for example, civil war (Boehnke et al. 1998). Therefore, worrying is not something that necessarily motivates avoidance or risk mitigation behaviors; instead worrying is an emotion that is culturally derived (Breakwell 2014). Accordingly, Schwartz and Melech related different types of worry to Schwartz's embeddedness and autonomy dimensions, arguing that societies which value individual freedoms and goals will tend to have less worries (Schwartz and Melech 2003). As seen in Table 3, our dimension supports their findings. In countries such as Sweden, Netherlands, and New Zealand approximately half of the responses indicated that they worry very little about war, terrorism, spying, employment, or education for their children (per Table 2, the five questions that loaded most strongly on this factor); therefore demonstrating tolerance of societal risks. On the other hand, in Tunisia, Rwanda, and Malaysia, 80% of the respondents are worried about those top five issues, with the exception of government spying where only 60% of the people are worried. It is worth noting that historical and current situations (i.e. civil war, economic growth) within a country undoubtedly provide substantial context for the concerns in this dimension; nevertheless, it is still a cultural value if societies worry about these situations.

2.8.2 *Comparison with Existing Models*

Table 3 shows how our discovered cultural dimensions relate to other quantitative models of currently available and published cultural dimensions as listed in Table 1. Each of the five dimensions described here correlates with at least one dimension described by Hofstede, Inglehart & Welzel, Schwatz, and GLOBE. Trompenaars' values were not included in this comparison because they were never published (Minkov 2013). It is also important to note that the correlations between the two different GLOBE approaches (See Section Existing Culture Models) are different both from each other and from the correlations with Hofestede's dimensions on which the GLOBE dimensions were based.

Interestingly, the correlations shown in Table 2.4 show that each of the factors in our model have strong correlations with one or more of cultural dimensions from the other cross-cultural models. While none of the correlations are strong enough to suggest that these new dimensions are in fact the same as the old dimensions, they are significant in validating these new

dimensions with theory and also in defining what is important and measurable across different countries. For example, Religiosity is directly correlated to not only embeddedness but also power distance and in-group collectivism. Embeddedness (the maintenance of social order (Schwartz, 1999), power distance (the imbalance of power (Hofstede 2001), and in-group collectivism (the pride in group structure (House et al. 2004) support what religion typically offers - social hierarchy providing community and discouraging selfish actions. Therefore, the new factors discovered in this model provide new perspectives on existing cultural theory that has been developed and rigorously tested in numerous studies.

Table 2.4. Country Factor Score Correlations with Published Cultural Dimensions

		# of Countries	Religiosity	Neutrality	Fairness	Skepticism	Uncertainty Tolerance
Hofstede	Power Distance	34	0.49**	0.41*	-0.43*	-0.17	-0.68***
	Individualism	34	-0.48**	-0.25	0.20	0.01	0.56***
	Masculinity	34	0.26	-0.01	-0.04	-0.13	-0.45**
	Uncertainty Avoidance	34	0.07	0.33	0.47**	0.76***	-0.22
	Long Term	47	-0.52***	0.28	0.03	-0.13	0.20
	Indulgence	47	-0.13	-0.59***	0.06	0.06	0.09
Inglehart/ Welzel	Self-Expression	54	-0.72***	-0.48***	0.14	0.22	0.56***
	Secular	54	-0.68***	0.14	0.07	-0.20	0.40**
Schwartz	Harmony	38	-0.43**	0.08	0.26	0.24	0.21
	Embedded	38	0.83***	0.19	-0.21	-0.10	-0.68***
	Hierarchy	38	0.26	0.06	-0.24	-0.50**	-0.29
	Mastery	38	0.09	0.00	0.01	-0.35*	0.02
	Affective Autonomy	38	-0.63***	-0.13	0.22	0.08	0.66***
	Intellectual Autonomy	38	-0.71***	-0.01	0.35*	0.25	0.46**
	Egalitarianism	38	-0.17	-0.21	0.24	0.34*	0.25
GLOBE - Practices	Uncertainty Avoidance	30	-0.35	-0.41*	-0.20	-0.56***	0.37*
	Future Orientation	30	-0.10	-0.39*	-0.21	-0.51**	0.09
	Power Distance	30	0.65***	0.24	-0.11	0.05	-0.49**
	Instit. Collectivism.	30	-0.41*	-0.13	-0.18	-0.49**	0.22
	Humane Orientation	30	0.30	-0.14	-0.28	-0.50**	-0.31
	Perform. Orientation	30	-0.08	-0.41*	-0.23	-0.50**	0.11
	In.group Collectivism.	30	0.65***	0.41*	-0.25	-0.15	-0.65***
	Gender Egalitarianism.	30	-0.32	0.00	-0.27	0.29	0.10
	Assertiveness	30	0.36	0.09	0.04	0.21	-0.14
GLOBE-Values	Uncertainty Avoidance	30	0.57**	0.25	-0.17	-0.03	-0.63***
	Future Orientation	30	0.73***	-0.11	-0.10	0.04	-0.48**
	Power Distance	30	-0.08	0.00	-0.17	-0.46*	0.14
	Instit. Collectivism.	30	0.41*	-0.14	-0.05	0.06	-0.25
	Humane Orientation	30	0.22	0.22	-0.04	0.04	-0.17
	Perform. Orientation	30	0.34	-0.46*	-0.39*	0.25	-0.16
	In.group Collectivism.	30	0.19	-0.15	-0.09	0.28	-0.14
	Gender Egalitarianism.	30	-0.38*	-0.46*	-0.03	0.46*	0.38*
	Assertiveness	30	-0.09	0.00	-0.28	-0.46*	-0.19

(Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05)

2.9 CONCLUSIONS

In this study, we leveraged high power computing to inductively create five cultural dimensions based on the World Values Survey using a multidimensional item response model. The five cultural dimensions identified were (1) Religiosity, (2) Neutrality, (3) Fairness, (4) Skepticism, and (5) Uncertainty Tolerance. Building on previous studies, which used an average country score to create cultural dimensions, we instead include the variation in a country's responses as we discover values that are important across different countries. This study was limited by the available data, and therefore only 56 countries are included in this model. Future studies should consider expanding to more countries and a broader timeline. This could be done through using the additional waves of the WVS or through new data collection in additional countries. Using an inductive approach, we were limited to the questions included within the existing WVS survey. These questions defined the cross-cultural dimensions discovered here; however, future studies should add more questions related to the theoretical foundation of the five cultural concepts identified in order to gain a deeper understanding of the dimensions that have been identified. Finally, this research created a set of country scores for each of the five cultural dimensions. These country scores are a quantitative tool that may be used in future research and in statistical modeling of cross-cultural differences. These country scores allow us to understand where a country tends to fall on a specific cultural dimension. However, it should never be assumed that all individuals within a country follow those trends. Future research should consider how the distribution of individual scores from a single country can be used to more accurately show how a country has cultural variability within its borders.

The current study produced a new set of cultural dimensions measured across 56 countries. The model used a nationally representative data set, inductively discovered new cultural dimensions, provided a computationally reproducible and fully documented methodology, accounted for variation among the individuals within a country, and finally allows future research to apply the methodology to additional WVS data sets. While all of these pieces have been used in various models, they have never before been applied in a single model. Today, this is possible thanks to the tremendous effort of the people behind the World Values Survey and thanks to recent advances in computing capabilities.

2.10 SUPPLEMENTAL INFORMATION:

The R code which created this cultural model and the data file containing the country scores for each of the five dimensions can be found at www.heterogenous-engineering.org or at https://github.com/Laalliso/CrossCulturalDimensions

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2.11 REFERENCES

Please see the last chapter for references for the entire document

Chapter 3. NATIONAL CULTURAL DIMENSIONS DRIVING WIND ENERGY DEVELOPMENT

Abstract

Wind power development, both on and offshore, over the past decade has expanded dramatically; however, considerably more wind power is need to fight against climate change. Previous research has explored the Techno-Economic (e.g. generation and consumption), Socio-Technical (e.g. social acceptance), and Political (e.g. institutional structure) challenges to renewable energy extensively through case studies and regional comparisons. In this article, we quantitatively explore how cultural dimensions provide further insight into the challenges renewable energy face by considering the question of what national cultural values influence the development of wind energy in different countries. Uncertainty Tolerance (the acceptance of ambiguity and risk) and Fairness (importance of cooperative behaviors) were found to have direct, significant relationships with the installed wind capacity of 42 nations around the globe using a multivariate linear regression. Based on diffusion theory, these findings suggest that countries with high scores for Uncertainty Tolerance and Fairness are more accepting of wind development. We suggest that Fairness supports wind development through developing opportunity for new technology to enter the energy market as well as through support for equitable impacts (i.e. positive externalities). Similarly, countries with high levels of Uncertainty Tolerance are more likely to adopt wind energy despite the variability in electricity production. Finally, religiosity (dedication to God and religious customs) indirectly relates to the proportion of installed wind capacity. While the relationship is an order of magnitude smaller than the influence of Uncertainty Tolerance and Fairness, the results suggest that nations with less affiliation with religion tend to have more installed wind energy. The results of this study contribute to the literature focused on cultural values' impact on infrastructure design and construction. Future research should build on these findings to validate this model and furthermore to understand how wind development can be culturally adapted to implement successful renewable energy projects in different cultural contexts.

Keywords: Culture, Fairness, Uncertainty Tolerance, Wind Energy, Energy Infrastructure, Transitions

3.1 INTRODUCTION

Energy has always been a part of people's lives and the advancement of electrical technologies has allowed for many changes in not only our social rituals (e.g. cleaning clothes or cooking meals), but also in how society is structured to provide electricity (e.g. public utility commissions and independent power producers) (Lovins 1977; Winner 1980). As the reality of climate change intensifies, more nations are focusing on how their energy needs can be met through renewable energy sources. When first introduced, wind energy technology was developed as a decentralized source of renewable electricity. This is dramatically different than how the majority of the world generate and distribute electricity. The majority of the developed world has created strong centralized electricity systems due to their inherent advantages in economies of scale and reliability. For example, the United States has developed large electrical transmission systems which can move power to the majority of people within its borders (US EPA 2015). However, this centralized development has also come with a consolidation in authority on its generation and transmission. Following this trend, wind energy has transformed from a small decentralized power source to a much larger power generator. Today, many wind farms are large utility scale operations which sell power directly to public utilities or commercial and industrial customers both in the onshore and offshore markets.

Wind energy is first and foremost dependent on the natural resources. However, in order to be successful, national energy transitions (such as the transition from fossil fuels to renewables) require not only renewable energy resources but also the motivation to adopt wind energy and support from transmission infrastructure, power markets, and local actors (Köhler et al. 2019). The field of technological innovation systems has conducted years of studies on why early mainstream adopters take on innovations (Bergek et al. 2008; Jacobsson and Johnson 2000; Rogers 2003). Many studies have emphasized the importance of social acceptance in the development of renewable energy (Enevoldsen and Sovacool 2016; Fournis and Fortin 2017; Wüstenhagen et al. 2007). Furthermore, recent research has established that the energy resource and the energy market are not strong drivers of wind or solar development (Gosens 2017). Instead there is limited evidence that cultural values play a significant role in diffusion of renewable innovation (Kaminsky 2016). In this study we build on the work of

Kaminsky by focusing on wind energy and by exploring the relationships with an alternative cultural model (Allison et al. In Preparation).

3.2 Research Problem

In this study, we consider the question of *what national cultural values influence the capacity of wind energy installed around the world* to better understand why countries install wind energy. While often difficult to measure, culture represents a shared set of values and ethics, which help people, interpret and act in the situations that surround them. In this study, we use a recently developed cultural model (Allison et al. In Preparation) to explore the quantitative relationships between wind energy development and cultural values at the national level. Unlike previous work (Kaminsky 2016), this is an exploratory study and does not attempt to establish theoretical hypotheses. As such, we start with a broad overview of the literature with respect to challenges in the integration of renewable energy into the existing electricity system to understand how cultural values have previously been considered. Unfortunately, there is a lack of research on how cultural values influence the success of a renewable energy transition, specifically wind energy, at the national level. The notable exceptions (Geels and Verhees 2011; Kaminsky 2016) are identified in the following sections. It is important to note that cultural values play a duel role in the development of wind power because they influence not only the public policy and demand, but also the acceptance of specific projects. In this exploratory study, we study trends at the national level, while in Chapter 4 we will look into trends related to the acceptance of specific projects.

3.3 Background

In order to rapidly slow climate change, nations must begin to transition to renewable systems. Many countries have already started. In 2016, renewable electricity production grew to 2,016GW with over half being produced by hydropower, followed by wind at 24% (Beiter et al. 2017). To help the world transition, Jacobson *et al.* (2017) released the Solutions Project, a road map for how 139 countries could produce 100% of their energy needs from renewable energy. The Solutions Project finds that 11,800 GW of renewable electricity is needed with 24% onshore wind and 14% offshore wind as the largest contributor to this transition (Jacobson

et al. 2017). Electricity production from wind and solar resources has developed immensely in the past decade and has become cost competitive in many parts of the world. Still, these technologies are limited physically by electric grid infrastructure and administratively by human perspectives on how and where electricity should be produced. This research addresses this latter factor. As such, we structured this literature review using the Cherp *et al.* (2018) framework. Cherp *et al.* (2018) argues that national energy transitions are dependent on three co-evolving perspectives: (1) techno-economic perspective, (2) socio-technical perspective, and (3) political perspective. First, the techno-economic perspective focuses on the raw energy resources that are available and the production of electricity for consumers. Second, the socio-technical perspective focuses on the technology that is converting that energy into electricity. Third, the political perspective focuses on energy policies and institutional structure. Finally, we discuss the literature on culture and energy before discussing the method used in the present study.

3.3.1 *Techno-Economic*

The techno-economic perspective highlights that the success of renewable energy technologies is location dependent. Quality resources must be available in order to convert the renewable energy to electricity in a cost-effective manner (Cherp et al. 2018). Furthermore, traditional electricity markets are set up to buy and sell large amounts of power from centralized sources of power on demand (Negro et al. 2012). However, without the support of batteries, wind and solar technologies can only create electricity when wind or sun is available. Thus, most renewable energy technologies do not integrate well with the electrical gird as it is currently designed and operated because they cannot provide consistent electricity on demand (i.e. they are variable non-dispatchable sources). The notable exception to this is hydroelectric generation, which is not considered an emerging renewable energy technology as it has been a form of electricity generation for centuries. Therefore, new renewable energies create more variability and less predictability within the energy market, potentially, creating a less stable energy market.

To define the impact of the market on renewable energy transitions, several recent studies found that wind power development has been shown to not be directly related to wind resources nor fully explainable by varying market structures nor the incumbent market (Gosens et al.

2017; Gosens 2017; Jenner et al. 2013). The Gosens *et al.* (2017) study on the effect of renewable resource of deployment of solar and wind. They found that the domestic market for renewable electricity creates a positive feedback loop for continued development and that the distribution of the other energy resources did not have a significant influence on the renewable market share. In a survey of developer preferences, one study found that instead the market was shaped by existing policies related to the administrative process, legal security, and grid access and recommended that for market growth policy makers should focus on risk minimization in those areas (Lüthi and Prässler 2011).

3.3.2 *Socio-Technical*

Within the socio-technical perspective, renewable energy technologies face problems in that they are up against the existing energy infrastructure, which is primarily made up of combustion fossil fuel plants (Cherp et al. 2018; Jacobsson and Johnson 2000). Jacobsson and Johnson (2000) argue that in order for new renewable energy technologies to enter a national energy market they need energy actors to not only know the technology, but also the actors must have the right network and institutions of support in order for any renewable energy development to be successful. Legitimacy becomes essential for these actors gain social acceptance because legitimacy allows developers to use resources to create demand and create political strength (Negro et al. 2012). While much of the research literature has focused on the creation of legitimacy or legitimation during the formation of the renewable energy technologies (Bergek et al. 2008b), legitimation is defined as *"a matter of social acceptance and compliance within relevant institutions"* (Bergek et al. 2008a p. 416) and is thus of particular relevance when new technologies are being expanded to a large scale. A notable exception is a study of the nuclear industry in the Netherlands. Geels and Verhees proposed that cultural legitimacy (also referred to as social acceptance) of new technologies is created through successful framing of issues during social movements. As a way of collective sense making, frames that were culturally legitimate created an emergent discourse or general way of thinking about a technology, which contested the dominant discourse (Benford and Snow 2000; Bergek et al. 2008; Geels and Verhees 2011; Köhler et al. 2019). Nevertheless all discourses are based in the cultural repertories of the society in which they are developed. Therefore, both frames and discourses are developed by a similar cognitive structure within a

society. Study of the cultural-cognitive structure rather than legitimacy created out of it, is discussed in Section 3.3.4.

The definition of social acceptance varies depending on the level of application because stakeholders as well as risks change depending on scale (Upham et al. 2015). In fact, Fournis and Fortin (2015) argue that social acceptability of wind energy should be viewed a continuous scale with varying levels of analysis (local, national, and international). For example, the acceptance of wind energy as a reliable technology to produce electricity is drastically different than acceptance of a wind project in a community. General national acceptance of an energy technology implies that it has the potential to improve how energy is produced, but it does not mean that all projects with that technology are acceptable. On the other hand, national acceptance of energy technologies (i.e. renewable energy targets) affects specific wind project sites because general acceptance of wind technology allows for market acceptance, legitimacy, and political support, as previously discussed. Nevertheless, site-specific acceptance allows infrastructure to actually be built. Therefore, many scholars see social acceptance as both a socio-technical issue and a political issue.

3.3.3 *Political*

The political perspective takes into account that energy policy is influenced by the available institutions, the structure of the government, and the influence of other nations (Cherp et al. 2018). An important prerequisite to public policy is the state of techno-economic and socio-technical perspective. In other words, if the technology has a proven ability to create power and revenue, and it has gained support of the public, then policies in support of the technology tend to follow. Interestingly, research on energy policies have yet to find policy mix that is transferable to other contexts. In a study of thirteen different countries, Sovacool (2009) found thirty different policy mechanisms that have or should be used to enable renewable electricity development. Each of these mechanisms take on different forms depending on the country and energy market. The four most popular mechanisms were the elimination of subsidies for conventional or mature technologies, the creation of representative electricity prices, the creation of a national feed-in tariff, and finally establishment of a national systems benefit charge to educate the public (Sovacool 2009). Furthermore, Sovacool argues these mechanisms cannot be expected to succeed independently; these policies work in conjunction

with one another to create a favorable environment for renewable electricity and energy efficiency.

In a quantitative analysis of the impact of policies on the development of renewable energy instalments, Gosens (2017) attempted to study the effects on policy on solar and wind installation as well as market growth (Gosens et al. 2017) but was prohibited from drawing any conclusions due to the lack of quality policy data. These studies tested the cumulative number of policies related to renewable electricity within a country against installation and market growth rates in a random effects panel data analysis and found little to no effect. Cumulative number of policies is a poor way of operationalizing policies; however, due to the desire to study trends at a global level, it was the only reasonable method (Gosens et al. 2017; Gosens 2017). A study of 26 European Union countries focused more specifically on feed-in tariffs was able to create a more comprehensive indicator of FIT policies. (Jenner et al. 2013). Using the effect of the FIT policy on return on investment, they found significant relationships between policy design, market context, and the deployment of solar photovoltaic installations. For wind power development, the policies were not found to be as impactful since particularly onshore wind is a relatively mature technology with high return on investments even without policy incentives (Jenner et al. 2013).

3.3.4 *Culture*

Culture impacts policy and social understandings (Burstein 1991), and it is a vital component that is underrepresented in sustainability research. Commonly culture is studied indirectly through a comparison of different countries. For example in a multi-national European study, Toke *et al.* (2008) demonstrates that economic, social, and political mechanisms are inter-connected, and the correct combination of economic, social, and political mechanisms is essential to the success of wind installations is a country. In Denmark, Germany, and Spain, stable financial systems allowed for serious investment in wind energy. In Denmark and Germany grass-roots support also supported the development of wind power while in Spain lack of interest in landscapes allowed for the development of wind. Conversely, in the United Kingdom (England and Scotland) and the Netherlands, unstable financing schemes reduced investment. In the UK, specifically, strong opposition from a landscape preservationists limited wind development (Toke et al. 2008); however, more recently United

Kingdom has become a leader in the development of offshore wind energy (Higgins and Foley 2014).

Beyond case study comparisons of countries, structured frameworks defining and measuring culture are common (Hofstede 2001; House et al. 2004; Schwartz 1999). Within the engineering literature, the most common representation of culture is Hofestede's national cultural dimensions. These six dimensions were created from a multinational survey and quantitatively rank nations on different values and beliefs. Related to renewable energy technologies, Hofstede's dimensions have been shown to influence not only the diffusion of renewable energy (Kaminsky 2016), but also the acceptance of carbon capture and storage systems (Karimi et al. 2016). Hofstede's dimension of uncertainty avoidance was directly correlated with higher risk perceptions (lower acceptance) of carbon capture and storage, but was inversely correlated with higher proportions of installed renewable energy. While this may seem contradictory, renewable energy technology changes across scales (Fournis and Fortin 2017). In general, renewable energy offers an avenue for diverse, domestic electricity with less uncertainty; however, for specific technology or project, there is still uncertainty in performance and impact. While this may explain some of the discrepancies, many researchers have also documented some of the serious limitations to Hofstede's dimensions (Baskerville 2003; McSweeney 2002), questioning both his methodology and the extent to which his results can be generalized.

Therefore, in a previous study (Allison et al. In Preparation), we used an inductive big data approach to discover five new cultural dimensions based on the World Values Survey, a nationally representative survey covering 60 countries. This approach is drastically different than previous cultural models, including Hofstede's models, because the latent dimensions were discovered using multidimensional item response functions which analyses responses by country and creates a scale which is equal across all the countries. In addition, it uses statistically representative samples and accounts for response distribution within countries rather than relying on means. The GLOBE study is the only previous study to attempt using this method for cross-cultural comparison (House et al. 2004) and thanks to recent advancements in computing capabilities, we were able to analyze a much larger and more diverse set of questions than was possible in earlier work. This new national cultural model

contains five cultural dimensions representing (1) Religiosity, (2) Neutrality, (3) Fairness, (4) Skepticism, and (5) Uncertainty Tolerance. Each dimension is measured on a quantitative scale, giving each country a score for each dimension. Religiosity estimates the extent to which a country is devoted to religious customs. Neutrality assesses the value placed in engagement in organizations. Fairness evaluates the value placed in equal and equitable actions. Skepticism measures a lack of confidence in institutions. Finally, Uncertainty Tolerance estimates the extent to which people accept risks and ambiguity.

3.4 APPROACH

In this study, we focus on wind energy because it is a major contributor to the global renewable energy portfolio and is developed to the point where most installations are utility scale. In several recent studies, wind power development is not fully explainable by wind resources or by varying market structures (Gosens 2017; Gosens et al. 2017; Jenner et al. 2013; Toke et al. 2008). Therefore, we explore how culture impacts the development of wind resources by creating an statistical model relating our cultural dimensions to the amount electricity generated by wind energy technologies within a country.

3.4.1 *Data*

In our regression, we included several control variables in addition to the dependent and independent variables. The dependent variable, named *Wind Capacity*, is a percentage of electrical generation capacity from wind energy. In 2014, the Energy Information Administration (EIA) collected wind electricity capacity and generation data for 228 countries in kilowatts and kilowatt-hours, respectively (EIA 2018a). *Wind Capacity* ranges from 0.007 to 21.6%, representing the electrical capacity from wind energy over the total electricity capacity for a given country. Both were measured by the EIA in millions of kilowatts. Figure 1 below shows the absolute wind capacity. For example, China produces 96 million kilowatts, which is approximately 7% of the total electrical capacity of 1376 million kilowatts in 2017 (EIA 2018b). In this study, the dependent variable, wind capacity installed includes both onshore and offshore wind capacity. While onshore wind currently makes up the majority of installations in many countries, it is a rapidly growing market with 4.49 GW installed in 2018

(0.8% of global wind capacity) (GWEC 2019). Offshore wind differs from onshore wind development in that there are still technological challenges to create affordable power, due to the harsh marine environment and transmission of electricity back to land. Furthermore, offshore wind turbines can be places far enough away from the general population to reduce visual impacts (Fishman and Graedel 2019; Kaldellis et al. 2016; Rodrigues et al. 2015).

Our independent variables are the five cultural dimensions discovered in our previous study along with a series of control variables. The discovered cultural dimensions were derived from questions in Wave 6 of the World Values Survey (WVS). Wave 6 was distributed to approximately ninety thousand people in 60 countries from 2010 to 2014 (WVS 2016). Using a multidimensional item response function to perform an exploratory and confirmatory factor analysis, the responses from the WVS were condensed into five cultural dimensions: (1) Religiosity, (2) Neutrality, (3) Fairness, (4) Skepticism, and (5) Uncertainty Tolerance. This range for all five cultural dimensions is show in Figure 3.2.

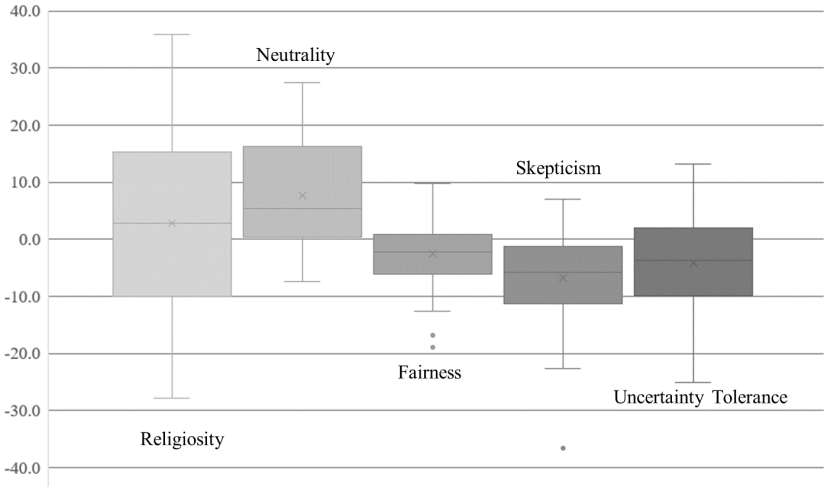

Figure 3.1. Distribution of Country Scores on Cultural Dimensions

As seen in Table 3.1, the regression contained several control variables. First, quality wind resource was estimated based wind resources between wind class c3 to c9 as created by the National Renewable Energy Lab. Assuming a 90 meter hub height and a 5MW/km^2 turbine density, an three wind resource variables were developed by aggregating wind class groups (c1-c3, c4-c6, c7-c9). The capacity factor (CF) for each range of wind classes are listed in Table 3.1. All wind resources are within 50 miles of a load onshore and within 20 nautical

miles and less than 60 meters in depth for offshore (NREL 2013). Quality wind resource has more predictive power for wind development than the total wind resource due to the improved economic potential of quality wind resources (Gosens 2017).

Development of wind energy also requires a robust and reliable grid infrastructure to transmit the electricity. In fact, the cost of transmission and distribution is a significant part of the cost of the electricity to the consumer. Unfortunately, the levelised cost of electricity varies from project to project depending on the specific location of the project; therefore, we unable to provide a control variable for grid access and future research should consider developing and adding this variable to the regression. We considered using percent of the population with access to electricity to represent the expanse of the grid network (World Bank 2014); however, in many countries the majority of the dense urban areas have electricity while the rural areas, where wind development in more likely does not. Finally, the choice to development wind power also relies on available capital, represented by Gross Domestic Product (GDP) and the energy market, represented by the percentage of the energy market producing electricity from oil, natural gas, and coal resources (ElecFF). The percentage of employment in agriculture (AgEm) is used to control for amount of people dependent on the natural resources for their livelihood (World Bank 2014). We choose not to include total electricity consumption because it is collinear with the electricity capacity, which was used to calculate the dependent variable. Gross domestic product per capita (GDPP) and electricity use per capita (EPC) are significantly correlated (0.86). Therefore, we choose only to include GDPP because previous studies have established the connections between personal wealth and values (Inglehart 2005).

Table 3.1. Control Variables

Control Variables	**Control For**
Wind Resource c1-c3 (WRc1c3)	Wind Class c1-c3 (CF: 0-0.26)
Wind Resource c4-c6 (WRc4c6)	Wind Class c4-c6 (CF: 0.26-0.38)
Wind Resource c7-c9 (WRc7c9)	Wind Class c7-c9 (CF: 0.38-1)
GDP	Wealth
Electricity from Fossil Fuels	Energy Market
Employment in Agriculture	Dependence on natural resources

3.4.2 *Data Analysis*

In this section, we step through the creation of our exploratory regression model. This model is not predictive; it was only built to explore the relationships between culture and infrastructure systems. Furthermore, the authors do not believe that nations are culturally homogeneous; however, for this study, nations are the common unit of analysis and offer a platform for understanding global trends. Currently, wind electricity capacity and generation data is limited to a national scale; and therefore, the relationships discovered are applicable only at the national level and cannot be assumed to describe every project within a country (Piantadosi et al. 1988).

Of the 56 countries for which we have cultural values, 20 countries have no installed wind capacity. In a binary logistic regression, GDP and WRc4c6, as defined above, were significant predictors of the likelihood of installed wind capacity within a country, meaning that installed wind development depends on the availability of wind resources above c4. There are 14 countries in our sample, which do not have onshore or offshore winds above wind class 4 in our data set. We removed 12 of these countries from our data set because they also did not have any wind installed; however, the remaining two countries, Cyprus and Romania, have wind capacity installed. Therefore, we retained these two countries in the analysis. We choose not retain all the countries in the analysis because the dependent variable would have contained 20 countries with zero installed wind capacity. Zero-inflated and hurdle models are not practical for this analysis due to the limited size of our sample and high number of independent variables. Therefore, the final data set contains 42 countries of which seven have wind resources about class c4 but have not developed wind energy facilities. Figure 3.2 below shows that the 42 countries included in the regression analysis.

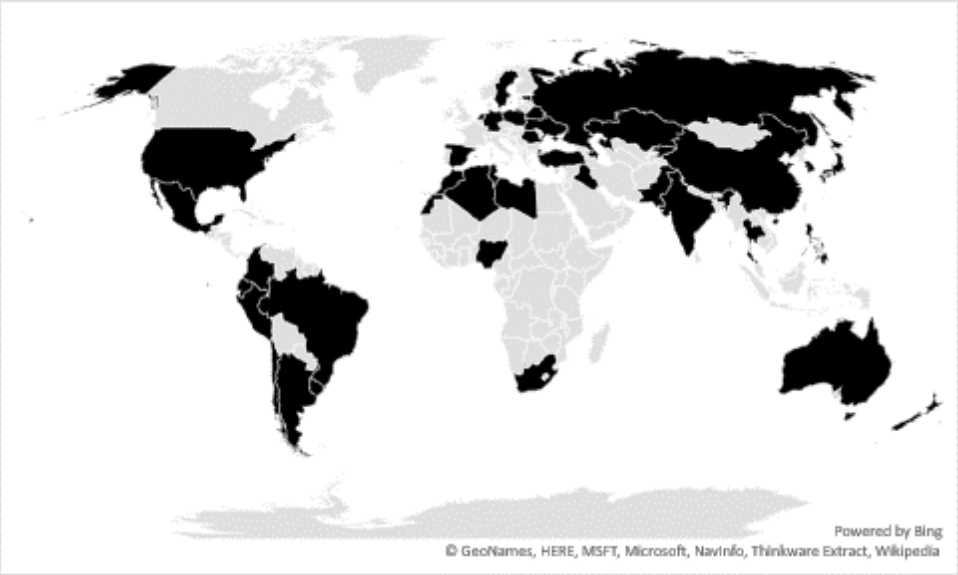

Figure 3.2. Countries Included in Study (n=42)

The final regression therefore had 11 predictor variables (five cultural variables and six control variables). GDP and GDPP were log transformed to reduce skew in the variables and were found to be collinear; therefore considering that the dependent variable is already a proportion GDP was removed from the analysis. The five cultural variables are abbreviated as follows: Religiosity (REG), Neutrality (NEU), Fairness (FAIR), Skepticism (SKEP), and Uncertainty Tolerance (UT).

$$lm(formula = (Wind\ Capacity\ Proportion) \sim REG + NEU + FAIR + SKEP + UT + log10(WRc4c6 + 1) + log10(WRc7c9 + 1) + AgEm + ElecFF) \quad (3.4)$$

In a linear regression analysis, each predictor has one coefficient, and there is one intercept. Unfortunately, multivariate linear regression models are susceptible to over fit, particularly when the predictor variables are correlated, and there are a limited number of observations, as is the case in this study. In order to reduce to the likelihood of over fit, unnecessary predictor variables were removed from the analysis using the Least Absolute Shrinkage Selector Operator (LASSO) regression (Agresti and Finlay 1997; Ribbing et al. 2007). The LASSO regression analyses all the variables at the same time and penalizes the residual sum of squares. Only variables with non-zero coefficients are retained (James et al. 2013). The LASSO regression was run in R using *glmnet*, and the tuning parameter was set to the lambda value that creates the minimum mean cross-validated error (Friedman et al. 2010). Model selection

procedures alter the traditional statistical inference parameters because instead of testing a single null hypothesis; the variables are selected because they contribute to better model fit (Berk et al. 2010; Taylor and Tibshirani 2015). While there are some selectiveInference programs available (Ryan Tibshirani et al. 2017), we believe that the best approach would be to expand the dataset and validate the relationship with the additional data. Therefore, we present only the values of the non-zero coefficients.

3.5 RESULTS

The LASSO regression reduced the variables in our model to four predictor variables, as seen in Equation 3.5 and the coefficients can be seen in Table 3.2.

$$lm(formula = (Wind\ Capacity\ Proportion) \sim \text{REG} + FAIR + UT + ElecFF \quad (3.5)$$

Table 3.2. LASSO Regression Results

Variable	**Estimate**
(Intercept)	-2.17
Religiosity	-0.02
Fairness	0.14
Uncertainty Tolerance	0.17
ElecFF	-0.02

The results show that Fairness and Uncertainty Tolerance had similar influences on the percent of wind installed, while Religiosity had a small inverse relationship with the dependent variable. The discussion focuses on the implications of the three significant cultural variables.

Only of the control variables were retained as non-zero coefficients. The percentage of electricity from coal, oil, and natural gas (EleFF) has small effects of the percentage of installed wind capacity within a country. High percentages of ElecFF indicate that the electricity market is dominated by fossil fuels and suggests that energy regimes are impacting the development of wind energy (Bergek et al. 2008). GDP did not retain a non-zero coefficient in the relationship because the dependent variable is a proportion of the total electrical capacity of a country. If the nominal amount of wind capacity in a country is placed in a linear regression, GDP retains a non-zero coefficient due to large investments of time, resources, and finances for utility scale wind farms (Sovacool et al. 2017); however, the resulting model has poor fit.

3.6 DISCUSSION

This analysis used a subset of 42 countries to understand which cultural values influence the extent to which wind has been accepted within a country. With the limited data set, we do not focus on the magnitude of the relationships; instead, we focus on the directionality. It is worth noting that our goal is not to change cultural values to be more accepting of wind; rather it is to start the discussion about how wind developments can be adapted to be successful in different cultural environments. Therefore, in this section we provide suggestions about how wind developers can approach different cultural situations.

3.6.1 *Religiosity*

Religion is a social institution that offers members both moral codes and worldviews; it is broken down into many different types of religious groups and beliefs. Religiosity as a cultural dimension does not privilege any of these types over another; it merely reflects respondents' reported strength of religious adherence. Religious groups often have substantial amounts of social influence, which often is focused on being respectful and kind to others, particularly the hungry and poor. The regression shows an inverse relationship between Religiosity and percentage of wind installed. In other words, the data show that countries with weaker religious ties have been more successful at installing wind energy projects, while countries with higher typical levels of faith have lower levels of wind installed. This suggests common ways of framing and promoting wind projects – for example, environmental protection or economic benefits - have tended not to resonate with religious values. Previous research has explored the relationship of environmental and economic values with religion; however, they contain limited discussion and mixed results on the mechanisms by which religious values impact attitudes and more importantly actions related to energy development (Barker and Carman 2000; Biel and Nilsson 2005; Greeley 1993; Keely 2003). Indeed, existing climate change research suggests that two of the reasons that climate initiatives fail are (1) because of the relationships between climate destruction and the end of times and (2) because they fail to motivate religious congregations into action (Clingerman and O'Brien 2014; Haluza-DeLay 2014).

Nevertheless, as a prominent community group, religious congregations have considerable ability to influence policy (Fairbanks 1977). As such, policy makers and wind developers looking to establish new markets should consider the religious affiliations of different areas and attempt to establish positive relationships. For example, connections with local religious leaders or venues may help wind projects achieve public legitimacy and avoid protest. Especially in contexts with high Religiosity scores, our research suggests that outreach efforts that link wind energy to local religious priorities and framings would be well received. Of course, it is needless to say that this work is best done in good faith and in collaboration with local religious leaders. In addition, even contexts with lower Religiosity scores are likely to have important and deeply religious subsets of the community that would be more easily reached if the benefits of wind energy were explained as relevant to locally important religious values. Finally, it is worth noting that the coefficients of the Religiosity dimension are an order of magnitude smaller than the other two cultural dimensions. While the statistical model was not intended to be predictive, this does suggest that Fairness and Uncertainty Tolerance – as described below – are more important to wind energy development.

3.6.2 *Fairness*

The Fairness dimension measures the acceptance and importance of cooperative behaviors that avoid inequitable impacts (Allison et al. In Preparation). Our analysis shows a direct relationship between Fairness and *Wind Capacity*. In other words, in countries with high Fairness scores, wind energy projects have been more successful. We propose two reasons why Fairness may support wind energy projects. First, in countries with high Fairness scores, wind energy projects may often be perceived as equitable and democratic (Winner 1980). Second, people in countries with high Fairness scores may believe that new technologies should be given the opportunity to enter the energy market rather than maintaining the status quo of privileged, established technologies. These ideas are discussed below, but we note that future research should investigate these and other competing explanations of the statistically observed relationships.

Wind energy projects have the potential to prevent inequitable impacts at varying scales. For example, wind energy projects produces power without greenhouse gas emissions, benefiting not only the global climate (Buonocore et al. 2016) but also the local air quality

(Millstein et al. 2017). Both climate change and poor air quality impact disadvantaged populations disproportionately, and are thereby inherently unfair (Shi et al. 2016; Tessum et al. 2019). In addition, wind power projects can revive or inspire new and different economic development, particularly in rural areas where farms are struggling (Munday et al. 2011; Slattery et al. 2011). In countries with high Fairness scores, both of these perspectives could be used to justify wind farm impacts (Corvellec 2007). Supporting this interpretation, Hofstede's Power Distance Index (PDI) is significantly ($p<0.05$) associated with Fairness (Allison et al. In Preparation). PDI measures the extent to which a society accepts unequal power distributions or hierarchies (Hofstede 2001). Unfortunately, past research that used Hofstede's dimensions to explore the global diffusion of renewable electricity was not able to consider PDI due to collinearities (Kaminsky 2016). Still, the correlation between Fairness and PDI implies that societies with high Fairness scores also tend to prefer less hierarchical societal structures and a higher acceptance may therefore be more accepting of decentralized wind energy projects.

Fairness may also support wind development through the opportunity for innovations to enter the market. In high Fairness contexts, people may perceive it to be unfair to prevent new technologies from entering the energy market, a common problem for renewable energy technology systems (Bergek et al. 2008; Cherp et al. 2018). In other words, countries with high Fairness scores may be more accepting of innovation and new technologies, including wind energy. While further research is needed, we note that these opportunities are enabled through countries' regulatory systems. Our data does not represent the mechanisms within the regulatory systems; however, previous literature does suggest that infrastructure permitting regimes are culturally influenced (Kaminsky 2019). More research should consider how best to operationalize these framings, which we would expect to be particularly effective in high Fairness contexts. In low Fairness contexts, these framings of wind energy projects would typically be less effective with the public and decision makers. In these contexts, wind advocates should consider the other strategies as discussed in the next section.

3.6.3 *Uncertainty Tolerance*

Uncertainty Tolerance measures a lack of worrying about, or an acceptance of, ambiguities and risks that threaten societies. Our analysis shows that countries with higher Uncertainty

Tolerance scores tend to have more wind energy installed. Broadly, this means that contexts with higher Uncertainty Tolerance scores have tended to be more accepting of wind projects. In these contexts, exploration of innovative policy structures, turbines, or storage technologies would likely be more acceptable. This makes sense, as wind energy is a relatively new technology in most contexts and would therefore be perceived as more uncertain or risky. For example, wind farms are dependent on weather patterns for revenue (Gatzert and Kosub 2016), and must be managed differently than fossil fuels if they are to provide reliable electricity. This relationship agrees with diffusion theory since it implies that countries which have adopted higher amounts of wind energy are more tolerant of the uncertainties related to changes like the shift to wind energy (Rogers 2003).

A previous study considering culture and renewable energy found significant relationships between Hofstede's Uncertainty Avoidance Index (UAI), Individualism (IDV), Masculinity (MAS) and the diffusion of renewable energy. High Uncertainty Avoidance, high Individualism, and low Masculinity all drive renewable energy diffusion (Kaminsky 2016). However, this study did not analyze wind energy in isolation. Despite the similarity in name, there is no significant correlation between UAI and our Uncertainty Tolerance dimension. In contrast, IDV is directly correlated with Uncertainty Tolerance and is associated with more renewable energy installments (Kaminsky 2016). IDV is defined by Hofstede as the preference for a loosely knit social framework wherein people are more self-reliant (Hofstede 2001). The decentralized nature of wind energy enables the independent, more local control (Kaminsky 2016), which may in turn increase uncertainty in reliability and supply. MAS is indirectly correlated with both renewable energy (Kaminsky 2016) and Uncertainty Tolerance. Low MAS scores indicate a empathic preferences and has been found to associate with innovation (Rogers 2003). This past work supports our proposed interpretations of the relationships between Uncertainty Tolerance, innovations in general, and wind energy in particular. Still, more research is needed to understand the relationship between these cultural dimensions and their influence on wind energy development.

Uncertainty Tolerance may be a key leverage point for wind developers and advocates, as some uncertainty and risk metrics can be controlled through project design. Nevertheless, it is virtually always preferable to reduce risk in energy supply, even in societies with high

Uncertainty Tolerance. Developers should be try to reduce uncertainty whenever possible. Still, this is particularly true in low Uncertainty Tolerance contexts, where many wind energy projects may otherwise be considered unacceptably risky. Therefore, future research should explore what uncertainties people are most concerned with and how those concerns function to impact acceptance and installation of wind energy projects. There is a considerable amount of research related to how people perceive risk related to energy development, particularly nuclear energy development (Renn 2008; Taylor et al. 2012; Whitfield et al. 2009). However, there is considerably less research that considers the perceived risks of wind energy projects or how these perceived risks vary with cultural values (Renn and Rohrmann 2000). In addition to thoughtful risk communication (Renn 2008), methods for reducing uncertainty around wind energy projects can include pilot projects, detailed analyses around the benefits and impacts of a potential wind farms, and the presentation of benefits and impacts from other projects around the world.

3.7 CONCLUSION

At the start of this paper, we claimed how each country must transition its energy system towards renewable energy. However, without any true global governance, it is a unique decision of each nation on how and when it will transition (Sovacool 2016). National renewable energy goals and international agreements to reduce greenhouse gas emissions have inspired countries to speed up this transaction. Some countries (notably Denmark and Iceland) have been successful at transitioning to primarily renewables, while many other countries still have a long way to go. Previous research has explored the Techno-Economic, Socio-Technical, and Political impacts to wind energy and other renewable energy extensively through case studies and regional comparisons. In this article, we suggested and explored how quantitative cultural dimensions provide insight into the quantitatively difficult to measure social and political influences within a country.

Our study focused particularly on wind energy due to the advanced, stable technology and its widespread utility scale implementation. In this study, we present a resource for wind developers and energy policy makers to understand how values play into the development of wind energy at the national level. Religiosity was found to have a small but significant indirect

relationship suggesting that the current development practices of wind projects align better in countries with low Religiosity scores and that future development should consider how to meet the needs of more Religious populations. Fairness and Uncertainty Tolerance were found to have stronger direct impacts on the development of wind energy. For example, we saw that Fairness plays a significant role in wind development in that it may influence the rules guiding wind development. Therefore, a decentralized structure may be more successful. In addition, the smaller scale will allow more flexibility to values beyond Fairness. Similarity the decentralized nature of wind energy likely will increase uncertainty and therefore will be more successful in countries with high Uncertainty Tolerance. Therefore, in countries with lower Uncertainty Tolerance thoughtful risk communication is likely to support future wind development. While undoubtedly there are other factors at play in the transition to wind power, this study confirms culture also plays a significant role. The results of this study contribute to the nexus of social and technical knowledge so that we can make informed choices about energy transitions. Future research should build on these findings by adding additional countries to the model as well as by investigating wind development within culturally diverse contexts.

3.8 REFERENCES

Please see the last chapter for references for the entire document

Chapter 4. A CROSS-CULTURAL COMPARISON OF WIND ENERGY DEVELOPMENT IN THE UNITED STATES AND SWEDEN

Abstract

Wind power is a key tool in the fight against climate change; however, the development of wind power has been sporadic. In a recent study at the national level, three cultural values (Religiosity, Fairness and Uncertainty Tolerance) were found to significantly impact the development of wind energy at the national level. This study builds on this previous work by presenting a national analysis to gain a better understand of how culture affects the development of onshore wind projects through a comparison of Sweden and the United States. Both countries have mature wind markets, but considerably different scores for Religiosity and Uncertainty Tolerance but similar scores for Fairness. Twenty-one developers from Sweden and the United States were interviewed. The interviews were qualitatively analyzed using social acceptance as theoretical framework. Social acceptance includes the planning, market, and siting of a wind project. The analysis showed differences in Uncertainty Tolerance in both planning and siting. In Sweden, high Uncertainty Tolerance is visible through planning policies such as the municipal veto, whereas in the United States, lower Uncertainty Tolerance is observed through zoning ordinances. The United States and Sweden have similar Fairness scores, which are visible through the inclusion of public participation in planning polices, and the use of compromises with stakeholders during project siting. Practically, these findings help developers understand the importance of the cultural context that they are operating within and help them better meet the needs of communities during wind development.

Keywords: Social Acceptance, Culture, Fairness, Uncertainty Tolerance, Wind, Energy Transitions

4.1 INTRODUCTION

World leaders recognize that fighting climate change means an immediate shift in how we produce electricity. Nevertheless, sustainable development takes careful planning and valuable time (Kasperson 2017). Accordingly, countries across the globe are slowly making the transition. Extensive literature has been published about the various policies which support (e.g. feed in tariffs and certificate programs) and challenge (e.g. existing fossil fuel monopolies and land use change) renewable energy transitions. However, today's energy transition will require more changes in land use than any other form of development (Trainor et al. 2016), spurring countless local siting discussions and debates. Many studies have emphasized the importance of social acceptance in the development of renewable energy (Enevoldsen and Sovacool 2016; Fournis and Fortin 2017; Wüstenhagen et al. 2007); however, international comparisons lack of analysis of cultural differences. Two recent studies have established that cultural values play a significant role in renewable energy development, more specifically wind energy development (Allison and Kaminsky In Preparation; Kaminsky 2016). However, the mechanisms by which cultural values impact renewable energy development remain unknown. Therefore, the goal of the project is understand how cultural values impact wind farm development in different national cultures.

We specifically hope to answer the question ***How do the cultural values of Religiosity, Fairness and Uncertainty Tolerance impact the development of utility scale wind projects in the United States and Sweden?*** In a previous study, Religiosity, Fairness and Uncertainty Tolerance were identified as significant cultural variables in the development of wind energy (Allison and Kaminsky In Preparation). Sweden holds the highest Uncertainty Tolerance score of the 56 countries measured and the lowest Religiosity score, but has similar Fairness scores to the United States. Furthermore, both countries are leaders in policy and market development for the wind industry. For example, Sweden established a successful Tradable Green Certificate program with mandatory quotas in 2003 and produces 10% of the electricity from wind, (IEA 2016; Wang 2006). The United States started the Production Tax Credit in 1992 and produces about 6% of its electricity comes from wind (Barradale 2010; EIA 2018c). Therefore, the United States and Sweden offer cultural similarities and differences that will be useful in understanding how Religiosity, Uncertainty Tolerance and Fairness affect the social

acceptance of wind energy. In the following sections, we introduce our analytic framework of social acceptance theory, as well as review the previous studies on the influences of culture in renewable energy development.

4.2 BACKGROUND

Social acceptance was first defined as the combination and interaction of three levels: socio-political (e.g. zoning or permitting regulation), market (e.g. financial incentives and green certificate programs), and community (e.g. participation during siting and distribution of impacts) (Wüstenhagen et al. 2007). Unfortunately over the years, the term social acceptance is often confused with public acceptance (Wolsink 2018). Therefore, a second group of scholars uses legitimacy to describe the approval of a particular technology in conjunction with different system and actor level variables (Bergek et al. 2008). The system level variables are easily divided into politics and economics, making the framework particularly useful for considering the level of analysis between the different arenas of acceptance (Mignon and Bergek 2016). Both frameworks refer to the importance of culture without much explanation of how culture affects acceptance, perhaps due to the complexity associated with measuring and comparing different cultures. Culture has been defined and measured in many ways over the years, and only a limited group of studies attempt to explain culture's potential impact of renewable energy development (Allison and Kaminsky In Preparation; Geels and Verhees 2011; Kaminsky 2016). None of the existing literature on energy transitions use social acceptance theory to understand cross-cultural differences. In this study, we fill this gap by operationalizing the social acceptance framework to study the impacts of cultural dimensions on wind energy development as seen in Table 4.1. In this analysis, we differentiate between planning, which is applied to multiple wind projects within a region or nation and siting which is related to the strategies used to successfully build a particular project.

Table 4.1. Social Acceptance Framework

Previous Components	**Operationalized Components**
Market	Market Conditions (Economic Policies & Demand)
Socio-Political	Planning Policies (Non-Economic & Land Use Policy)
Community	Project Siting (Unique Project Location)

4.2.1 *Market*

The market perspective includes both demand for green electricity from consumers and investors as well as the configuration in which supply and demand are created. It is important to note that the separation between the physical supply and demand of electricity has created a conflict during the siting of wind projects. General demand for green electricity does not always mean support for particular projects (Wolsink 2000; Wüstenhagen et al. 2007); however, Toke describes effective demand creation and construction for green electricity through grass roots movements (Toke et al. 2008). As the market is considered the broad supply and demand for a product, we follow previous literature and separate a general demand for wind power from the specific conflicts that arise during siting. In order to gain demand for wind energy, the focus should be on what the customers' needs or desires from the innovation, not on the great benefits of the innovation in general (Dunphy and Herbig 1995; Rogers 2003). Wind energy developers have a particularly challenging situation because the vast majority of people in the United States and Sweden already have electricity. This makes it more difficult to create relative advantage, and so it is common for developers to instead argue about the climate benefits or the negligible local impacts (Corvellec 2007; Corvellec and Boholm 2008).

Demand for green electricity from investors is largely dependent on policies, which regulate the electrical grid distributing the electricity. Energy policies and governance has been extensively studied and shown remarkably difference results depending on the national context (Carley 2009; Florini and Sovacool 2009; Jacobsson et al. 2009; Jenner et al. 2013; Nelson et al. 2015; Sovacool 2009). Both feed-in-tariffs and mandatory green certification programs have shown to be particularly effective. However, arguably more important is simply clear and consistent policy (Gan et al. 2007; González and Lacal-Arántegui 2016). Similar to the planning mechanisms, energy markets vary drastically depending on the country and region. Table 4.2 compares the United States and Swedish Electricity Markets.

4.2.2 *Planning*

In wind energy development, planning primarily refers to land use planning (Nadaï 2007). Fiscal policies influence both supply and demand and are therefore included in the market conditions. Unlike fossil fuel facilities, renewable energy facilities are limited to areas where

there is a resource available; therefore, the development of renewable energy facilities sometimes surprises or challenges existing land-use policies. Furthermore, wind facilities require large amounts of area, creating visual and habitat impacts (Kiesecker et al. 2011; Trainor et al. 2016). To avoid controversy during the siting of wind farms, most jurisdictions create land use policies and permitting requirements, which help the community and the developer understand the requirements for siting a project in the jurisdiction. Land use policies will decide not only who and what is involved, but also who will make the final decision about the proposed project and how costs and benefits should be distributed (Agterbosch et al. 2009; Aitken 2009; Nadaï and van der Horst 2010). Previous research has largely focused on the influence of the public within the planning system. In particular, most studies focus on the development of opposition during planning (Aitken 2010). A notable exception is Bergek's study of national wind power policy in Sweden. She discovered that the planning initiatives juxtaposed public and private interests such that wind development did not benefit from the national planning initiative. She suggested that for national planning initiatives to be successful, they must create more local incentives (Bergek 2010). Land-use of policies vary widely depending on the country and jurisdiction. Therefore, we have provided some details about land-use policy in Sweden and the United States in Table 4.2.

4.2.3 *Siting*

Siting a wind energy project starts with the developer searching for sites and conducting preliminary investigations into the wind resources, wildlife, existing infrastructure, and policies. It is common during this phase for the developer to speak with the immediate neighbors to get a sense of their attitudes towards wind and to let them know what the developers plans to do on the adjacent property. After selecting a site, developers take on more detailed wind and environmental studies of the area as well as evaluate the permitting requirements. Furthermore, until a permit is granted the financing of investigations and public engagements is supported completely by the developing company. Developers secure investors for construction and operation after the permits have been secured (Cronin et al. 2015).

A large part of the permitting process is the interaction between the developers, the public, and the local authorities. Temporary public exhibitions or open houses are common to show

and talk with people about the proposed project. Similarly, public hearings are often legally required, as are letters to neighboring land owners, and meetings with different community groups (Cronin et al. 2015). At this point, wind developers receive and address comments, formally. To be successful, developers address concerns through engagement with the public and decision makers to reduce overall concerns about the proposed project.

During siting, people who are involved with or have an interest in the project but are outside the authority of the project team are typically called stakeholders (Cleland 1997). Stakeholders are a group of people with varying backgrounds and experiences. They are motivated by different reasons to support, alter, or challenge a project. In wind projects, external stakeholders range from a local birder or hunter to organizations protecting landscapes or rejecting wind in favor of other forms of electricity production. External stakeholders provide consent, influence decision makers, increase fairness, etc. See (Greenwood 2007) for more examples of the varying purposes of stakeholder engagement. Often the most important stakeholder is the one who is making the permitting decisions. In both the United States. and Sweden, locally elected officials tend to review project applications. Elected officials are in office to be the voice of their constituents and to make decisions, which support their constituents' views; unfortunately, it is very difficult to make everyone happy. Elected officials must then make a decision amidst conflict within their own community.

Unlike solar, wind power requires large areas for development (Pasqualetti 2011). Due to the size and height of these wind farms, they pose a serious threat to the aesthetics of the surrounding area, not only in terms of the turbines but also the transmission lines and the supporting roads for construction and maintenance (Pasqualetti 2011). Permitting issues once started are difficult and costly to resolve (Kahn 2000). Therefore, while projects are affected by other higher-level factors (i.e. national policy, market share), the community's attitudes towards the project defines not only the efficiency of the project, but also future projects (Fournis and Fortin 2017; Hall et al. 2015; Kahn 2000; Wüstenhagen et al. 2007). For example, in 2017, a wind developer chose not to involve the tribal community when applying for a permit and did not stop construction even after the permit was revoked. Subsequently, the Osage Nation has a strong stance against future wind developments as a means on maintaining their rights over their land (Dennison 2017).

To increase positive relationships with external stakeholders, it is important for developers to consider that there may be multiple groups within the public with differing opinions and that they are likely hold emotional reasons for support or opposition. Of course, project risk is typically lowered if people voluntarily support a project rather than it being forced upon them (Cronin et al. 2015). Furthermore, the developer's stakeholder engagement strategy will shape the public's expectations (Hall et al. 2015). For example, Walker et al. (2010) explored the importance expectations and how they influence interactions between stakeholders and developers. In the United Kingdom, they found that wind developers generally expected community hostility and would therefore focus on community benefit. On the other hand, the public (as a group and individually) felt overwhelmed (Walker et al. 2010) by arguments related to climate change, dwindling fossil fuels and arguments of no impact (Corvellec 2007; Corvellec and Boholm 2008). Therefore, research has shown that if developers have permeant, local staff at the project site, they can establish long-term relationships, manage expectations, and avoid town hall meetings. Town hall meetings often provide a platform for opposition (Enevoldsen and Sovacool 2016; Hall et al. 2015).

Table 4.2: Social Accpetance Comparison of United States and Sweden

	United States	Sweden
Fuel Mix	• Fossil fuels (63%)[1], • Nuclear (20%)[1], • Hydropower (8%)[1], • Wind (6%)[1]	• Nuclear (40%)[2] • Hydroelectric (40%)[2] • Wind (10%)[2]
Market	Structure: Mixed Regulation • (1978/1992) Utilities are required to allow transmission access to independent power producers to maintain a competitive market. (PURPA/EPAct)[3,4] • (1992) Production Tax Credit allows Wind Energy to be competitive on market[5] • (1999) Regional Transmission Authorities established to ensure competitive grid operation and maintenance (7 systems)[6] • (1983) Renewable Portfolio Standards start to be adopted by states (mix of voluntary or mandatory)[7].	Structure: Liberalized • 1996 – Generation and transmission deregulated[8] • 2003 Green Tradable Certificate Program began with mandatory Quotas implemented[9]
Planning	National Goal: • None National Policies: • National Environmental Policy Act (NEPA)[10] State/Local : • Land Use Policy & Permitting varies by state and/or county. and type of development[10]	National Goals: • 100% Renewable by 2040[11] National Policies: • Areas of National Interest[9] • Planning and Building Act & Environmental Code[9] Local: • Municipal Veto gives municipality final permission authority[12]
Siting	• Scoping required for federal, state, and most local permits[10] • If no permit is required, voluntary environmental investigations done for ESA, BEPA, MBTA[10] • Public acceptance at local level can be avoided in some locations[10]	• Consultation required for all permits[12] • Environmental impacts evaluated by regional authority (County Administrative Board)[12] • Public Acceptance required[12]

1-(EIA 2018c), 2- (IEA 2016), 3- Public Utility Regulatory Policies Act (PURPA) & Energy Policy Act (EPAct), 4- (Gan et al. 2007), 5- (Lantz et al. 2014; Menz and Vachon 2006), 6- (Kury 2015), 7- (Carley 2009; Wiser et al. 2007) , 8- (Amundsen and Bergman 2006; Bergman 2001), 9- (Bergek and Jacobsson 2010; Wang 2006), 10- (Geissler et al. 2013), 11- (IEA 2019), 12- (Nilbecker 2014)

4.2.4 *Culture Driving Wind Diffusion*

Culture impacts everything from policy and social understandings (Burstein 1991). However, it is underrepresented in renewable energy development research. In the energy literature, culture is most often studied through a case study analysis (Gross 2007; Langer et al. 2018; Petrova 2013) and only rarely through a comparison of different countries (Mignon and Bergek 2016; Toke et al. 2008). Toke et al. compared four institutional variables (planning, financial support, landscape protection, and local ownership) in six European countries and concluded that the social and political culture directly influenced the formation of the institutional variables (Toke et al. 2008). Mignon and Bergek compared new adopters of renewable energy in France and Sweden and found that system level challenges varied considerably between the countries, while actor-level challenges were relatively similar. System level differences were considered a function of the national institutional framework (Mignon and Bergek 2016).

Of relevance to this analysis, Geels and Verhees (2011) qualitatively link culture directly to social acceptance. Using the nuclear industry in the Netherlands as a case study, Geels and Verhees proposed that successful framing of issues during social movements creates cultural legitimacy (also referred to as social acceptance) of new technologies. As a way of collective sense making, frames that were culturally legitimate formed an emergent discourse or general way of thinking about a technology that contested the dominant discourse (Benford and Snow 2000; Bergek et al. 2008; Geels and Verhees 2011; Köhler et al. 2019). The limitation of this study is that only the Netherlands was studied; thus, there was no contrasting cultural comparison. Still, this combined literature indicates the importance of culture for the development of renewable energy.

Building on the previous work, in this analysis we seek aspects of culture that seem to matter for wind projects in countries around the globe. To enable this type of analysis, and to overcome the analytic difficulties of robustly making cross-cultural comparisons, several structured frameworks have been developed (Hofstede 2001; House et al. 2004; Schwartz 1999). Hofstede's dimensions have been shown to influence not only the diffusion of renewable energy in general (Kaminsky 2016), but also the development of wind energy worldwide. Scholars using newer cultural dimensions from Allison et al (under review) found

that Uncertainty Tolerance and Fairness values within a nation have a direct impact on the development of wind energy, showing that as Uncertainty Tolerance and Fairness, increase so does the amount of electricity capacity of wind energy. Uncertainty Tolerance measures a lack of worry about ambiguities and risks in organizations and society. Fairness measures the importance society places on proactively creating cooperative behavior and reflectively judging actions. Finally, Religiosity, defined as dedication to God and religious customs, had a minor inverse relationship with wind development (Allison and Kaminsky In Preparation). The current analysis builds on that previous study by using social acceptance theory to qualitatively explore the mechanisms behind the global, statistically observed relationships between cultural dimensions described in Allison et al (under review) and the development of wind energy (Allison and Kaminsky In Preparation).

4.3 APPROACH

For this study, a series of semi-structured interviews explored the effects of culture in both organization and operation of wind project development, focused on planning and siting. Project developers in both Sweden and United States were asked a series of questions related to project startup, permitting, acceptance, and community influence. Sweden and the United States were selected because we had access to the wind development community in both, because they each have significant wind energy installations, and because they each have cultural dimension scores available from Allison et al. (under review). Since siting is so deeply embedded in the permitting process, project developers, public affairs as well as environmental managers were interviewed in order understand how the permitting process and external stakeholders affect development of wind energy projects. In total, twenty-one professionals were interviewed. Ten worked in Sweden and eleven worked in the U.S. The average number of years working in the industry was ten years. Starting from a list of companies actively developing wind in the United States or Sweden, a potential list of participants with over five years of experience was created. If their contact information was available, potential participants were contacted via email with a request to participate. Those who accepted were included in the sample, making it a convenience sample (Marshall 1996). As listed in the Appendix, there were eleven primary questions guided the conversations. The interviews

ranged in length from twenty-five minutes to two hours. The Swedish interviews were held in English and tended to be somewhat longer.

The goal of the project is to understand how **cultural values held in the United States and Sweden impact the planning and siting of utility scale wind projects.** Since culture is often used as a generic word for social challenges that are hard to describe and categorize, we avoided using the term *culture* in the interviews. Instead, the interview questions were created based on the three cultural dimensions (Religiosity, Fairness and Uncertainty Tolerance), which were developed previously (Allison et al. In Preparation) and were shown to statistically relate to wind energy development at the global level (Allison and Kaminsky In Preparation). Table 4.3 below shows how Sweden and the United States differ culturally based on these three dimensions.

Table 4.3. Cultural Dimension Comparison (Allison et al. In Preparation)

	Definition	**Sweden**	**United States**
Religiosity	Dedication to God and religious customs, but not any particular faith Global Range: (-27.9, 35.9) Global Mean: 2.8	-27.89	-3.27
Fairness	Priority of cooperative behaviors to avoid inequitable impacts Global Range: (-18.9, 9.7) Global Mean: 2.5	-2.1	-4.1
Uncertainty Tolerance	Acceptance of ambiguities and risks that threaten society Global Range: (-25.1, 13.1) Global Mean: -4.2	13.1	2.4

For example, participants were asked *What does your team do to show that their (stakeholder) concerns are being taken into consideration* to explore if and how Fairness affected the developer's actions. More examples of the questions used are listed in Appendix E. Since the interviews were semi-structured, the questions were altered and rearranged slightly to fit the context of the conversation and the terminology of the participant. The purpose of the interviews was to identify how ways in which Religiosity, Fairness and

Uncertainty Tolerance influence organizations and societal institutions, not to identify personal beliefs. Therefore, the interviews focus on organizational and societal norms and regulations all of which are influence by the cultural values in which they operate (Scott 2007).

The interview transcripts were reviewed two times to create and refine a coding dictionary using the Dedoose software (*Dedoose* 2019). During the initial exploratory assessment of the transcripts, descriptive coding allowed trends to emerge from the data. In the second pass, topical codes were grouped into categories as seen in Table 4.4. Each code is a specific behavior, situation or process (Saldana 2015). We collected the codes into three categories based on our operationalized social acceptance framework as seen in Figure 4.1. Fairness and Uncertainty Tolerance were operationalized as seen in Table 4.5 and applied to the interviews. Religiosity is not included because as described in the limitation section, the complexity of Religiosity was not adequately represented in our data.

Due to our unit of analysis and English being a second language for half of our respondents, we choose not to use value, taxonomic, or metaphoric coding analysis (Cameron et al. 2009; Saldana 2015; Schmitt 2005). Instead, category construction and the directed analysis of our content allowed us to discover relationships between our cultural values and wind development (Hsieh and Shannon 2005; Saldana 2011). Quotations are used to demonstrate the relationships in the results and discussion and have been lightly edited for fluency and grammar. The detailed description including inclusion and exclusion criteria for each code can be found in Appendix E (Bernard et al. 2016).

Table 4.4. Categories & Codes in Coding Dictionary

Category	**Codes**
Market	Financial Policies, Power Market, Power Offtake
Planning	Authority of Indigenous People, Application Cost, Jurisdiction, Land use, Lawsuits/Appeals, Project Review Time, Regulations (consultation, property rights, hearings)
Siting	Access to Information, Alternative Interests in Land (Economic, Non-Economic, Security), Conflict, Engagement (campaign, exchange, compromise, relationships), External Stakeholders, Grid Connection, Local Impacts, Project Review, Skepticism, Spread of Misinformation, Wildlife, Wind Resource

Table 4.5. Operationalization of Fairness and Uncertainty Tolerance

Fairness (F)	Support for cooperative behavior to avoid inequitable impacts
Long Definition	Fairness measures the importance society places on proactively creating due process and cooperative behavior
Inclusion Criteria	Professionals describing behaviors that are mandatory or voluntary which ensure that the process and impacts are equitable to themselves, surrounding people and wildlife. For example, mandated public meetings, taxation, and the ability to appeal are regulated ways to build in equity. Public meetings are considered part of fairness because they create procedural fairness, even if nothing changes due to their participation. Voluntarily developers will improve roads, create community funds and mitigate wildlife impacts to compensate neighbors for the impact of the wind farm. Compromises are typically developed through conversations. Conversations are different than just collecting information from the public; they are meant to support cooperation. They show that developers are really listening and willing to match their history and meet their needs, and goals in exchange for the impact the wind project has on the community. Finally, differing perspectives on advantages and disadvantages of the wind park as well as how those items and other opinions are weighted towards the public or wildlife are considered part of fairness.
Exclusion Criteria	Professional describing what is morally right and wrong describes his/her belief, not how to create a fair system. Power by itself is not related to Fairness because different contexts define fair use of power differently. The exchange of information nor the collection of information about concerns in order to reduce the likelihood of oppositions is not Fairness (see Uncertainty Tolerance).

Uncertainty Tolerance (UT)	Acceptance of uncertainty
Definition	Uncertainty Tolerance measures a lack of worry about ambiguities and risks that happen in organizations and society.
Inclusion Criteria	Professionals describing behaviors and regulations, which have, create, or reduce unknown outcomes or risks. Uncertainty is created through ambiguity in the regulations. For example, regulations often do not require arguments from local citizens to be factually correct, or they are written in such a way that the authorities can interpret them differently for each project. In fact, some regulations do not mandate how decisions should be made; therefore, emotions, which are unpredictable and uncontrollable to developers heavily influence decision making. In particular, emotions can impact elected officials whose job relies on public attitude. To reduce uncertainty, connections are built and information is collected to avoid conflict. In fact, some developers hire a third party to develop trust with local communities to reduce uncertainty. Who developers select to engage with and how they choose to engage (e.g. education, campaign, personal relationships) can affect project support and the likelihood of opposition
Exclusion Criteria	Professionals describing the complexity of norms and regulations. Complexity does not necessarily create uncertainty. Convincing or persuading politicians or locals is done to create trust and/or reduce Skepticism (another cultural dimension that likely plays a moderating factor with UT and F). Similarly, doubt in scientific evidence is likely due to Skepticism not Uncertainty Tolerance; however, Skepticism is likely to cause uncertainty particularly in low UT countries. Wildlife investigations and other impact studies specific to the project are for reducing skepticism.

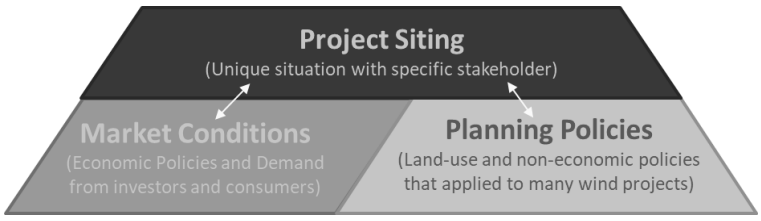

Figure 4.1: Dimensions of Wind Project Development

Adapted from (Wolsink 2018; Wüstenhagen et al. 2007)

4.4 LIMITATIONS

In our interviews, wind developers were asked to describe how they include external stakeholders, defined here as those who are relevant in their permitting process, but outside the developers' control in their development process. This study does not focus on who are the right stakeholders to be involved; instead, this study explored existing stakeholder interactions with developers. Furthermore, since we did not interview local stakeholders impacted by existing or proposed wind farms, this study is limited to the perspective offered by the wind developers. Future research should consider external stakeholders perspectives with respect to Religiosity, Uncertainty Tolerance and Fairness in different countries. A comparison of public acceptance studies or analysis of stakeholder comments from project applications in different countries could identify some of ways in which Religiosity, Uncertainty Tolerance and Fairness impact sitting and local acceptance of wind farms.

The analysis of Religiosity in both countries proved inconclusive in part due to the lack of external stakeholder perspective, but also due to developers' avoidance of faith based groups. The Religiosity scores for each country imply that religion would play a very small role in Sweden and a larger role in the United States. As expected, none of our data indicates the influence of religion within wind planning policy in Sweden. In the United States, several developers mentioned that conservative politics influencing the energy market. American conservatives tend to support not only oil and gas but also limit on religiously tied social actions such as abortion and marriage (Lakoff 2010). However, these planning policies do not directly tie wind energy and Religiosity. Furthermore, during siting, Swedish developers mentioned that the indigenous populations argue against wind farms on sacred lands, implying that Religiosity may be better analyzed at the subnational level. Unfortunately, we did not talk

to any indigenous tribes about their sacred lands and therefore, we cannot conclude how their religious values are impacting the siting process. In the United States, we expected to see more faith based groups. This was observed in our data to a limited extent. However, while a few developers acknowledged that faith based groups are present in the communities they work in, they largely avoided. Therefore, our data does not represent the potential impact Religiosity has on the development of wind energy because in the United States developers avoid such conversations. Future research should study high scoring Religiosity countries, such as Jordan and Pakistan, to determine how developers have interacted with different faith based groups.

Furthermore, we did not interview investors or consumers about their demand for wind energy nor did our questions did not ask about the electricity market. We chose not include market related questions due to the complexity of the regulations that surround the electricity market particularly in the United States. This is a considerable limitation in our study and future research should investigate how Uncertainty Tolerance and Fairness impact investor and consumer decisions related to wind energy. We would expect for consumers in high Fairness and high Uncertainty contexts to support more renewable energy as supported by diffusion theory and explained in Chapter 3.

Finally, our study does not include some of the technological challenges that renewable energy technologies must still overcome. For example, a technological challenge for wind energy is the variable nature of wind resources. In other words, electricity from wind cannot be generated on demand like electricity has been made in the past. Incorporating wind energy into the energy market requires smarter grid systems, particularly as the amount of renewable energy grows (Aghaei and Alizadeh 2013; Hammons 2008).

4.5 Results & Discussion

The results were organized into the three dimensions of social acceptance (Wolsink 2018; Wüstenhagen et al. 2007): planning, siting, and market. As expected, there was a noticeable difference in the Uncertainty Tolerance within the planning and siting dimensions. For example, in the United States, several of the interview developers focused on campaign-like stakeholder engagement in order to reduce the likelihood of opposition during project siting. Since Sweden and the United States have similar Fairness scores, we expected and found

similarities in planning and siting such as the inclusion of participation and the use of compromises, respectively. As mentioned previously, our interviews did not focus on the market due to the inconsistencies across the United States electrical market; however, a few interviews suggested some differences with respect to Uncertainty Tolerance. Those quotes are briefly described in these results. Table 4.6 summarized the differences and similarities that were found between the countries with the support of quotes.

4.5.1 *Planning*

From a planning perspective, wind developers must navigate regulations in order to gain the proper approval to build a wind farm in the United States and Sweden. This is typically incorporated into a permitting process, which can create systemic (un)certainty or build in (un)Fairness. We expected and observed more uncertainty in wind planning in Sweden than in the United States. The increased uncertainty in Sweden stems from the structure of land use policy and the decision-making process. In the United States, as described below, there is less uncertainty due to land ownership rights and regulations in decision making. On the other hand, we saw similar Fairness values in planning policies of both Sweden and the United States.

4.5.1.1 Uncertainty Tolerance

In Sweden, the setup of the regulatory system has considerably more uncertainty than the United States system due to the decision-making process included in wind development. This uncertainty is acceptable due to the Swedish high Uncertainty Tolerance scores. In Sweden, municipalities create land use plans based on the national interest for wind, as defined by that national government. This creates uncertainty because municipalities are allowed to change land use plans at will (Bergek 2010) and even, without justification. Therefore, Swedish municipalities can change their wind power plans fluidly. Furthermore, the municipal veto adds a considerable amount of uncertainty for wind developers. The intention of the veto is for the municipality retain control over local land use; however, there are no mandatory guidelines on how to make the veto decision. Many Swedish developers mentioned that the *"only requirement is that they … say yes or no to the project… it is not regulated" [SWE P1].* Thus, the ambiguity of municipal veto creates considerable uncertainty in the development

process because the municipality not only can veto the project for any reason, but also can change their decision at any point during the permitting process. Finally, the veto decision is made by elected officials making their decision political. In fact, as one developer said *the "environmental office makes suggestions, but the politicians can make another decision. So, the environmental office can be pro or con and you can have the opposite from the [politicians]" [SWE P3].* This creates more uncertainty for the developers.

In the United States, there is no direction from the federal government about how the land should be used for wind energy. Instead, land development follows the regulations associated with its jurisdiction, often called zoning regulations. Therefore, developers in the United States must first look to who owns the land and which jurisdiction(s) it falls under, meaning that developers retain some control over the type of jurisdiction where they do business. This choice mean they can reduce uncertainty by avoiding disadvantageous zoning regulations. For example, a developer *"would rather work with a county, if the county is friendly to renewables. If they are not friendly to renewables, I will look for state land because …the states I found are very good to work with, because they have less of an emotional opinion about renewable energy" [US P4].* Wind developers can often circumnavigate county jurisdiction by building only on state or federal land, building a wind farm of sufficient size to engage state-level permitting processes, or engaging with an energy siting board (Geissler et al. 2013; Lazar 2011; Ottinger et al. 2014). Furthermore, there are a number of states without permitting requirements. In these contexts, the landowner has considerably more authority and upon the signing of a lease agreement, the developer has considerably less uncertainty because political leaders are not involved. The ability to avoid local level policies adds considerable complexity to the permitting process, but it does not add uncertainty. If a permit is required, the application is reviewed by the jurisdiction's zoning or planning commission. County commissioners have the responsibility of deciding about specific projects as well as more generally about land use ordinances. Unfortunately, very few of the U.S. respondents expanded on how commissioners should make their decisions. In an exception, one participant mentioned*, "some counties have no building permits. They don't have zoning; they don't have a land use ordinance…so the [county] respected the private landowners, saying, hey, it's your land, you can do what you want" [US P11].* In this case, wind developers are able to explore the siting of wind farms with private landowners.

4.5.1.1 Fairness

While there are planning differences in Sweden and United States, similarities support the countries similar Fairness scores. With respect to the rest of the world, both the United States and Sweden have average Fairness scores (see Table 4.3), implying a balance between compromises for the greater good and individual rights. In both countries, the majority of wind farms retain jurisdiction at the local level. Retaining jurisdiction at the local level allows those who will be most impact to retain some control over the decision-making process, creating the opportunity for a fair decision. The development of wind farms in the majority of the United States and Sweden include participation from external stakeholders. In areas without formal permitting requirements, such as Texas, wind developers can solicit public input to gain favorable tax breaks. Public participation facilitates compromises between the developers and the local stakeholders. Developers are able to gain insight into the concerns of the public and adapt the proposed project accordingly. In both countries, developers formally respond to comments in the consultation or scoping process. As was shown in Table 4.3, in Sweden, *"there was a certain time that they could write to us or email us or talk to us and give their opinion and we also, as the law says, we have to take these comments into consideration and we have to write answers and we have to tell authorities whether or not we have been to [do] something" [SWE P6*]. In the United States*, "on the permitting side, … you have to do is schedule X number of scoping meetings, where you put notice in the paper... a presentation at a given time at a given place, and … you have a court reporter for there to a record conversations, and you take those comments into account and then that kind of helps shape the way that you approach a project" [US P10].* The permit-granting authority will then decide if the developer has created a project, which fairly impacts the public, with respect to the potential gain for the landowners, community, and the developer. Unfortunately, as mentioned by developers in both countries, many participation mechanisms are biased by a loud opposition even if there is a considerable population in support. The strong influence from vocal stakeholders who are not necessarily representative stakeholders, lead a recent study to suggest that collaborative deliberation may be more fair than the current mechanisms (Ottinger et al. 2014).

4.5.2 *Siting*

The final stage of social acceptance is the siting of a specific project. It is during the siting process that the benefits of wind farms are realized and the impacts are felt. Despite being in two very different areas of the world, the impacts of wind farms to people and wildlife in Sweden and the United States should be similar, given that the technology is the same. For example, the wind turbines are highly visible, as tThey are tall and are required to have aviation lights. They create sound because just like wind moving through the tree, wind moving through a wind farm creates sound. During siting, the primary goal for a developer is to be granted a permit and retain positive relationships with the decision makers and community members. Wind developers must choose a site where they can successfully engagement with different external stakeholders and decision makers to gain local acceptance. There are two primary perspectives during siting: those siting the projects (i.e. the developers) and those who will be impacted by the project (i.e. the community including the landowners, neighbors, and all other users of the area surrounding the wind farms). In this paper, we focus on Uncertainty Tolerance and Fairness as perceived by the developer. Developers in Sweden showed higher Uncertainty Tolerance through their flexible and unrestrictive approach to stakeholder engagement while as expected lower Uncertainty Tolerance in the United States led developers to more selective stakeholder engagement strategies. Since both countries have similar Fairness scores, we predicted and saw that all developers create fairness through compromises with stakeholders.

Table 4.6. Uncertainty Tolerance & Fairness Influence on Social Acceptance of Wind

	Uncertainty Tolerance			Fairness		
	Result			Result		Quote
Planning	Municipal Veto and variable court judgments creates high uncertainty in Sweden. In the U.S, authorities are required to use zoning guidelines to make decisions	SWE	*"Only requirement is that they … say yes or no to the project, and it should be about the land use, but… it is not regulated" [SWE P1].*	In both countries, project applications include participation from locally impacted people.	SWE	*"There was a certain time that they could write to us or email us or talk to us and give their opinion and we also, as the law says, we have to take these comments into consideration and we have to write answers and we have to tell authorities whether or not we have been to [do] something" [SWE P6]*
		US	*"Some counties have no building permits. They don't have zoning; they don't have a land use ordinance…so the [county] respected the private landowners, saying, hey, it's your land, you can do what you want" [US P11].*		US	*"On the permitting side, … you have to do is schedule X number of scoping meetings, where you put notice in the paper... a presentation at a given time at a given place, and … you have a court reporter for there to a record conversations, and you take those comments into account and then that kind of helps shape the way that you approach a project. [US P10]*
Siting	United States developers structure the selection of stakeholders and target campaign messages more tightly than developers in Sweden do.	SWE	*"We also invite a very broad perspective, because we invite personally, everybody who have property in three kilometers, and if they have a house, and it's going to be visible from the house in five kilometers, and if there are villages we, we send out to everybody and we make ads in all the local newspaper and the regional newspaper…we really try to include everybody at the meetings" [SWE P9]*	Developers from both countries must make considerable compromises to retain a positive relationship with the communities	SWE	*"You can maybe move a turbine or change the road layout in fact the purpose of the hearing meeting is to try to find a solution, which is acceptable, both from a residential perspective, and for us as a professional developer. You may not be able to do everything, but some adjustments could eventually be possible"[SWE P4].*
		US	*"I'm going out into the field and trying to trying to garner public support. The folks that I focus on are the ones that are already in supportive, and they're the ones that I can get to write letters and come and speak at the public hearings" [US P4].*		US	*"We try to identify those needs, and those wants those communities there. And, you know, as part of your development is there something that the developing company can try to do…and it ranges from doing kind of like, you know, recurring contributions, a city project or fire departments where they need a piece of equipment…. long term sustaining kind of things" [US P7].*
Market	Low demand for electricity compounds uncertainty with siting issues in Sweden, but low demand in U.S. motivates developers to relocate to avoid siting issues.	SWE	"*Why do we need so much renewable energy because we have lots of electricity, here in Sweden"[SWE P8] AND "because as long as [nuclear plants] are up and running, [they have], no climate effect at all [SWE P3].*	**Not Discussed** Future Research should look into access to the transmission networks in each country	SWE	Not Discussed
		US	*"the whole game is getting someone to buy your power. If you can get someone to buy the power for a reasonable price, the project will most likely get built. [US P1].*		US	Not Discussed

4.5.2.1 Uncertainty Tolerance

A major challenge for developers in both Sweden and United States is the political or social environment in which the decision makers review the project applications. In both countries, elected officials review processed projects and make decisions based on their constituents. It is very difficult to understand stakeholders' opinions related to wind energy before entering a community. Developers use previous decisions on wind projects as an imperfect guide. However, emotions add a considerable amount of uncertainty into the decision making process (Schwarz 2000), largely because the emotions elicited are unknown to the developer. "*So they [the decision makers] are very sensitive to looking bad, or making a bad decision and so the best and easiest way to help somebody make a good decision on facts, is to educate them on the facts" [US P6].* Therefore, developers heavily emphasized the exchange of information. This exchange of information is meant to inform the public about the potential project and to provide developers with important information about the community. For example, developers are interested in hearing people's concerns about particular areas. *"We understand that people are concerned, because it is a change in environment if a wind farm would come, so we respect that, but we try to address the concerns with information and with openness" [SWE 8].* Since in many cases the developers do not live near the proposed site, community members also hold valuable information about the plans, and alternative uses of different areas.

Developers in Sweden and the United States have the ability to choose which community members that they interact with. In particular in the United States, half of the developers mentioned generating support for their supports through selective relationships and campaign strategies. Developers appeal to communities' needs and are more focused on *"trying to garner public support. The folks that I focus on are the ones that are already in supportive, and they're the ones that I can get to write letters and come and speak at the public hearings" [US P4].* They build relationships with select community members to understand the community sentiments and rumors. Targeted engagement strategies has been shown to reduce uncertainty in project management (Ward and Chapman 2008). In fact, several developers mentioned hiring a trusted local third party to encourage trust and gain support which has been shown to reduce uncertainty (Widén et al. 2014) As one U.S. developer pointed out, the goal of the opposition is to create uncertainty while the developer's goal is to prevent it. With a

cultural tendency to avoid uncertainty, the opposition can be very effective by creating chaos and doubt with respect to a wind project in the United States. *"The opposition's number one job is to cause uncertainty and delay so that projects are at risk... and that is their new goal, they figured out how to just create chaos, so that things get delayed, versus actually winning on any specific point" [US P6].* Swedish developers are less selective in who they talk with and how they shape their engagement strategies. *"We also invite a very broad perspective, because we invite personally, everybody who have property in three kilometers, and if they have a house and it's going to be visible from the house in five kilometers, and if there are villages we, we send out to everybody and we make ads in all the local newspaper and the regional newspaper…we really try to include everybody at the meetings" [SWE P9].* In Sweden, project development is perceived as a balance between the requirements of the wind farm and the neighbor's needs; therefore, everyone should be involved, despite the uncertainty additional people could create. Reliance on primarily on personal relationships as well as lack of a clear stakeholder strategy can create uncertainty (Jensen et al. 2006; Ward and Chapman 2008).

4.5.2.2 Fairness

In both countries, the developers worked with communities to find a balance of impacts and benefits that were acceptable to themselves and the community. Several developers, particularly those who work for companies that own, operate, and maintain wind farms, discussed how they aim to become contributing members of the community, providing not only jobs, but also sponsorship for events and improvements. Developers in both countries mentioned the relocation and/or removal of turbines in order to gain public acceptance. *"If it is one turbine, it is no problem. We take away the turbine that is of course possible when you are working with a box model. You can move the turbines and sometimes you don't lose it; you can put it somewhere else." [SWE 2].* Removal of a turbine has immense impacts on the bottom line of a wind project because wind farm produces less electricity. While it may seem like a small gesture to the public, the developers are truly attempting to efficiently layout a wind farm that is acceptable the surrounding community. These compromises and relationships create not only an open dialogue between the stakeholders and the developers but also demonstrates to the local stakeholders that the developer and the proposed project is meant

to be a part of the community and to ultimately benefit the community. Developers in the United States use project siting as a time to *"identify those needs and those wants for those communities and as part of your development if there something that the developing company can try to do from recurring contributions, a city project or fire departments or police services [US P7].* Similar sentiments were expressed by Swedish developers. *"It's really important to have not only the hearings, but actually getting to know people, both living there and working at a municipality to understand what the concerns are, and what you can do about that. Sometimes is pretty easy things to just fix that you didn't know was a big problem for them. [SWE P1].*

It is worth noting again that the United States and Sweden do not have high Fairness scores; in fact they are at the global average (Allison et al. In Preparation), meaning that Fairness is balanced between the greater good (i.e. emission free electricity) and self-interest from both sides. For wind development companies, wind projects must be able to bring in revenue; therefore, wind developers are limited in the extent to which the compromise. One strategy developers use to ensure they are able to adapt the wind farm to better fit community needs is proposal of many turbine sites. This way community members are able to identify which wind turbines are most impactful while the wind developers are able to create a profitable wind farm. For communities, self-interest was initially labelled as NIMBY, which has since been replaced with a more accurate and nuanced understanding of people's opposition to wind farms (Devine-Wright 2009; Petrova 2013). Environmental externalities might be seen as another way to link the Fairness dimension to wind energy. However, both in the United States and Sweden, developers mentioned that the positive externalities associated with reducing carbon emissions was rarely effective in gaining public acceptance, despite the positive impact reduced emissions has on the world. Future research should explore this in countries with high Fairness scores where this factor may be more visible.

4.5.3 *Market*

The market includes the demand for wind power from industrial and residential consumers as well as the competition between power generators. We did not aim to study the impacts of culture on the electricity market, due to the complexity of the United States system. Still

uncertainty emerged from our interviews in both the United States and Sweden, and it is therefore discussed here.

In Sweden, there is a clear divide between those who support nuclear in operation today and those who support the development of wind. As one developer said, there is a *"clear paradox between the wind power and nuclear. ...if you are positive, to renewables then you say no to nuclear and if you are positive to nuclear, you say no to wind power" [SWE P9]*. Furthermore, in Sweden, they already export electricity, and the majority of their electricity comes from nuclear and hydroelectric and is already carbon neutral. Thus, Swedish communities have also asked developers "*why do we need so much renewable energy because we have lots of electricity, here in Sweden"[SWE P8]* or argued that *"because as long as [nuclear plants] are up and running, [they have], no climate effect at all" [SWE P3].* Therefore, the Swedish developers are concerned about the market due to uncertainty in demand.

In the United States on the other hand, developers emphasized the market's importance by saying *"the whole game is getting someone to buy your power. If you can get someone to buy the power for a reasonable price, the project will most likely get built" [US P1] o*r in other words if you have *"everything going for you except that you had local opposition. That project is going to get built." [US P1].* In the United States, developers' focused on the importance of being able to sell the power, but due to the focus of the interview, they did not expand on the conditions on the market. This focus on the markets from U.S. developers may come from the complexity of the energy market in United States, and the ability to avoid public opposition by simply changing the project site. As the previous quotes show, developers in the United States do not fight public opposition unless the market demand is strong enough; the country is large enough and regulations are complex enough to make this a viable option. Therefore, future research is needed to investigate how different cultural values specifically influence the energy market. We suspect that Skepticism, defined as doubt in institutions may impact the development of the energy market globally (Allison et al. In Preparation; Shin and Managi 2017).

4.6 CONCLUSION

In this study, twenty-one wind developers in both Sweden and the United States were interviewed to gain a better of how wind development embodies differing cultural values. We explored how cultural values (Fairness and Uncertainty Tolerance) impact both planning and siting in the United States and Sweden. For example, wind planning policies in United States align with a low Uncertainty Tolerance due to the reliance on written regulation and decision-making policies. In Sweden on the other hand, the municipal veto aligns with a high level of Uncertainty Tolerance. During siting, wind developers in the United States align with low Uncertainty Tolerance by using selective campaigns while in Sweden wind developers focus on broader involvement. In Sweden and the United States, similarities in Fairness are apparent through public participation in planning policies and with compromises between developers and local stakeholders during siting.

To avoid imposing culturally inappropriate development strategies, the results of this study provide two primary recommendations to help developers align with existing cultural values. In the United States, a lower Uncertainty Tolerance score implies that developers should employ robust methods of risk communication with stakeholders to reduce uncertainty and project opposition (Renn 2008). In Sweden, tolerance for uncertainty is higher; however, it is not limitless. Swedish developers should consider more strategic stakeholder engagement plans to reduce the likelihood of losing a project due to a few loud opposing stakeholders. However, establishing and retaining a high level of trust with stakeholders is particularly essential to success in areas with high Uncertainty Tolerance (Huijts et al. 2012). Since both Sweden and the United States have similar Fairness scores, we can only observe that compromises which balances the benefits with the impacts help to support wind projects. We suggest that future research explore wind projects in countries with more extreme Fairness scores. Furthermore, future research should consider the relationships between the different values and how they might impact the development process. In conclusion, this study explored some mechanisms by which Uncertainty Tolerance and Fairness impact the planning and siting of wind projects. Developers considering entering new cultural environments should consider the countries' Uncertainty Tolerance and Fairness scores as well as how the planning and siting

phases embody those values in order to properly train staff and allocate resources to work in a new cultural environment.

4.7 Supplemental Information

Appendix E contains the coding dictionary, IRB Exemption Approval, and the interview template

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4.8 References

Please see Chapter 6 for all references

Chapter 5. SUMMARY & CONCLUSIONS

As the title of this dissertation implies, the goal of the three studies in this dissertation was to understand how wind development is influenced by and can operate more successfully in different cultural environments. All three chapters were developed to answer the overarching question of *how do cultural values impact wind energy development?* In short, we claim that countries are able to install more electrical capacity from wind energy when wind development aligns with the country's views on Uncertainty Tolerance and Fairness. Figure 5.1 summarizes the contributions that this dissertation made.

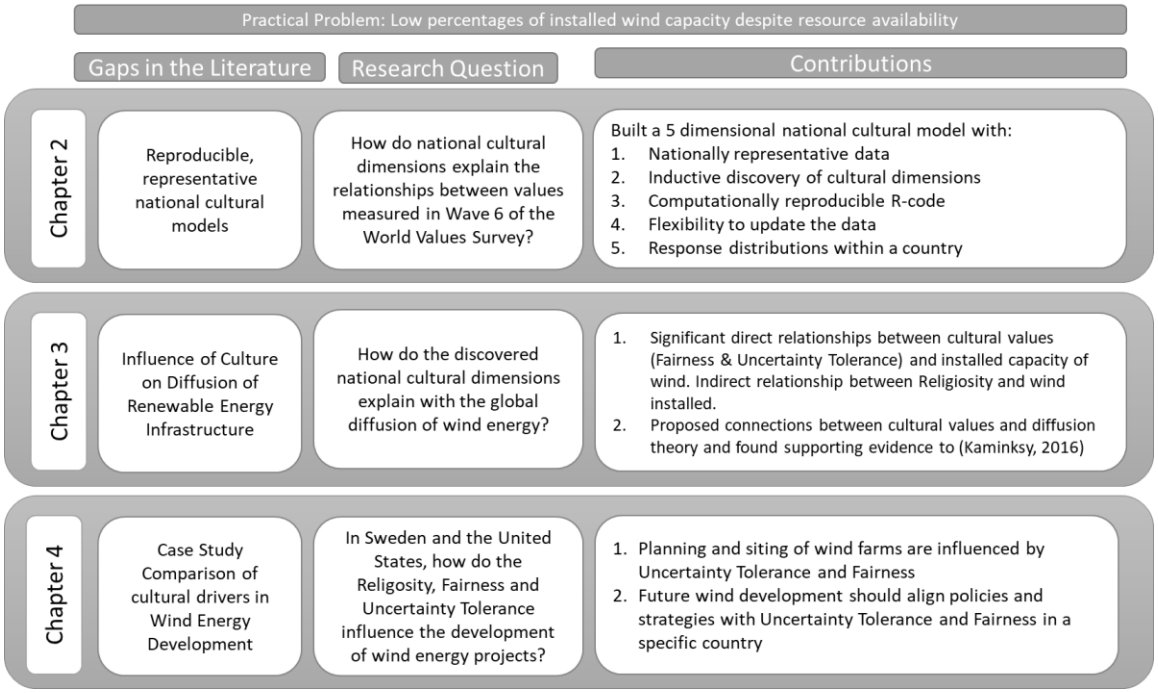

Figure 5.1. Dissertation Summary

Starting in Chapter 2, we present a reproducible, representative quantitative cultural model of culture at the national level. Chapter 3 shows that quantitatively Religiosity, Uncertainty Tolerance and Fairness align with the development of wind energy. It is important to note that we do not believe that culture within a country is homogenous; however, nations provide a valuable and reasonable unit of analysis to understand cultural trends. Nevertheless, for countries with high Uncertainty Tolerance scores, we would expect not only developers and policy makers to be more accepting of uncertainty, but also local populations that are impacted by proposed wind farms. Fairness on the other hand may allow equal opportunity into the

power market for developers and participation for the local impacted public. Religiosity was found to have a small but significant indirect relationship suggesting that the current development practices of wind projects align better in countries with low Religiosity scores. Future development and research should consider how to meet the needs of more religious populations.

Finally, in Chapter 4, we explored the current state of wind development in the United States and Sweden. We found evidence that each country was influenced by cultural dimensions (Uncertainty Tolerance and Fairness) in planning and siting. For example, wind development policies in United States align with a low Uncertainty Tolerance with the reliance on written regulation and decision-making policies, while in Sweden the municipal veto aligns with a high level of Uncertainty Tolerance because of the unpredictability of the decision by a single authority. In practice, wind developers in the United States reduce uncertainty to align with the low Uncertainty Tolerance scores through systematic stakeholder campaigns focused on facts while in Sweden wind developers focus on compromises to meet the unique needs of the community.

5.1 Contribution to Practice

The findings of this dissertation can be used in multiple ways. First and most broadly, the national cultural model can be used in conjunction with or as a replacement of previous national cultural models. In particular, Hofstede's cultural models have been used to develop global business practices, training for both leaders and relocated employees, negotiation practices, and much more (Bing 2004; Hofstede et al. 2010). The cultural model developed in Chapter 1 eliminates some of the methodological limitations of the previous national cultural models and is a considerable step forward in the development of quantitative cultural models.

Second, Chapters 3 and 4 are meant to guide the renewable energy industry. Establishing how culture drives energy innovations allows international renewable energy companies to understand the values that drive energy development within a country. In particular, the direct relationship between Uncertainty Tolerance and diffusion of wind energy indicates that countries with higher levels of installed wind capacity will tolerate considerable uncertainty in the development process and wind development companies should be prepared to take on those

risks. Similarly, in countries with average to high scores of Fairness, international developers should be prepared to engage with the public and expect some form of local participation. For developers working within a single country, these studies also provide valuable insight into the set up of the development system and may inspire new policy ideas. For example, in the United States where Uncertainty Tolerance is low, education programs about wind and more broadly recognizing false information and reducing politicization may be more effective than streamlining the permitting process (Bergstron and West 2017; Bolsen and Druckman 2015; Ottinger et al. 2014). In Sweden, there is a tendency to accept uncertainty. Therefore, it may be more beneficial to focus on trusting relationships; however, reducing uncertainty only further supports likelihood of a successful project. Thus Swedish developers may also consider additional engagement strategies to reduce likelihood of opposition (Strömbäck and Nord 2008).

5.2 Limitations & the Path Forward

It is important to remember that each study is only a sample of the population. The scope of our findings are limited to 56 countries in Chapter 2, 42 countries in Chapter 3, and the United States and Sweden in Chapter 4. Future research should work expand this work to additional countries. In Chapter 2, the national cultural model can be expanded by merging it with the European Values Survey, as is documented on the WVS Website (WVS Association 2019a). Furthermore, additional waves of the World Values Survey could be analyzed to understand how the cultural dimensions vary over time. Updating the analysis would require manual cleaning of the data; however, the multidimensional item response analysis code (Chalmers 2018) will run automatically once this is accomplished. Data cleaning cannot be automated. The questions do not have to be exactly the same because we would expect similar concepts to emerge from questions which cover similar topics but may vary in exact wording. The multidimensional item response approach can also be applied to surveys at the regional or possibly state level. Therefore, future research should look into the regional differences within nations.

In Chapter 3, only 42 countries were included in the regression because not all countries have both cultural dimensions and quality wind resources. Including countries with zero wind

installed causes considerable modelling difficulties, but is nonetheless feasible and should be explored. For example, with additional countries, zero-inflated models or hurdle models may be a reasonable choice for understanding the countries with no wind energy installed. Furthermore, it would be interesting to consider change over time as some previous research has done (Gosens et al. 2017) with our cultural covariates.

Finally, in Chapter 4, we compared the United States and Sweden with a purposeful sample of developers; however, this sample is not representative in the statistical sense. We attempted reach developers from across the countries; however, both countries are quite large, and there are undoubtedly areas with unique situations. Furthermore, as is the case with all interviews, free recall or respondents simply not mentioning certain aspect of the development process is highly likely given its complexity (Kimball Romney and Weller 1984). Similarly, particularly with respect to participation and the views of the public, it is possible that respondents answered in what they consider the socially desirable manner (Krumpal 2013). Finally, the Swedish interviews were done in English. While English is an official language in Sweden, it is a second language. We did our best to prevent language issues by piloting the survey with professors at the Chalmers University.

In the United States and Sweden, future research should continue to collect evidence from developers, but also collect evidence from external stakeholders. By interviewing or surveying stakeholders, future research would be able to identity how different cultural values drives stakeholder actions and reactions. Additionally, developers in more countries should be interviewed. For example, neither the U.S. nor Sweden is at the extreme of the fairness scale; it would be informative to hear from wind developers in South Africa (low Fairness scores), Turkey (high Fairness scores), and Tunisia (low Uncertainty Tolerance).

5.3 SO WHAT, WHAT NEXT?

This dissertation was topic was inspired by a vision to support the world's transition to renewable energy sources. An extensive literature lists the obstacles for wind development that are caveated within the cultural environment. The studies in this dissertation show how cultural trends are not only measurable but useful in understanding the development of wind energy. In particular, we have connected measurable values of culture to the different

dimensions and scales of wind energy development, and provided recommendations on how cultural values support that development. We brought together distinct fields of study to show that culture influences infrastructure development and that not only policies and stakeholders but also developers themselves are influenced by these cultural norms. We show that engineers, while good at solving problems, particularly technical and economic ones, will constantly face social challenges. These challenges require the future generation of engineers to understand that projects do not exist in a vacuum. Projects, in this case wind projects, need to meet the needs not only of the greater public but also of the people directly impacted by the project. Finally, I hope this research has contributed the problems that wind developers faces and inspired at least one idea for how to meet the challenges that they face.

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APPENDIX A: NATIONAL CULTURAL MODEL DETAILED RESULTS

Table A.1: Factor Loadings for National Cultural Model

VAR	QUESTION	F1	F2	F3	F4	F5	Interpretation
V9	For each of the following, indicate how important it is in your life. Would you say it is: Religion	-0.61	0.00	0.00	0.00	0.00	Religion is very important
V148	Do you believe in God?	-0.61	0.00	0.00	0.00	0.00	Believe in God
V153	Please tell us if you strongly agree, agree, disagree, or strongly disagree with the following statements: "Whenever science and religion conflict, religion is always right"	-0.51	0.00	0.00	0.00	0.00	Strongly agree that whenever science and religion conflict, religion is always right.
V146	Apart from weddings and funerals, about how often do you pray?	-0.47	0.00	0.00	0.00	0.00	You pray several times a day
V19	Here is a list of qualities that children can be encouraged to learn at home. Which, if any, do you consider to be especially important?: Religious faith	-0.44	0.00	0.00	0.00	0.00	Religious faith is an important quality for children to learn at home.
V149	Do you believe in hell?	-0.43	0.00	0.00	0.00	0.00	Believe in hell
V147	Independently of whether you attend religious services or not, would you say you are:	-0.41	0.00	0.00	0.00	0.00	You are a religious person
V206	Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between: Sex before marriage	-0.41	0.00	0.00	0.00	0.00	Sex before marriage is never justifiable
V154	Please tell us if you strongly agree, agree, disagree, or strongly disagree with the following statements: "The only acceptable religion is my religion"	-0.38	0.00	0.00	0.00	0.00	You strongly agree that the only acceptable religion is my religion
V203	Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between: Homosexuality	-0.37	-0.23	0.00	0.00	0.00	Homosexuality is never justifiable.
V204	Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between: Abortion	-0.34	0.00	0.00	0.00	0.00	Abortion is never justifiable
V33	Now I am going to read off a list of voluntary organizations. For each organization, could you tell me whether you are an active member, an inactive member or not a member of that type of organization?: Consumer organization	0.00	-0.76	0.00	0.00	0.00	Not a member of a consumer organization

VAR	QUESTION	F1	F2	F3	F4	F5	Interpretation
V32	Now I am going to read off a list of voluntary organizations. For each organization, could you tell me whether you are an active member, an inactive member or not a member of that type of organization?: Humanitarian or charitable organization	0.00	-0.74	0.00	0.00	0.00	Not a member of a humanitarian or charitable organization
V34	Now I am going to read off a list of voluntary organizations. For each organization, could you tell me whether you are an active member, an inactive member or not a member of that type of organization?: Self-help group, mutual aid group	0.00	-0.72	0.00	0.00	0.00	Not a member of a self help or mutual aid group
V31	Now I am going to read off a list of voluntary organizations. For each organization, could you tell me whether you are an active member, an inactive member or not a member of that type of organization?: Professional association	0.00	-0.71	0.00	0.00	0.00	Not a member of a professional association
V27	Now I am going to read off a list of voluntary organizations. For each organization, could you tell me whether you are an active member, an inactive member or not a member of that type of organization?: Art, music or educational organization	0.00	-0.65	0.00	0.00	0.00	Not a member of an art, music, or education organization
V35	Now I am going to read off a list of voluntary organizations. For each organization, could you tell me whether you are an active member, an inactive member or not a member of that type of organization?: Other organization	0.00	-0.65	0.00	0.00	0.00	Not a member of other organizations
V29	Now I am going to read off a list of voluntary organizations. For each organization, could you tell me whether you are an active member, an inactive member or not a member of that type of organization?: Political party	0.00	-0.61	0.00	0.00	0.00	Not a member of political party
V26	Now I am going to read off a list of voluntary organizations. For each organization, could you tell me whether you are an active member, an inactive member or not a member of that type of organization?: Sport or recreational organization	0.00	-0.60	0.00	0.00	0.00	Not a member of a sport or recreational organization
V25	Now I am going to read off a list of voluntary organizations. For each organization, could you tell me whether you are an active member, an inactive member or not a member of that type of organization?: Church or religious organization	0.00	-0.60	0.00	0.00	0.00	Not a member of a church or religious organization

VAR	QUESTION	F1	F2	F3	F4	F5	Interpretation
V28	Now I am going to read off a list of voluntary organizations. For each organization, could you tell me whether you are an active member, an inactive member or not a member of that type of organization?: Labor Union	0.00	-0.59	0.00	0.00	0.00	Not a member of a labor union
V85	Now I'd like you to look at this card. I'm going to read out some forms of political action that people can take, and I'd like you to tell me, for each one, whether you have done any of these things, whether you might do it or would never under any circumstances do it: "Signing a petition"	0.00	0.25	0.00	0.00	0.00	Would never sign a petition
V83	During the past two years have you…Participated in a demonstration for some environmental cause?	0.00	0.32	0.00	0.00	0.00	No participation in a demonstration for some environmental cause
V200	Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between: Stealing property	0.00	0.00	-0.77	0.00	0.00	Never justifiable to steal property
V202	Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between: Someone accepting a bribe in the course of their duties	0.00	0.00	-0.74	0.00	0.00	Never justifiable for someone to accept a bribe in the course of their duties
V201	Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between: Cheating on taxes if you have a chance	0.00	0.00	-0.70	0.00	0.00	Cheating on taxes in you have the chance is never justifiable
V210	Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between: Violence against other people	0.00	0.00	-0.63	0.00	0.00	Violence against other people is never justifiable
V208	Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between: For a man to beat his wife	0.00	0.00	-0.58	0.00	0.00	A man to beat his wife is never justifiable.
V199	Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between: Avoiding a fare on public transport	0.00	0.00	-0.58	0.00	0.00	Avoiding fare on public transport is never justifiable
V198	Please tell me for each of the following actions whether you think it can always be justified, never be justified, or something in between: Claiming government benefits to which you are not entitled	0.00	0.00	-0.51	0.00	0.00	Claiming government benefits to which you are not entitle is never justifiable

VAR	QUESTION	F1	F2	F3	F4	F5	Interpretation
V117	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: Parliament	0.00	0.00	0.00	0.65	0.00	No confidence at all in Parliament
V118	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all? The Civil service	0.00	0.00	0.00	0.59	0.00	No confidence at all in the Civil Service
V115	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: The government (in your nation's capital)	0.00	0.00	0.00	0.59	0.00	No confidence at all in the government (in your nation's capital)
V116	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: Political parties	0.00	0.00	0.00	0.58	0.00	No confidence at all in political partities
V114	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: The courts	0.00	0.00	0.00	0.54	0.00	No confidence at all in the courts
V112	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: Labor unions	0.00	0.00	0.00	0.50	0.00	No confidence at all in labor unions
V110	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: The press	0.00	0.00	0.00	0.48	0.00	No confidence at all in the press
V111	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: Television	0.00	0.00	0.00	0.47	0.00	No confidence at all in television
V120	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: Major Companies	0.00	0.00	0.00	0.47	0.00	No confidence at all in major companies

VAR	QUESTION	F1	F2	F3	F4	F5	Interpretation
V113	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: The police	0.00	0.00	0.00	0.46	0.00	No confidence at all in the police
V121	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: Banks	0.00	0.00	0.00	0.46	0.00	No confidence at all in banks
V122	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: Environmental organizations	0.00	0.00	0.00	0.45	0.00	No confidence at all in environmental organizations
V123	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all? Women's organizations	0.00	0.00	0.00	0.45	0.00	No confidence at all in women's organizations
V126	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: The United Nations	0.00	0.00	0.00	0.44	0.00	No confidence at all in the United Nations
V119	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: Universities	0.00	0.00	0.00	0.44	0.00	No confidence at all in Universities
V124	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all? Charitable or humanitarian organizations	0.00	0.00	0.00	0.41	0.00	No confidence at all in charitable or humanitarian organizations
V109	I am going to name a number of organizations. For each one, could you tell me how much confidence you have in them: is it a great deal of confidence, quite a lot of confidence, not very much confidence or none at all?: The armed forces	0.00	0.00	0.00	0.38	0.00	No confidence at all in the armed forces
V142	How much respect is there for individual human rights nowadays in this country?. Do you feel there is:	0.00	0.00	0.00	0.25	0.00	There is no respect at all for individual human rights nowadays in this country

VAR	QUESTION	F1	F2	F3	F4	F5	Interpretation
V185	To what degree are you worried about the following situations? A civil war	0.00	0.00	0.00	0.00	0.82	No at all worried about a civil war
V183	To what degree are you worried about the following situations? A war involving my country	0.00	0.00	0.00	0.00	0.80	Not at all worried about a war involving my country
V184	To what degree are you worried about the following situations? A terrorist attack	0.00	0.00	0.00	0.00	0.80	Not at all worried about a terrorist attack
V182	To what degree are you worried about the following situations? Not being able to give my children a good education	0.00	0.00	0.00	0.00	0.49	Not at all worried about not being able to give my children a good education
V186	To what degree are you worried about the following situations? Government wire-tapping or reading my mail or email	0.00	0.00	0.00	0.00	0.47	Not at all worried about the government wire-tapping or reading my mail or email
V181	To what degree are you worried about the following situations? Losing my job or not finding a job	0.00	0.00	0.00	0.00	0.43	No at all worried about losing my job or not finding a job

Table A.2 Average Country Scores for Five Dimensions

Country	**Religiosity**	**Neutrality**	**Fairness**	**Skepticism**	**Uncertainty Tolerance**
Algeria	26.4	16.3	-12.6	-1.7	-10.6
Argentina	-8.3	4.6	-2.8	2.3	6.4
Armenia	7.5	23.2	2.0	0.5	-14.9
Australia	-20.2	-2.4	0.2	-5.8	5.6
Azerbaijan	0.8	27.4	5.4	-10.2	-6.3
Belarus	-5.6	5.6	-5.3	-7.7	-2.0
Brazil	3.0	2.5	-1.6	-1.5	-4.9
Chile	-7.0	4.0	-1.6	-3.3	2.6
China	-22.8	19.8	-6.5	-22.7	-0.7
Colombia	7.3	0.6	-1.4	-2.0	-14.8
Cyprus	-0.2	5.8	2.0	-7.7	-0.5
Ecuador	6.0	10.8	-2.6	-3.0	-9.8
Estonia	-19.1	12.0	-2.6	-11.6	-0.4
Georgia	16.1	20.9	9.0	-2.1	-17.1
Germany	-17.0	2.8	0.5	-8.7	6.8
Ghana	22.1	-0.8	0.6	-18.2	-14.4
Hong Kong	-13.1	1.0	-7.8	-13.2	4.0
India	11.2	-1.6	-5.8	-18.1	-3.2
Iraq	23.1	16.6	-6.9	-0.6	-5.8
Japan	-17.4	8.5	7.0	-7.3	-9.8
Jordan	35.9	17.1	2.3	-5.1	0.7

Table A.2 Average Country Scores for Five Dimensions (Continued)

Country	Religiosity	Neutrality	Fairness	Skepticism	Uncertainty Tolerance
Kazakhstan	-6.2	16.4	-6.5	-12.0	-6.4
Kyrgyz Republic	9.9	5.0	-6.0	-10.7	-9.9
Lebanon	6.0	2.5	-11.0	0.0	-5.8
Libya	33.9	9.9	-1.4	-0.5	-13.1
Malaysia	17.2	9.4	-6.4	-18.8	-19.0
Mexico	2.7	-0.6	-7.1	-1.0	-17.3
Morocco	26.6	19.7	0.8	-10.0	-1.8
Netherlands	-25.3	1.2	3.0	-4.4	12.5
New Zealand	-16.0	-4.5	1.0	-8.6	8.9
Nigeria	23.6	-4.3	-5.2	-9.5	-8.3
Pakistan	30.3	13.2	0.4	-3.1	-5.6
Peru	2.8	4.4	-5.3	5.3	-9.5
Philippines	12.3	-1.9	-16.8	-17.5	-11.2
Poland	0.5	9.7	-1.5	-1.4	1.6
Romania	6.8	13.6	5.4	2.3	-2.2
Russian Federation	-10.6	19.0	-7.6	-1.6	-4.1
Rwanda	3.8	-6.1	-5.8	-12.3	-20.6
Singapore	-1.3	5.2	-8.7	-19.0	3.0
Slovenia	-17.8	5.0	-0.1	4.1	5.5
South Africa	5.8	-7.4	-19.0	-7.6	-0.2
South Korea	-9.8	2.7	-2.8	-8.4	-3.0
Spain	-17.9	10.6	1.3	-1.1	-0.6
Sweden	-27.9	-2.8	-4.1	-11.2	13.1
Thailand	-0.5	1.0	-0.8	-12.7	-1.1
Trinidad and Tobago	12.3	-0.5	4.1	-3.5	2.8
Tunisia	26.0	23.7	-2.2	7.1	-25.1
Turkey	16.8	20.7	9.7	-10.1	-5.1
Ukraine	-5.0	16.9	-5.7	0.0	-4.3
United States	-3.3	-3.0	-2.1	-3.7	2.4
Uruguay	-13.9	9.9	2.3	-5.9	1.8
Uzbekistan	0.9	17.8	-3.0	-36.7	3.9
Yemen, Rep.	25.5	14.5	-1.9	7.0	-13.9
Zimbabwe	15.0	-1.7	-6.9	-12.1	-6.8

APPENDIX B: ADDITIONAL WVS ANALYSES

We attempted two other exploratory statistical analysis to discover national cultural dimensions embedded in the values measured by the WVS before the one that is presented in Chapter 2 as show in Figure B.1 below. The first two analyses explore transform the data via aggregation methods (numerical dummy variables and central tendency variables) and use two different analysis methods for discovering latent dimensions (principle component analysis and exploratory factor analysis). However, both of the models were rejected for the final analysis due to poor fit. The methods are presented here as a reference for those attempting to study large data sets of individual responses at a higher unit of analysis.

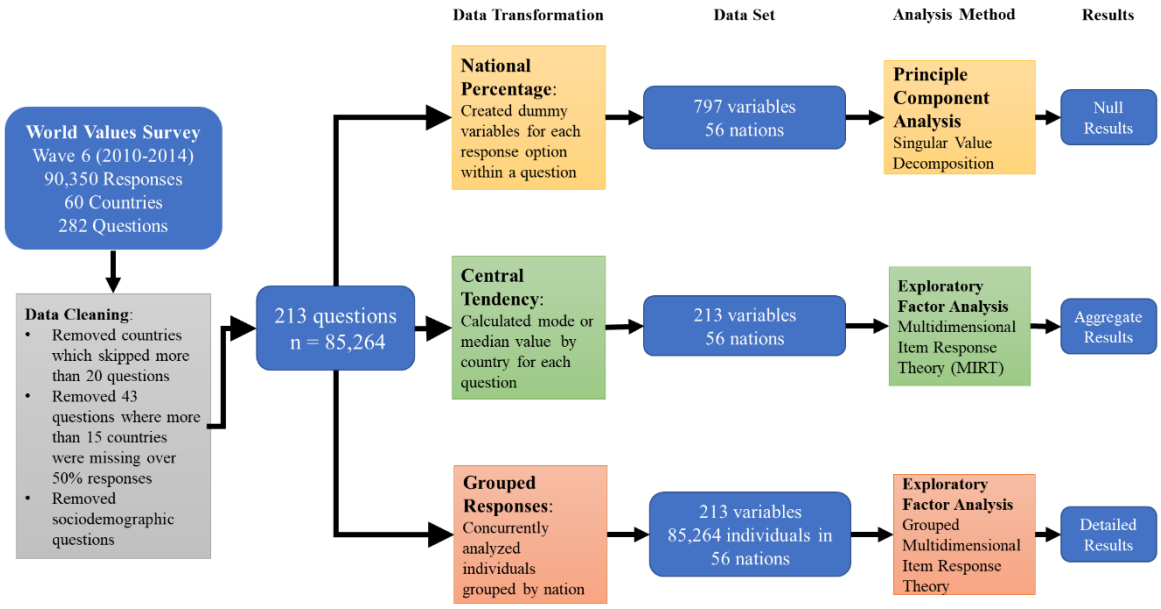

Figure B.1: Additional Analyses in National Model Creation

Data Transformation

This study aimed discover new national cultural dimensions using data from Wave 6 of the WVS. We do not believe that nations are culturally homogeneous; however, for this study, nations are the common unit of analysis and offer platform for understanding global trends. There is considerable debate about how to create this aggregate metrics and analyze the relationships (Peterson and Castro 2006). In cross-cultural research (i.e. Hofstede's study of IBM employees), researchers tend to aggregate the individual responses before looking at the relationships between the variables. The relationships are then only applicable to the aggregate level and cannot be an assumed trait in any lower level. Like many other cross-cultural studies, this study also focused on relationships at the national level. However, unlike most cross-cultural studies, we are using the entire dataset collected by World Values Survey collected between 2010 to 2014. As downloaded, there are 339 coded questions from 60 countries in the Wave 6 WVS Data (accessible at www.worldvaluessurvey.org). The questions are a combination of ordinal (interval), nominal (unordered), and metrical responses. The data had a considerable amount of missing values that had to be removed prior to any sort of data analysis. Instead of removing individuals with missing responses, which would remove over

half of our data and many countries all together, the missing values were turned into variables whereby the amount of missing responses per questions and per country could be analyzed. The R code to clean the data can be seen in Appendix A. From the original data, four countries and 42 questions were removed from the analysis due to large amounts (over 50%) missing values for more than 20 questions and 15 countries, respectively. All sociodemographic questions were also removed from the dataset. Sociodemographic information while relevant to ethnicity and community are not values. The resulting dataset contains 56 countries (85,264 individual respondents) and 213 question variables, moving forward this will be called the *WVS_Dataset*. The first and second data transformations were to aggregate the data to the national level as shown in Figure B.1. As would be expected, there are several ways to aggregate individual level responses into a national score. First, the percentage of respondents by country for answer category was calculated. This created a set of dummy variables, measured from 0% to 100% that could be further analyzed using principle component analysis. Second, each county's median or mode response for every question. This created a set of ordinal and nominal values that was analyzed using a unique type of exploratory factor analysis called the multidimensional item response function.

Numerical Percentage Variables

The remaining 213 variables were divided into nominal and ordered questions. Nominal questions (unordered) and short interval questions with four or less response options were broken into multiple dummy variables. Each variable represented a nominal response option. Table B.1 shows an example of how the variables were created. Binary or dichotomous questions are questions with only two response options. Only one of the two response options for binary questions was modeled since the variables are compliments of each other. Each variable represents the proportion of people within a given country who choose that response option. Ordered or ordinal responses (i.e. Likert scale from 1 to 10) were grouped together so that there would be consistency in the number of variables created per question and therefore more reasonable comparisons between variables. The majority of nominal questions and short interval questions has four response options. For example, responses 1 and 2 for a Likert response question was grouped into one variable and the proportion of people within a country who answered 1 or 2 was calculated. Thus every question, which had a Likert scale from 1 to 10 as response options, resulted in five variables.

Table B.1: Expansion of Questions to Variables

<u>Question 223</u>: How often do you use the internet to obtain information about what is going on this country and the world?

Variable Name	Response
223_Cat 1	Daily
223_Cat 2	Weekly
223_Cat 3	Monthly
223_Cat 4	Less than Monthly
223_Cat 5	Never

The resulting data set contained 56 countries with 213 questions but 797 variables. Moving forward this data set is called the *WVS_Precentage_Variables*. Since dummy variables were created such that the sum of all the variables related to the same question sum to one, each question's variables are highly correlated with each other. These correlations create problems for both dimension reduction techniques and linear regressions. In order to avoid the collinearities that this design setup creates, five variable reduction strategies were attempted. From each strategy, a different data set is created. The first dataset removed a reference variable from each set of variables representing a single question *(WVS_ Precentage_Variables1*). This avoids the risk of multicollinearity (Hardy 1993). For our second dataset, the number of variables was reduced by running a chi-square test on each question's set of dummy variables, independently (McHugh 2013). All the contingency tables created in the chi-square test had significant p-values, and no variables were excluded. Third, a principal component analysis reduced the set of variables for each question to its first principle component *(WVS_ Precentage_Variables2*). The first principle component for each question is then used in another principle component analysis to combine the different questions into latent dimensions. This method is controversial because you are essentially are aggregating the data twice; however in exploratory data analysis, it is useful to explore a variety of ways of representing the data. It is important to note that the question dimensions will represent different proportions of the original dummy variables. For example, the first principle component for question V5 represents 78% of the original dummy variables whereas the first principle component for question V91 represents only 45% of the original dummy variables. Thus, some question dimensions are more representative than others.

Next, variables were eliminated from the dataset based on its variation. The assumption here is that the variables with the most variability across countries will have the highest potential of showing difference between nations since the variables themselves have a considerable amount of spread. Variables with less than 20% of the maximum variability in the dataset were eliminated to create our third dataset *(WVS_ Precentage_Variables3*). This data set contained 150 variables including the reference questions. No question retained all the dummy variables after low variability filter therefore no additional variables were removed to avoid collinearity. Finally, a Kendall correlation coefficient was used to determine which

variables to retain in the dataset *(WVS_ Precentage_Variables4*). Only variable which had a positive or negative correlation above 0.7 were kept in the dataset. Hofstede used Spearman coefficients at 0.7 or higher to identify some of his variables (Hofstede 2001). Next, one variable per question was selected to prevent over representation of a single question *(WVS_ Precentage_Variables5*).

In order to reduce these five different datasets to their latent dimensions, principle component analysis was used. The details of this analysis are explained in the latent dimension section, below. The results of this analysis are shown in the results section under national dummy variables. While creating dummy variables retains the most amount of data at the national level, it also creates spurious correlations between the variables of the same question. Therefore, the results presented are inconclusive and led to a second strategy of data transformation and eventually to the grouped analysis of the individual data

Central Tendency Variables

Starting with the individual responses from the *WVS_Dataset*, a country median or mode was calculated for every country. For questions with ordered responses (Likert scales 1 to 10), the country's median response was calculated as the point where more than 50% of country had responded with equal or lower responses. For categorical and dichotomous questions, the most common response or mode within a single country was found. The resulting dataset contains a country's median or mode for each question. This dataset was further cleaned to remove questions where the mode or median value was the same for all countries. The resulting data frame had 188 question variables and 56 country observations. Any remaining missing values were imputed using "mice" package in R. The mice package uses a logistic regression for two factor and a polytomous (unordered) variables and regular regression for factors greater than two levels. For numeric data, which the Likert data is assumed to be, the imputation is based on predictive mean matching (Buuren and Groothuis-Oudshoorn 2010).

This dataset is called the *WVS_Central_Tendency* for the remainder of this document. While this dataset does not retain the level of detail as *WVS_Precentage_Variables*, this dataset does not create spurious correlations between the variables. Variable correlations are assumed to be caused by latent dimensions that cannot be measured. Furthermore, this dataset can be analyzed using an exploratory factor analysis. Figures 1, 2, 3 and 4 in Appendix C show the distribution of the medians and modes for each question. From these figures, it is apparent that the variables are non-normally distributed and that many of the available responses are not longer included in the dataset. For example in question V197, asking weather they see the world as being better off (10) or worse off (1) from science and technology. All countries have a median values between 6 and 10, indicating that of the countries surveyed most people believe that the world is better off because of science and technology.

Latent Dimensions

Unlike like manifest variables (i.e. age), latent dimensions (i.e. happiness) cannot be directly measured. Therefore, latent dimensions are typically measured through a series of manifest variables. A principle component analysis is a descriptive way and factor analysis is a model-based technique of combining variability from these manifest variables into a smaller number of uncorrelated components or factors, often representing latent dimensions. These latent dimensions are essentially new variables that are measuring the latent dimension on a

numerical scale (Bartholomew et al. 2008). Throughout this discussion, the term latent dimensions is used to describe the output of the latent models. In principle component analysis, the outputs are sometimes referred to as the principle components or just components. In the factor analysis, the outputs are often referred to as the latent factors, abilities or traits. We choose to use the term latent dimensions in order to stay consistent with the existing cultural literature, but latent dimensions are also the outputs of the multivariate models.

Inglehart and Welzel used principle component factor analysis (Inglehart and Welzel 2005), while Hofstede used a factor analysis (Hofstede 2001). Fundamentally, these analyses are biased by the manifest variables that are included in the analysis. For example, previous analyses of the WVS use less than 25 of the original questions; in fact the most recent analysis only uses ten questions (Inglehart and Baker 2000). Hofstede uses even only three questions in his power distance and uncertainty indexes and only four questions for individualism and masculinity indexes (Hofstede 2001). Since this research is exploratory, we include a large variety of questions for variable reduction because it allows the theoretical constructs to emerge from the WVS dataset. We will now explain more about principle component analysis and factor analysis.

Principle Component Analysis

Principle component analysis (PCA) is a multivariate statistical method, which reduces the number of variables by linear combination into components, which account for the majority of the variability in the original variables. In other words, PCA converts a set of correlated variables into a set of uncorrelated components, as represented in the equations below as x_i and y_p respectively (Bartholomew et al. 2008). When the equations below are evaluated, the resulting values are called component scores.

$$y_1 = a_{11}x_1 + a_{21}x_2 + \cdots + a_{p1}x_p$$
$$y_2 = a_{12}x_1 + a_{22}x_2 + \cdots + a_{p2}x_p$$
$$\cdots$$
$$y_p = a_{1p}x_p + a_{2p}x_2 + \cdots + a_{pp}x_p$$

Where a_{pp} is the loading of the variable of the component.

Typically, PCA starts with a correlation and covariance matrix. Since our data has more variables (p = 621) than observations (n = 56), we used singular value decomposition to calculate the loadings and scores. Singular value decomposition uses the matrix (*n* x *p*, where n is the number of observations, and p is the number of variables) to calculate three vectors – u_{ik}s, v_{jk}s, and singular values. The vector $u_{jk}\sqrt{n-1}$ holds the component scores; the vector $v_{jk}\sqrt{\lambda_k}$ holds the loadings; and finally, the singular values which are proportional of the eigenvalues, $\lambda_k s$. Eigenvalues are used to determine the importance of the components. Using the prcomp function in R, we analyzed each data set. The output of the principle component analysis is the eigenvector also known as loadings and are the coefficients in front of the each

variable in the linear combination. In order to create loadings between -1 and 1, the raw data is standardized for both center and scale. After a principle component analysis is complete the researcher must decide how many components are relevant to maintain and how to interpret the components. Most commonly the number on components are retained based on the components' eigenvalues and the scree plot. Components with eigenvalues larger than one are retained or the components before "the elbow" in the scree plot. The elbow is when the plot begins to level out and therefore the components are not adding significantly different amounts of variance (Bartholomew et al. 2008; Costello and Osborne 2005). Interpreting the meaning of the principle components often requires researchers to decide which variable coefficients or loadings are strong enough to contribute significant meaning to the component, particularly if there are large amount of variables. A study by Richman and Gong studied the effect of at varying cutoff points and determined that researchers should look for sharp changes in the loading to determine the cutoff points should be. With sample sizes over 50, they found that generally loadings between +/- 0.2 to 0.35 could be ignored during interpretation (Richman and Gong 1999).

Since three different analysis procedures were explored, similarly there are three sets of results: one from the principle component analysis, one from the aggregate exploratory factor analysis, and finally one from the grouped MIRT analysis. The PCA results are noisy due to the large number of variables and unfortunately do not provide useful results as can be seen in Table 2. On the other hand, the *WVS_Central_Tendency* dataset was analyzed with an exploratory factor analysis and provided much clearer results. Finally, the Grouped Response Model is currently running on the high performance computing cluster operated by the University of Washington. As such no results can be reported on this model.

Exploratory Factor Analysis with Item Response Functions

The second form of analysis used in this study was an exploratory factor analysis. As was mentioned earlier, a factor analysis is a model-based technique that aims to explain the correlations between the variables rather than the other all variance. Factor analyses are traditionally used when it is assumed that both the observed variables and latent dimensions are metrical variables. The model is set up is very similar to a principle component analysis expect that a factor analysis focuses on how the observed variable is the result of a combination of latent dimensions as well as the variables' own uniqueness. The most common factor model also called the principal axis factor model is a linear combination of the factor loadings (α) and the common factors (f_q) as well as the observed variables residual (e_i) to estimate the value of the manifest variable (x_i), as seen below (Henson and Roberts 2006).

$$x_i = \alpha_{i0} + \alpha_{i1} f_1 + \alpha_{i1} f_2 + \cdots + \alpha_{iq} f_q + e_i \quad (i = 1, \ldots, \mathrm{p})$$

Where there are p observed variables and q latent dimensions.

Other assumptions for the tradition linear factor model include that the observed variables are normally distributed with mean zero and variance one and that the correlations among the observed variables are explained fully by the factors (Bartholomew et al. 2008). The *WVS_Precentage_Variables* datasets severely violate the second assumption; furthermore, the

majority of the variables are not normally distributing again making it an impractical application of this model; therefore, only PCA was performed on the *WVS_Precentage_Variables* datasets while the *WVS_Central_Tendency* dataset can be used in an exploratory factor analysis for ordinal and nominal variables.

An exploratory factor analysis is a model based technique that looks for relationships within the data without prior assumptions about those relationships. There are many options for extracting the factors from the original data set. As was explained above, the principal axis factoring method is the most common, particularly for numerical data which is non-normal. For normally distributed data, the maximum likelihood methods is preferable (Costello and Osborne 2005). The results of a factor analysis are a series of component loadings which represent the relationship between the observed variables and latent dimensions. These factors can then be rotated in order to clarify interpretation. Rotating the factors does not change the model, but it does change how the factors distribute the variance. In other words it is a new perspective on the same factors and rotations are often used to clarify interpretations. Representing a considerable amount of the original variance and failing to reject the null hypothesis in a goodness of fit test are two good ways of establishing model fit (Bartholomew et al. 2008).

When the observed variables are categorical (ordered and unordered), as in the *WVS_Central_Tendency* dataset, the common factor model must be adapted into what has been historically called a latent trait analysis. Latent trait analysis uses distributions to estimate how categorical data can be projected into a numerical regression model using threshold distribution functions such as probit, logit and normit (Simpson 1995). Similar to binary regression analyses, a categorical factor analysis has two approaches for estimating the common factor model: (1) the underlying variable approach and (2) the item response function. The underlying variable approach suggests that the observe categorical variable is only a partial observation of a numerical variable and that there are unobserved thresholds that push observations from one category to the next. Instead of using Pearson correlations, the underlying variable approach uses polychoric correlations using a bivariate normal distribution (Bartholomew et al. 2008; Holgado–Tello et al. 2010). Those polychoric correlations can then be used in a common factor analysis using a weighted least squares or maximum likelihood estimation. On the other hand the item response function uses the logit model to model the probability of a response being in a response category (Bartholomew et al. 2008). As shown in the equations below, the logit function links the linear factor function of f_1 to f_q latent dimensions to the observed binary data. The probability of a positive response for the variable, *i*, given the latent dimensions is denoted as $\pi_i(f)$. Note that the functions above were developed for the dichotomous case; additional functions must be added when there are more than two categories, as explained below.

$$Link\ Function: \pi_i(f) = \alpha_{i0} + \alpha_{ij}f_i + \cdots + \alpha_{iq}f_q \quad (i = 1, \ldots, p)$$

$$Logit\ Link\ Function: logit\ \pi_i(f) = log_e\left(\frac{\pi_i(f)}{1 - \pi_i(f)}\right) = \alpha_{i0} + \sum_{j=1}^{q}\alpha_{ij}f_i$$

$$Rearranged: \ \pi_i(f) = \left(\frac{\exp\left(\alpha_{i0} + \sum_{j=1}^{q} \alpha_{ij} f_i\right)}{1+\exp\left(\alpha_{i0} + \sum_{j=1}^{q} \alpha_{ij} f_i\right)} \right) = \frac{1}{1+\exp\left(-\left(\alpha_{i0} + \sum_{j=1}^{q} \alpha_{ij} f_i\right)\right)}$$

The intercept (α_{i0}) is also called the difficulty parameter because as it increases in value the probability for all the factors shifts left and right. The discrimination factors $(\alpha_{i1} \ldots \alpha_{iq})$ will alter the steepness of the curve, altering the relationship between the factor values and the likelihood of a positive response for the observed variable. This model is called the two-parameter logistic model (2PL) due to the two parameters describing the response function. We will use this model for questions with have only two responses (i.e dichotomous variables).

When there are multiple categories, the item response function changes forms because instead of just having the probability of a positive response, the response function must determine the probability for any of the given response. There are four general approaches in creation of the item response function: (1) adjacent categories, (2) continuation ratio, (3) cumulative, and (4) nominal. For purposes of this study we will use an adjacency method for the ordered responses and the nominal approach for the unordered responses. The continuation approach focuses on responses that are sequential test questions (i.e. must get the first question right, to get the second right) and thus is not applicable to our data.

The cumulative approach estimates the probabilities of a response against the probability of being in the remaining response categories. The graded response model (GRM) is a widely used cumulative method. Graded response model replaces the category response function $\pi_i(f)$ can replaced by the cumulative response function $\gamma_{i(s)}(f)$. The cumulative response function is a sum of the category response functions, where the categories have been divided into two groups (Bartholomew et al. 2008). While the graded response model can be applied to our data, we decided use the adjacency approach as it is more similar to the nominal model as is explained below.

The adjacency approach measures the probability of choosing a certain response against the probability of the response directly below it and is considered a generalization of the 2PL model. It is a generalization because the probability must be calculated and compared between multiple groups whereas the 2PL model is specific to binary questions. The general partial credit model (GPCM) is a common application of the adjacency approach. Similar to the 2PL there are two parameters defining the relationship between the latent dimensions and the original manifest variables. The discrimination factor describes the steepness of the curve and the difficulty factor is the intercept.

The nominal response model (NRM) is used for questions which truly have no order in the responses. This model is a generalized version of the GPCM (Penfield 2014; Thissen and Steinberg 1986) because instead of comparing the probability of one response to the one adjacent to it, this model compares probabilities against all remaining categories (Bock 1972). The NRM has two parameters explaining how the latent dimension(s) relate to the probability of certain response. However, since there are now multiple categories the discrimination factor is divided into two different coefficients one for the entire item or question and another representing the specific response to a question. These are called the scoring coefficients (ak_i)

because they represent the probabilistic ordering of the categories and aid with interpretation of the model (Chalmers 2018).

In *mirt*, both the GPCM and the NRM are modeled using the same formula. In the GPCM model however, the scoring coefficients are constrained to integer values (0,1,…,k-1 where k is the number of categories for a question) defining the order of the categories. In the nominal model, these are mathematically modelled as a unknown parameter in the EM function. The equation below defines the probability of a certain response, k, of a question with defined values of the latent dimensions (θ) and parameters (ψ). The discrimination factors for the question on a specific factor are a_1, a_2,.. a_q and d_{k-1} indicated the frequency of being selected. Since the focus is on category k within an question, d_{k-1} is not considered the difficulty factor. If a nominal question had categories that were ordered, ($ak_1 < ak_2 < ak_3$, etc); however, if $ak_1 > ak_2$ this indicates that ak_1 is more related to the latent dimension than ak_2.

$$P(x = k \left| \theta, \psi \right.) = \frac{\exp\left(ak_{k-1} * \left(a_1 * \theta_1 + a_2 * \theta_2 + \cdots + a_q * \theta_q\right) + d_{k-1}\right)}{\sum_1^k \exp\left(ak_{k-1} * \left(a_1 * \theta_1 + a_2 * \theta_2 + \cdots + a_q * \theta_q\right) + d_{k-1}\right)}$$

Both the GPCM and the NRM are considered divide by total models as can seen in the equations where as the graded response model is a difference model (Thissen and Steinberg 1986). For ease of interpretation we have used the link functions which used the same definitions for the difficulty and discrimination parameters: 2PL, GPCM, and NRM. To model this relationship, the computer program R was used. Specifically, we used the *mirt* function which uses a maximum likelihood estimates for the specified item response functions to match the correlations between the original variables and the correlations between the proposed factors (Bartholomew et al. 2008; Chalmers 2012). With the *mirt* function we specified the 2PL for questions which had only two response categories or where only two response categories were used, the GPCM for questions with ordered responses, and the NRM for questions with unordered responses. This was an iterative process because although the questions may have been written with an intended order, the responses do no always reflect that ordering; therefore, questions that showed unordered results were modelled under the NRM, even if they were created as an ordered question.

To estimate the parameters of the link functions the *mirt* function used the Monte Carlo expectation maximization algorithm (MCEM). The expectation-maximization function is an iterative process where an initial set of parameters are chosen and the probability distributions for different response patterns are created based on the values of the latent dimension (Bock et al. 1988). This is called the expectation step because the expected values of the latent dimensions are calculated. In the maximization step, most likely values of the latent dimensions are used to create a new estimate of the parameters. These two steps are repeated until the model parameters converge (Do and Batzoglou 2008). The MCEM repeats the EM process using Monte Carlo simulations by iteratively picking samples from the dataset (Levine and Casella 2001; Natarajan et al. 2000). An alterative method of estimation is called the Metropolis-Hastings Robbins-Monroe (MHRM). Unlike the MCEM method, the MHRM method randomly selects the latent dimension values and then solves the parameters using loglikelihood. This method is often not as accurate as the EM; however, with high dimensional

models, MHRM is computationally easier and is often used For our analysis, both estimation methods were used and the better fitting model based on the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). Both AIC and BIC are model selection tools based on penalized criteria. The model fit is penalized as the number of parameters increase. AIC assumes that a true model does not exist and instead focuses on how well the model predicts future data while BIC looks for models with the highest probability of being the true model. However, in both estimates, the best model with minimize both values (Burnham and Anderson 2004; Kuha 2004).

In exploratory factor analysis, choosing the number of factors is often done by eigenvalues, scree plots, or the percent of variance explained by the resulting latent dimensions (Costello and Osborne 2005; Henson and Roberts 2006); however, since our model is based on item response functions, only the percentage of variance is directly calculated from *mirt*. Therefore, we also analyzed the model fit using AIC and BIC; both of which should be minimized in the creation of better fitting models. Finally, rotation of the axes as was explained above is often useful to ease interpretation. The varimax rotation maintains an orthogonal relationship between the factors; whereas the oblimin rotation allows the factors to be correlated. When selecting a rotation or perspective to present the data, it is best to have variables relate to only one variable and reduce variables relating to multiple factors, called cross-loading. As can be seen in Figure 5, the varimax rotation accomplishes this as seen through the closer clustering near the axes for factors one and two. Finally, to estimate the factor scores for an multidimensional polytomous item response model, *mirt* uses maximum a posteriori (MAP) to estimate the factor scores which selects the score with the maximum likelihood for the given response pattern of the country (Embretson and Reise 2013).

Since the *WVS_Central_Tendency* data set contains observations for 56 countries across 188 questions, the Monte Carlo function was used in order to stabilize the results. While 56 observations is a limited sample size (Foley 2010; Jiang et al. 2016; de Winter et al. 2009), previous research has found that small sample sizes can provide reliable models particularly when the variable loadings are high, the number of factors are limited, and the observed variables are numerous (Foley 2010; de Winter et al. 2009). Meuleman and Billet (2009) studied the minimum number of countries needed in a cross cultural multilevel structural equation model, which was looking at both the variation between countries and within countries and determine that 40 countries should suffice to detect reliable difference in countries (Meuleman and Billiet 2009). However, models with less parameters are easier to estimate even with smaller samples; therefore, it is recommended to limit the model to as few as factors as are representative of the underlying data. In an exploratory factor analysis, the research specifies the number of factors to model; however, interpretability and representativeness are working against each other. Since variables can load on to multiple factors having too many factors in a model can disguise their meaning; however having too few factors can create loss of valuable information.

APPENDIX C: R CODE FOR NATIONAL DIMENSIONS

(For the full downloaded code, please see https://github.com/Laalliso/CrossCulturalDimensions)

Exploratory Factor Analysis

```
#load required libraries
library(mirt)
library(plyr)

#Load Cleaned Data File
Individual_MIRTData <- read.csv("Individual_MIRTData_NBO198.csv")
Individual_MIRTData <- Individual_MIRTData[,c(3:202)]
Individual_MIRTData_test <- Individual_MIRTData

#Specify number of factors for exploratory model
model=5

# Specify the question type by in order by column name
itemT <- rep('graded', 198) #Ordered
itemT[1:11] <- '2PL' #Categorical, but reduced to binary
itemT[12:22] <- 'nominal'
itemT[19] <- '2PL' #Categorical, but reduced to binary
itemT[21] <- '2PL' #Categorical, but reduced to binary
itemT[22] <- '2PL' #Categorical, but reduced to binary
itemT[23:52] <- '2PL' #Binary

#This code will run five iterations of the analysis (specified in NCYCLES).  We only run
   five iterations to demonstrate how to checkpoint (stop and save current progress).
Grouped_MIRT <- multipleGroup(Individual_MIRTData_test[,c(3:200)],
                              model = model,
                              group = as.character(Individual_MIRTData_test$V2.x),
                              rotate = "none",
                              invariance = c("slopes","intercepts","free_means"),
                              itemtype=itemT,
                              method = "EM",
                              technical=list(NCYCLES=5),
                              survey.weights = Individual_MIRTData_test$V258.x)

Parameters <- mod2values(Grouped_MIRT_Model_All_Countries_SIM)
timestamp <- format(Sys.time(), "%Y%m%d_%H%M%S")
filename<-  paste("Parameters_NBO_198Q56C_5F_MCEM",timestamp,".Rdata",sep="")

save(Parameters , file="StartingParameters.Rdata")
save(Grouped_MIRT, file="EFA_Model.Rdata")
```

```
#Now you have completed and saved five iterations of the analysis, now you will restart the
analysis from where you left off.  Please note that if your analysis converges quickly you may
not need to checkpoint your code like this.

    load("StartingParameters.Rdata ")
    Grouped_MIRT <- multipleGroup(Individual_MIRTData_test[,c(3:200)],
                                  model = model,
                                  group = as.character(Individual_MIRTData_test$V2.x),
                                  rotate = "none",
                                  invariance = c("slopes","intercepts","free_means"),
                                  itemtype=itemT,
                                  method = "EM",
                                  technical=list(NCYCLES=20),
                                  pars=Parameters,
                                  survey.weights = Individual_MIRTData_test$V258.x)

    save(Parameters  ,file=filename) #saves a unique file
    save(Parameters , file="StartingParameters.Rdata") #overwrites the previous file
    save(Grouped_MIRT, file="EFA_Model.Rdata") #saves the model

#Continue to iterate until the parameters values have converged.  Watch the max change value
in the output.
```

Confirmatory Factor Analysis

```
Grouped_MIRT_Model_All_Countries_Summary <- summary(Grouped_MIRT,
                                                    rotate="oblimin")

Summary_Names <- paste("Summary_Oblimin",
                       unique(Individual_MIRTData$V2.x),
                       sep = "_")
n=56
i=1

for(i in 1:n){#loops through the countries
  Country_Loadings <- Grouped_MIRT_Model_All_Countries_Summary[[i]] #focuses on
one country
  names(Country_Loadings)
  Country_Loadings_Values <- as.data.frame(Country_Loadings$rotF)
  assign(Summary_Names[i], Country_Loadings_Values)
  i=i+1
}
```

```
#Now identify all the variables which load onto a factor above 0.3 in magnitude

F1_Items <- which(abs(Summary_Oblimin_112$F1)>0.3)
cat(F1_Items, sep=",")
F1_Variable_Names <- colnames(Individual_MIRTData[,(F1_Items+2)])
F1_Variable_Names

F2_Items <- which(abs(Summary_Oblimin_112$F2)>0.3)
cat(F2_Items, sep=",")
F2_Variable_Names <- colnames(Individual_MIRTData[,(F2_Items+2)])
F2_Variable_Names

F3_Items <- which(abs(Summary_Oblimin_112$F3)>0.3)
cat(F3_Items, sep=",")
F3_Variable_Names <- colnames(Individual_MIRTData[,(F3_Items+2)])
F3_Variable_Names

F4_Items <- which(abs(Summary_Oblimin_112$F4)>0.3)
cat(F4_Items, sep=",")
F4_Variable_Names <- colnames(Individual_MIRTData[,(F4_Items+2)])
F4_Variable_Names

F5_Items <- which(abs(Summary_Varimax_112$F5)>0.3)
cat(F5_Items, sep=",")
F5_Variable_Names <- colnames(Individual_MIRTData[,(F5_Items+2)])
F5_Variable_Names

Oblimin_0.3Cutoff <- c(F1_Items, F2_Items, F3_Items, F4_Items, F5_Items)
Oblimin_0.3Cutoff_Unique <- unique(Oblimin_0.3Cutoff) #55 variables

Reduced_DF <-
Individual_MIRTData[,colnames(Individual_MIRTData[,sort((unique(Oblimin_0.3Cutoff)+
2))])]

Reduced_DF<-
cbind(Individual_MIRTData$V2.x,Individual_MIRTData$V258.x,Reduced_DF)
#write.csv(Reduced_DF, "CFAData_5F_0.3Cutoff_55Q56C_Oblimin.csv")

#Column numbers in new df, paste output into CFA mode set up
model_col <- which(colnames(Reduced_DF) %in% c(F1_Variable_Names))
colnames(Reduced_DF[,c(model_col)])
cat(model_col-2, sep=",")

model_col <- which(colnames(Reduced_DF) %in% c(F2_Variable_Names))
colnames(Reduced_DF[,c(model_col)])
cat(model_col-2, sep=",")
```

```
model_col <- which(colnames(Reduced_DF) %in% c(F3_Variable_Names))
colnames(Reduced_DF[,c(model_col)])
cat(model_col-2, sep=",")

model_col <- which(colnames(Reduced_DF) %in% c(F4_Variable_Names))
colnames(Reduced_DF[,c(model_col)])
cat(model_col-2, sep=",")

model_col <- which(colnames(Reduced_DF) %in% c(F5_Variable_Names))
colnames(Reduced_DF[,c(model_col)])
cat(model_col-2, sep=",")

ItemType_ReducedDF <-ItemType[ItemType$item %in% c(colnames(Reduced_DF)),]
ItemType_ReducedDF <-as.character(ItemType_ReducedDF$itemType)
#cat(paste(shQuote(ItemType_ReducedDF$itemType, type="cmd"), collapse=", "))

#CFA Model Setup
```

Model with all the factors being correlated (shown below) will create a non-postive latent trait matrix and fail.

```
model='F1 = 12,13,15,16,17,37,38,39,52,53,54
      F2 = 1,2,3,4,5,6,7,8,9,10,11,14,18,52
      F3 = 46,47,48,49,50,51,55
      F4 = 19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36
      F5 = 40,41,42,43,44,45
     COV = F1 * F2 * F3 * F4 *F5'

#load the files that are relevant to your subset
Reduced_DF<- read.csv("CFAData_5F_0.3Cutoff_55Q56C_Oblimin.csv")
Reduced_DF<- Reduced_DF[,c(2:ncol(Reduced_DF))]

# Specify the question type names from a csv file
ItemType <- read.csv("CFA_ItemType.csv")
#Matches names of column
ItemType_ReducedDF <-ItemType[ItemType$item %in% c(colnames(Reduced_DF)),]
ItemType_ReducedDF <-as.character(ItemType_ReducedDF$itemType)

model='F1 = 12,13,15,16,17,37,38,39,52,53,54
      F2 = 1,2,3,4,5,6,7,8,9,10,11,14,18,52
      F3 = 46,47,48,49,50,51,55
      F4 = 19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36
      F5 = 40,41,42,43,44,45'
```

```
#Check pointed CFA model

Grouped_MIRT_CFA_5F<- multipleGroup(Reduced_DF[,c(3:ncol(Reduced_DF))],
                        model = model,
                        itemtype=ItemType_ReducedDF,
                        group = as.character(Reduced_DF$`Individual_MIRTData.V2.x`),
                        invariance = c("slopes","intercepts","free_means"),
                        method = "EM",
                        technical = list(NCYCLES=25),
                        survey.weights = Reduced_DF$`Individual_MIRTData.V258.x`)

Parameters <- mod2values(Grouped_MIRT_CFA_5F)

timestamp <- format(Sys.time(), "%Y%m%d_%H%M%S")
filename <-  paste("Parameters_5F_CFA",timestamp,".Rdata",sep="")

save(Parameters  ,file=filename)
save(Parameters , file="StartingParameters_5F_CFA.Rdata")

#save model - nice to update the model name to something more descriptive
save(Grouped_MIRT_CFA_5F, file="Model_5F_CFA.Rdata")

#Restart CFA model

Grouped_MIRT_CFA_5F<- multipleGroup(Reduced_DF[,c(3:ncol(Reduced_DF))],
                        model = model,
                        itemtype=ItemType_ReducedDF,
                        group = as.character(Reduced_DF$`Individual_MIRTData.V2.x`),
                        invariance = c("slopes","intercepts","free_means"),
                        method = "EM",
                        technical = list(NCYCLES=25), pars=Parameters,
                        survey.weights = Reduced_DF$`Individual_MIRTData.V258.x`)

Parameters <- mod2values(Grouped_MIRT_CFA_5F)

timestamp <- format(Sys.time(), "%Y%m%d_%H%M%S")
filename <-  paste("Parameters_5F_CFA",timestamp,".Rdata",sep="")

save(Parameters  ,file=filename)
save(Parameters , file="StartingParameters_5F_CFA.Rdata")

#save model - nice to update the model name to something more descriptive
save(Grouped_MIRT_CFA_5F, file="Model_5F_CFA.Rdata")
```

#Global Fit Results for CFA model

The multiple group models do not have enough responses within each country to calculate RMSEA or CFI or TLI, particularly because missing data is not allowed. Therefore, we transformed the multiple group model into a single group model. We did this by transferring the parameters from the multipleGroup model to a single group model. We forced the model to converge instantly resulting in the same parameters in the global model as was modelled in each country. (Remember that we held the slope and intercept constant between all countries).

```
model='F1 = 12,13,15,16,17,37,38,39,52,53,54
      F2 = 1,2,3,4,5,6,7,8,9,10,11,14,18,52
      F3 = 46,47,48,49,50,51,55
      F4 = 19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36
      F5 = 40,41,42,43,44,45'

Reduced_DF<- read.csv("CFAData_5F_0.3Cutoff_55Q56C_Oblimin.csv")
Reduced_DF<- Reduced_DF[,c(2:ncol(Reduced_DF))]

ItemType <- read.csv("CFA_ItemType.csv")

ItemType_ReducedDF <-ItemType[ItemType$item %in% c(colnames(Reduced_DF)),]
ItemType_ReducedDF <-as.character(ItemType_ReducedDF$itemType)

Parameters <- mod2values(Grouped_MIRT_CFA_5F)

#the cutoff row changes depending on the number of parameters that were estimated. Look
in Parameters.csv to determine when group 1 ends.
Pars_Global <- Parameters[c(1:472),]
Pars_Global$group<-"all"
head(Pars_Global)

obj <- mirt(Reduced_DF[,c(3:ncol(Reduced_DF))],
          model = model,
          itemtype = ItemType_ReducedDF,
          TOL=NA,
          method="EM",
          survey.weights=Reduced_DF$`Individual_MIRTData.V258.x`,
          pars=Pars_Global)

summary(obj)
obj@Fit

#Check the model fit
# (na.rm will remove all responses with missing values, since we are using global data set;)
M2(obj, type="M2*", QMC=TRUE, na.rm=TRUE)
```

APPENDIX D: INTERVIEW SUPPLEMENTARY MATERIAL

Coding Dictionary

	Code	Definition
Planning	Authority of Indigenous People	Indigenous People often have different authority within the regulatory structure due to historical discrimination. This code includes how they have the authority to change or stop projects that conflict with their lands and/or livelihoods.
	Application Cost	In order to evaluate the impacts of a wind farm, a wind developer must develop an permit application, containing wildlife and historical investigations. These cost a considerable amount of money.
	Jurisdiction	In the development of a wind farm, there are several key decision makers depending on where you located. These people are who decide on application or review the permit. It is the characteristics of these areas. This does not include how they make their decision (see project review).
	Land Use Plan	This is a document that discusses how different areas of land should be used, often called a zoning plan or ordinance.
	Lawsuits/ Appeals	After a permit has been issued, it is not immediately irrevocable in Sweden permits can be appealed three times while in the United States, lawsuits can be filed against the permit.
	Regulations	Regulation stipulates how wind farms are approved. They set out a series of steps that developers should follow in order to get approval to build a wind project. They stipulate the authority of the jurisdiction.
	Regulations: Consultation Process	Developers are required to setup hearings and inform the public of what they are planning to do. They must also respond formally to those comments in the application. In the US, this is called scoping.
	Regulations: Property Rights	Property rights indicate to some extent how overarching the regulations are.
	Regulations: Hearings	In the US, when the jurisdiction is deciding on an ordinance or proposed project they will call a hearing and vote. People are allowed to speak out for or against the project at that time. This is NOT the same as the scoping process. This is the voting procedure by the jurisdiction is charge (typically township or county planning commission).
	Regulations: Mitigation	Regulations often require developers to have strategies to protect wildlife from potential impacts.
	Regulations: Review Time	The projects applications take several years to evaluate and wind turbine technology is continuing to improve. Therefore, in many cases the approved projects will have to be updated because they are too old.
	Regulations: Revenue Structure	This is how money is contributed to the community. Typically, taxes are collected for the county/municipality or for regional/state governments.

	Code	Definition
Market	Financial Policies	Incentives and tax credits have been developed to encourage and support wind energy by providing a reliable revenue stream. These policies are meant to reduce the financial risk of building a wind farm.
	Power Offtake	The electricity produced needs to be put on an electrical grid and sold to someone. Wind development companies secure investors to finance the project through guarantees that the project will produce revenue. If the power is not purchased the wind farm cannot make money. They need ACCESS to the grid.
	Production Competition	How electricity was produced and is currently produced within the country is likely to have an impact on how people view the construction of alternative energy production. Different wind energy companies compete for land leases, grid access, and power purchase agreements, but also with lobbyist from the fossil fuel industry.
Siting	Access to Information	People are learning about details of wind energy from family, friends, the internet and media. The information is easily accessible by large amounts of people which means that inconsistent information that is readily disputed. Therefore, developers must speak consistently.
	Alternative (Economic) Interests in Land	Wind development often occurs in areas that is already being used for other purposes such reindeer herding or timber harvesting or previous wind development in Sweden. In the US, wind farms are typically sited on agricultural land, either for crops or ranches.
	Alternative (Non-Economic) Interests in Land	Wind development often occurs in areas that is already being used for other purposes such as hunting, fishing, or recreation. It is not always the land owners who decide how to use their own land, particularly for large forestry companies. Ecosystem Services like species diversity and protection is included here because it typically does not provide direct income to company or individual.
	Alternative (Security) Interests in Land	Wind development often occurs in areas that is already being used for other purposes such as for military flight patterns and training routines.
	Conflict	Conflict often occurs due to the separation of the physical supply and demand for green electricity. Conflict occurs when local impacts of wind farms compete with other uses of the land (e.g. landscape views or recreation).
	Engagement	In order to gain local acceptance, developers gather information from external stakeholders as well as make stakeholders aware of what the company is intending to do. Different strategies are listed as subcategories
	Campaign	For this type of engagement, companies are not focused on giving the external stakeholders all the information they need; instead they are focusing on crafting a message that aligns with the motivates and values of the stakeholders.
	Compromise	Engagement Strategies are often used to determine what needs to happen in order for the development to continue. These compromises typically fulfill the "what's in it for me" type of attitude. They can be small payments or refurbishments of fires stations or schools.
	Experience	Developers use their experience to gain creditability and acceptance with different stakeholders. Typically it includes a description of the work that they have done and what they do within the development process.
	Exchange Information	Companies are only interacting with the community to inform them about what they are doing and understand if there is anyone who could stop them. These strategies usually include photomontages, field trips, expert opinions, open houses, informational meetings about the project.
	Relationships	Companies with engagement strategies typically try to build relationships with the community that they are working or attempting to work in. These relationships are usually formed by creating a dialogue in which information can be exchanged easily.
	Financial Repayment	Often times wind developers will give money back to the community or to neighbors surrounding the wind farm but who do not actually have a wind farm on their property.

	Code	Definition
Siting	Landowner Involvement	Assuming that the developer does not own the land that they want to build on, developers must sign agreements with land owners granting permission to build the wind farms. The landowners have a unique position because they will directly economically benefit from the wind farms.
	Local Impacts: Advantages	A wind farm can contribute to the local economy by bringing in construction work, permanent jobs, and providing revenue. These are inherit advantages, not compromises or additional things that the developer can do it make the wind farm more desirable for communities
	Local Impacts: Disadvantages	Wind farms are large structures that have impacts. They create sound, night lights, and shadow flicker and some have investigated health impacts. They also alter the landscapes and could alter the ambiance of historical sites or summer homes. Again, these are inherit disadvantages, including uncertainty. Wind farm developers often have to wait many years for a permit and people will not know exact details until the wind farm has already been approved.
	Local Impacts: Mixed	Wind farms have benefits and drawbacks for the same features.
	Public Review	This discusses how within a jurisdiction people follow or deviate from the regulations. Often elections will play a role in how people evaluate the application. During the review process, public acceptance is important and project failure is possible
	Project Failure	The rejection of a wind farm application is a loss of economic and human resources for wind development companies. Developers aim to create an application for minimum cost; however, if the application is rejected, the entire project is stopped.
	Public Acceptance	(Coded with project review) Generally used as a term that influences (the jurisdiction's) politicians' decision to accept the permit application.
	Environmental Review	In Sweden, this includes how within country administrative board people follow or deviate from the regulations. They are supposed to evaluate the environmental impacts of the proposed project based on the environmental laws
	Social Power	There are certain people or groups of people who have the ability to influence others through money or networks.
	Skepticism	Doubt in scientific evidence and studies about the impacts of wind turbines
	Spread of Misinformation	The spread of information against wind farms that is it accurate. Misinformation can create higher perceived risks for the authorities and public
	Wildlife (Birds/Bats)	Wildlife is a serious environmental consideration when building wind turbines. Wildlife is similar to an external stakeholder; however, there are many laws protecting species rights which makes it easier for environmental judges to make rulings and for developers to mitigate appropriately. Endangered and/or threatened species have strict laws. Developers typically pay for investigations of the wildlife & habitat in a potential project area. The risk for developers is that the environmental laws and the courts interpretation continues to change.
	Wind Resource	A wind resource is required to build a wind farm. This limits the locations where wind developers can even consider a wind farm.
	External Stakeholders	Undefined group outside the authority of the project but may impact the decision. This is who they are not what they argue about. They could be indigenous people, NGOs, lobby groups.
	Grid Connection	Large wind farms must be able to connect with a larger grid infrastructure.
Plan/Site	Positive Externalities	A major benefit of renewable energy such as wind power is that the do not emit GHG and they help to mitigate climate change. They also do not depend on detrimental resource extraction for electricity production.
	Investigations	Wildlife investigations are required for the permitting process, but also to answer questions from the public and authorities

Fairness (F)	Support for cooperative behavior to avoid inequitable impacts
Long Definition	Fairness measures the importance society places on proactively creating due process and cooperative behavior
Inclusion Criteria (Must include one of the criteria)	• Professionals describing behaviors that are mandatory or voluntary which ensure that the process and impacts are equitable to themselves, surrounding people and wildlife. • For example, mandated public meetings, taxation, and the ability to appeal are regulated ways to build in equity. Public meetings are considered part of fairness because they create procedural fairness, even if nothing changes due to their participation. • Voluntarily developers will improve roads, create community funds and mitigate wildlife impacts to compensate neighbors for the impact of the wind farm. • Compromises are typically developed through conversations. Conversations are different than just collecting information from the public; they are meant to support cooperation. They show that developers are really listening and willing to match their history and meet their needs, and goals in exchange for the impact the wind project has on the community. • Finally, differing perspectives on advantages and disadvantages of the wind park as well as how those items and other opinions are weighted towards the public or wildlife are considered part of fairness.
Exclusion Criteria	Professional describing what is morally right and wrong describes his/her belief, not how to create a fair system. Power by itself is not related to Fairness because different contexts define fair use of power differently. The exchange of information nor the collection of information about concerns in order to reduce the likelihood of oppositions is not Fairness (see Uncertainty Tolerance).
Typical Example (s)	*I think, people when they see that we are interested, and listen to them. And like I said before, we have a lot, a lot have a lot of inputs. So it's not feasible to actually listen to everyone, you know, and say, Can we do this this because in the end, I think we wouldn't have a productive profitable project. But I think if when people see that, there are things we do, some will be happy, and some will still think that. That's not good enough.*
Atypical Example(s)	*Entrepreneurs see that the opportunities with a wind farm like [that] they can actually be a part of building the wind farm, maybe they can work during the generation. And they can see that it actually, it brings a lot of job opportunities and money for the often money for the commune, and for the municipality, and then you have another group that are against like, change, or they want it to look like it's always been looking where they are living. So I think that's are like the two main pillars of people. And I am surprised that there are so few talking about, like, the renewable energy or the environment, it's more about the like, local environment, you know about, cutting down trees, and so on. But it's pretty rare that you hear people talk about that it's good for the environment.*

Uncertainty Tolerance (UT) Acceptance of uncertainty

Definition	Uncertainty Tolerance measures a lack of worry about ambiguities and risks that happen in organizations and society.
Inclusion Criteria (Must include one of the criteria)	• Professionals describing behaviors and regulations, which have, create, or reduce unknown outcomes or risks. • Uncertainty is created through ambiguity in the regulations. For example, regulations often do not require arguments from local citizens to be factually correct, or they are written in such a way that the authorities can interpret them differently for each project. • In fact, some regulations do not mandate how decisions should be made; therefore, emotions, which are unpredictable and uncontrollable to developers heavily influence decision making. In particular, emotions can impact elected officials whose job relies on public attitude. • To reduce uncertainty, connections are built and information is collected to avoid conflict. In fact, some developers hire a third party to develop trust with local communities to reduce uncertainty. • Who developers select to engage with and how they choose to engage (e.g. education, campaign, personal relationships) can affect project support and the likelihood of opposition
Exclusion Criteria	Professionals describing the complexity of norms and regulations. Complexity does not necessarily create uncertainty. Convincing or persuading politicians or locals is done to create trust and/or reduce Skepticism (another cultural dimension that likely plays a moderating factor with UT and F). Similarly, doubt in scientific evidence is likely due to Skepticism not Uncertainty Tolerance; however, Skepticism is likely to cause uncertainty particularly in low UT countries. Wildlife investigations and other impact studies specific to the project are for reducing skepticism.
Typical Example	*And this no, this no will not come the first day you have started because you have information for the town government in early stage, but they never decide yes or no in that situation. They wait until you have everything ready. It means that you can have been working for this project for three four years. And then they say no....on the area that they have pointed out is a good area for wind power.*
Atypical Example	*If you go into that thinking you can get through a construction, any construction process without having some stuff happen. You're, you're fooling yourself, yeah, you're, you're being ignorant. And so by developing those relationships, good relationships on the front end, you can whether through a construction process, when you've got construction workers who, you know, maybe have all good intentions, but they're just going to speed down the road, they're going to do this and they're going to do that, you know, there's just always little things that are going to happen, but you make it through..*

Request Email

Subject: Meeting Request for Research Study on Wind Project Approval in Sweden

Good Morning _____,

My name is Leigh Allison. I am a PhD student studying at the University of Washington and currently visiting as Chalmers University of Technology. My project is focused on how to increase approval of wind parks in Sweden and the United States. I am writing you to request a talk about your experience proposing and constructing wind parks. The goal of my project is to better understand the obstacles that are faced by developers when new wind projects are proposed and make recommendations about how to improve the approval process. Specifically, I'm hoping to learn more about:

- Project startup: What are primary considerations in choosing new sites and how important is the surrounding community in the choosing the site?
- Permitting & Acceptance: What are the most common challenges related to project permitting and how would you change the process?
- Community Influence: How do you involve the local community in project development?

The meeting (in person or on the phone) should not take more than an hour and will be very helpful in understanding the obstacles faced by developers today. I would greatly appreciate if you would take the time to meet with me and share some of your insights and experience.

I am available next week on Wednesday May 16 and Thursday May 17. Would you have any availability on either of these days? I am in Gothenburg and would be happy to meet with you at your office or another location convenient for you.

Thank you for your time and consideration. I look forward to hearing from you.

Sincerely,

Leigh Allison

Semi Structured Interview Template:

(Italics are what I will say to get started, transition, and wrap up the conversation)

Hi, my name is Leigh Allison. I am a PhD student studying at the University of Washington and currently visiting at Chalmers University of Technology interested in community acceptance of wind. I want to thank you for meeting with me. As my email said, my project is focused on how to increase approval of wind parks in Sweden and the United States. The goal of my project is to better understand the obstacles that are faced by developers when new wind projects are proposed and make recommendations about how to improve the approval process. Specifically, I'm hoping to learn more about siting decisions, permitting, and the community's influence. So today I am going to talk through a series of questions about your experience in the wind industry. I am really interested your opinions.

I would like to record our conversation so that I don't have to be constantly writing notes and this can be more conversation. I will transcribe the recording and then combine it with other interviews to look for patterns. I will be the only one with access to the recording and I will not share it. I will use the aggregate data in order to understand trends between the US and Sweden. I will attempt to publish in an academic journal, but I will not use your name or company in the article. Is it okay to record?

Shall we get started?

1. Can you briefly tell me about your career in the wind industry?
2. How are your involved in project selection & development?
3. When selecting new projects, what kind of information are you looking for?
4. Do you adapt your engagement strategy to the local situation? If so, how?
5. What kinds of concerns are brought up in public meetings?
6. What do you do to show the community concerns are being taken into consideration?
7. How do you think your company viewed in comparison with other local organization?
8. In what ways have you tried to establish confidence in the communities that a wind project is a good investment?
9. Do you feel that local communities trust you? Why or why not?
10. How would you estimate the impact of stakeholders and engagement programs on project cost?

IRB Exemption Approval

UNIVERSITY of WASHINGTON
HUMAN SUBJECTS DIVISION

DETERMINATION OF EXEMPT STATUS

March 7, 2018

Dear Leigh Allison:

On 3/7/2018, the University of Washington Human Subjects Division (HSD) reviewed the following application:

Type of Review:	Initial Study
Title of Study:	Culture's Impact on Renewable Energy Projects: Stakeholder Engagement Plans at Wind Parks
Investigator:	Leigh Allison
IRB ID:	STUDY00004300
Funding:	None

Exempt Status

HSD determined that your proposed activity is human subjects research that qualifies for exempt status (Category 2)

- This determination is valid for the duration of your research.
- This means that your research is exempt from the federal human subjects regulations, including the requirement for IRB approval and continuing review.
- **Depending on the nature of your study, you may need to obtain other approvals or permissions to conduct your research. For example, you might need to apply for access to data (e.g., to obtain UW student data). Or, you might need to obtain permission from facilities managers to approach possible subjects or conduct research procedures in the facilities (e.g., Seattle School District; the Harborview Emergency Department).**

If you consider changes to the activities in the future and know that the changes will require IRB review (or you are not certain), you may request a review or new determination by submitting a Modification to this application. For information about what changes require a Modification, refer to the GUIDANCE: Exempt Research.

Thank you for your commitment to ethical and responsible research. We wish you great success!

Sincerely,

Rachel Thomas
Human Subjects Review Administrator, Committee B
rthomas2@uw.edu
206-685-9379

APPENDIX E: CURRICULUM VITAE

LEIGH ANN ALLISON

Civil and Environmental Engineering
121 More Hall
352700
Seattle WA 98195

Email: laalliso@uw.edu
LinkedIn: www.linkedin.com/in/leigh-allison/
ORCID: 0000-0003-0305-5392

EDUCATION

Doctor of Philosophy in Civil Engineering 2019
University of Washington, Seattle, WA
Specialization: Construction, Energy and Sustainable Infrastructure
Advisor: Dr. Jessica Kaminsky
Dissertation: *Aligning Wind Energy Development with National Cultural Dimensions*

Master's of Science in Civil Engineering 2015
University of Washington, Seattle, WA
Specialization: Construction

Bachelor's of Science in Civil Engineering 2013
Clemson University, Clemson, SC

Bachelor's of Science in Biosystems Engineering 2013
Clemson University, Clemson, SC
Specialization: Ecological Engineering

RESEARCH EXPERIENCE

Aligning Wind Energy Development with National Cultural Dimensions 2017-2019
Research Assistant, Seattle WA & Gothenburg, Sweden
Funding: Valle Scholarship and Scandinavian Exchange Program (Exchange)
Responsibilities: Conducted a multidimensional item response analysis of wave 6 of the World Values Survey to discover five latent cultural dimensions across 54 countries, applied those latent dimensions to a multivariate linear regression, and conducted, transcribed, and qualitatively interviews of wind developers in US and Sweden.

Safety Communication Networks: Females in Small Work Crews 2015
Research Assistant, Seattle WA
Funding Pacific Northwest Transportation Consortium (PacTrans)
Responsibilities: Collected social network data from field construction workers as a part of a project studying the relationships among worker gender, communication patterns, and safety performance in work zones.

Culture in Construction 2014-2015

Research Assistant, Seattle WA

Funding: Valle Scholarship and Scandinavian Exchange Program (Scholarship)

Responsibilities: Performed a content analysis of a subset of articles within Journal of Construction Engineering and Management related to collaborative working arrangements, safety, and international markets with a focus of the definition of culture.

TEACHING EXPERIENCE

Teaching Assistant, Engineering in Developing Communities (CEE 420) 2016, 2019

Instructor: Dr. Jessica Kaminsky

Responsibilities: Assisted students in designing infrastructure for a small community in a developing country. Guided 50 students in proper data collection, analysis of results, and report writing.

Teaching Assistant, Construction Engineering (CEE 307) 2019

Instructor: Dr. Jessica Kaminsky

Responsibilities: Provided extra instruction to students on construction contracts, delivery methods, scheduling, productivity, and engineering economics. Developed and facilitated lab sections for MS Project. Created and delivered lecture on Careers in Construction to entire class of 70 students.

Teaching Assistant, GeoSurveying (CEE 317) 2017, 2018

Instructor: Dr. Kamal Ahmed

Responsibilities: Managed weekly labs covering leveling, resection, geometric highway curves, traverse, and mapping. Developed and facilitated computer labs covering AutoCAD, Civil3D, and ArcGIS for 140 students.

PROFESSIONAL EXPERIENCE

Engineering Intern, Clark Construction Group, West 2016, 2017

- VA Mental Health & Research Facility (Part-time): Processed submittals & RFIs and posted RFIs
- Sea-Tac International Arrivals Facility (Full-time): Performed quantity takes-offs, compared proposals to scope of work, addressed owner design comments, and created construction quality control reports and checklists

Environmental Educator & Conservation Steward, Student Conservation Association 2013-2017

- Built bridges and stairs for pedestrians and horses, developed curriculum and taught environmental education, and coordinated the Northeast Energy Association's annual trade show, BuildingEnergy
- Lead high school students in local projects (habitat restoration and trail building) while teaching them leadership skills to lead their own conservation projects after graduation

Undergraduate Intern, Clemson University Restoration Institute 2010, 2011, 2012

- Appointed as liaison with SM&E, the environmental consulting firm, to complete the Environmental Assessment for Wind Drivetrain Test Facility in North Charleston, SC

- Acted as "Owner's Representative," learned the basics of Leadership in Energy and Environmental Design (LEED) and organized kick-off meeting for project and tracked progress of meet reaching Silver Certification
- Worked on thermal modeling of facility, environmental regulations, and STEM (K-12 educational program) for the Zucker Family Graduate Education Center

PUBLICATIONS

Journal Publications:

Allison, L., Kaminsky, J., and Wang, C. (Under Review). "Religiosity, Neutrality, Fairness, Skepticism, & Uncertainty Tolerance: An Inductive Analysis of the World Values Survey."

Allison, L. and Kaminsky, J. (2017). "Safety Communication Networks: Females in Small Work Crews." Journal of Construction Engineering and Management, 143(8), 10.1061/(ASCE)CO.1943-7862.0001344

Conference Proceedings:

Allison, L., and Kaminsky, J. "Oh The Places You'll Go: How Renewable Electricity Is Constructed" Engineering Project Organizations Conference Proceedings, South Lake Tahoe, CA, June 2017.

Allison, L., Kaminsky, J. "Onsite Wastewater Treatment Management Systems." Construction Research Congress Proceedings, San Juan, Puerto Rico. June 2016.

Allison, L. and Kaminsky, J. "Culture in Construction Engineering," ICSC International Construction Specialty Conference Proceedings, June 2015.

Conference Posters:

Allison, L. and Kaminsky, J. "Safety Communication Networks: Women in Small Work Crews". Construction Research Congress 2016, San Juan, Puerto Rico, May 2016. [poster]

MENTOR & VOLUNTEER EXPERIENCE

- Student Conservation Association, Volunteer 2017 – Present
- Graduate and Professional Student Senator for Civil & Environmental Engineering 2015 – 2016
- Northeast Sustainable Energy Association, Volunteer 2013 – 2014
- Biosystems Engineering Ambassador 2012 – 2013
- Clemson University Rowing Association 2009 – 2013
- US. Fish & Wildlife Volunteer 2008

AWARDS & HONORS

- Valle Scholar, University of Washington 2014, 2018
- Washington Asphalt Pavement Association Scholarship Recipient 2016
- Member of Tau Beta Pi, Professional Engineering Honor Society 2010
- Clemson College of Engineering and Science Phi Kappa Phi Certificate of Merit 2013
- South Carolina Palmetto Fellows Scholar Recipient 2009 – 2013

PROFESSIONAL LICENSES & CERTIFICATES

- OSHA 30 HR Construction Health & Safety 2016
- Engineer in Training, Passed the NCEES Fundamentals of Engineering Exam 2013
- USGBC LEED Green Associate 2012