REPORT TITLE PAGE

An Empirical Analysis of Knowledge, Trust, Emotions, and Worldviews as Predictors of Attitudes and Risk Perceptions towards the Nuclear Sector in Saskatchewan

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EXECUTIVE SUMMARY

INTRODUCTION

Recent interest by industry and government to further expand into the latter stages of the nuclear life cycle in Saskatchewan, including fuel enrichment and nuclear power generation, has initiated conversations about understanding public attitudes towards those applications.

METHODS

Using telephone survey data from the 2013 Saskatchewan Nuclear Attitudes survey of 1,355 residents, this report assessed Saskatchewan residents' attitudes towards the nuclear sector in the province, as well as risk perceptions of nuclear power generation. Hypothesized predictors of knowledge, trust, emotions, and worldviews were tested. Methods of analysis included: cross-tabulation, bivariate analysis, factor analysis, multiple linear regression, and structural equation modeling.

FINDINGS

Saskatchewan residents had positive attitudes towards nuclear medicine, uranium mining, and nuclear power generation, and negative attitudes towards spent nuclear fuel practices and repositories. About half of residents believed the benefits of nuclear power outweighed the risks; about 30% thought risks outweighed the benefits. Males and non-Aboriginals were more likely than their counterparts to have positive attitudes towards nuclear activities; males also perceived less risk for these nuclear applications than females. Greater amounts of trust in government/industry and university scientists were positively correlated with attitudes and perceived benefits, while trust in environmental groups was negatively related. Similarly, positive emotions led to more positive attitudes and perceived benefits, while negative emotions led to less positive attitudes and greater perceived benefits. Subscribing to a hierarchal or individualist worldview resulted in greater support for nuclear activities and less risk perceptions, while being egalitarian led to less support and greater risk perceptions. When knowledge, trust, emotions, and worldviews were included in a single model, emotions were the greatest predictors of attitudes and risk perceptions and most other predictors were rendered insignificant or were reduced. Although knowledge/awareness was not a significant predictor of attitudes, additional analysis showed that, in the context of nuclear power, its effects were moderated through ethical concerns; those with high concerns showed more negative attitudes as knowledge increased, while those with low concerns had more positive attitudes as knowledge levels increased. Such findings fill a gap in the knowledge deficit literature and refine the understanding of the role and effect of knowledge as a predictor. In the context of nuclear power generation, structural equation modeling showed that a number of predictor variables made very small, indirect contributions to attitudes through risk perceptions; direct effects were much stronger than indirect effects. Risk perceptions were also weakly and negatively correlated to attitudes; as perceived risks increased, favourable attitudes decreased. The total effects of emotions, including indirect and direct effects, were the strongest in each of the final structural equation models which suggests that emotions influence attitudes more directly, rather than through perceptions of risk.

RECOMMENDATIONS

- Future public engagement should be framed in terms of emotions and trust, rather than knowledge or risk communication.
- Given that Aboriginal peoples constitute almost 80% of the population of northern Saskatchewan (the geographic area where a majority of nuclear sector related activities would likely take place) and are more likely to have negative attitudes, public engagement campaigns could be different than those for non-Aboriginals.

- Given females, who constitute 51% of the adult population in Saskatchewan, are significantly less likely to have a positive attitude and were more risk averse than males, public engagement campaigns could be different for females than for males.
- Using the existing dataset, researchers should explore if there is a causal relationship or inter-relationship between emotions, trust, and worldviews in explaining attitudes towards nuclear sector activities.
- Using the existing dataset, researchers should analyze gender differences in attitudes towards nuclear activities and the role that emotions play in such differences.
- Using the existing dataset, researchers should assess differences in attitudes towards nuclear sector applications between Aboriginal and non-aboriginals.
- Using the existing dataset, researchers should further explore the role of ethical concerns as a moderator of attitudes towards nuclear medicine, uranium mining, uranium enrichment, and storing spend nuclear fuel with respect to knowledge, as well as trust, emotions, and worldviews.
- Using the existing dataset, researchers should consider the role of risk/benefit explanations as a mediator of attitudes towards nuclear medicine, uranium mining, uranium enrichment, and storing spend nuclear fuel.
- Future research should use knowledge measures that assess objective scientific knowledge of nuclear items, rather than factual awareness. These should vary in terms of difficulty to increase the amount of variance in responses.
- When applicable, future research should employ specific trust measures that explicitly connect a nuclear activity, such as nuclear power generation, with the actors responsible for regulating it.
- Future research should explore the influence of other positive and negative emotional measurements, such as dread, contempt, fear, sorrow, guilt, shame, worry, pessimism, interest, satisfaction, and optimism, as predictors of attitudes and risk perceptions.
- Future research should incorporate additional questions that measure perceptions of social deviance and regulations in order to tease out differences between hierarchal and individualist worldviews.
- Future research should develop measures for the fatalist worldview.
- When measuring risk perceptions, researchers should employ a two-stage process to independently measure an activity's risks and benefits. This process can be used to produce evidence for the presence of the affect heuristic.
- Future research should develop dependent measures to assess
    a) impressions of uranium enrichment practices; and
    b) support for the future of uranium enrichment in Saskatchewan.

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1.0 INTRODUCTION

1.1 PROJECT OBJECTIVES AND PROBLEM

Using telephone survey data from the 2013 Saskatchewan Nuclear Attitudes survey, this report assesses Saskatchewan residents' attitudes towards the nuclear sector. The main objectives are to quantitatively analyze if support for the future of the nuclear sector in Saskatchewan, impressions of nuclear activities, and risk perceptions of nuclear power are a function of knowledge/awareness of nuclear topics, trust in groups surrounding the nuclear industry, emotions towards nuclear power generation, and/or worldviews based on the culture theory of risk perception. After developing theoretic models from a literature review and from discussions with the client, the report addresses the following research questions:

Research question 1: What are Saskatchewan residents' attitudes and risk perceptions towards nuclear sector applications?

Research question 2: What is the role of knowledge/awareness, trust, emotions, and worldviews in predicting attitudes and risk/benefit perceptions?

Research question 3: Do ethical concerns about nuclear power generation moderate the link between knowledge/awareness and attitudes towards nuclear power generation?

Research question 4: Do perceptions of risks and benefits of nuclear power generation mediate the relationship between knowledge/awareness, trust, emotions, and worldviews and attitudes towards nuclear power generation?

1.2 CLIENT AND RATIONALE/IMPORTANCE

The Social Sciences Research Laboratory (SSRL) is a research facility at the University of Saskatchewan (U of S) that provides infrastructure and support for social science research. The SSRL contains the Survey and Group Analysis Laboratory (SGAL) that undertakes telephone, online, and mixed-mode surveys for academic research using computer-assisted technology. Dr. Loleen Berdahl is an Associate Professor in the Political Studies department at the U of S, Project Leader at SGAL, co-investigator for the Nuclear Policy Research Initiative (NPRI), and a lead investigator for the Saskatchewan Nuclear Attitudes survey. NPRI's mandate is to examine opinions and attitudes of stakeholders and the public towards activities in the nuclear sector.

Given recent interest by the public, media, industry, and government to develop uranium enrichment and nuclear power generation in Saskatchewan, the NPRI conducted the 2013 Saskatchewan Nuclear Attitudes survey, a telephone survey of a random sample of 1,355 Saskatchewan residents 18 years or older, to understand attitudes towards the future development of the nuclear industry within the province. As of yet, there have been only a few studies of such attitudes in Saskatchewan. Some of these suffered from small sample sizes and large margins of error, while others were more robust[1]. Further, while these studies assessed public opinion towards the nuclear industry, they did not consider predictors of attitudes beyond socio-demographics. From a policy development perspective, this project is important for understanding attitudes towards the possible development of alternative sources of energy and the future of energy security in the province. It is also important for exploring how the public forms opinions about complex scientific policy; this can inform the creation of public policy. Assessment of such attitudes is important to NPRI, the SSRL, relevant government agencies, industry, and the residents of Saskatchewan.

[1] See Table 1 for a summary of previous studies, including their sample sizes and margins of error.

1.3 BACKGROUND

With over one billion pounds of known resources, Saskatchewan has some of the most abundant and rich deposits of uranium in the world. After almost 60 years of uranium mining, Saskatchewan is the largest regional supplier of uranium to the world market, accounting for over 20% of world market production. Despite these vast deposits, the province does not have any facilities operating in the later stages of the nuclear fuel cycle to enrich uranium, generate nuclear power, or store spent nuclear fuel (Government of Saskatchewan, 2009, p. 1).

RECENT INTEREST IN DEVELOPING THE NUCLEAR INDUSTRY

It is estimated that Saskatchewan will have to acquire an additional 3,300 megawatts of power by 2030 to meet demand from a growing population (SaskPower, 2008, p. 12). In 2008, Bruce Power put forward a feasibility study and proposal to develop a large-scale nuclear power plant in Saskatchewan by 2020 (see Bruce Power, 2008). In response, the provincial government created the Uranium Development Partnership (UDP) to explore the potential opportunities for the development of enrichment and nuclear power generation facilities. The UPD's report, *Capturing the Full Potential of the Uranium Value Chain in Saskatchewan*, was released the following year and proposed a strategic plan that included 26 recommendations to develop enrichment and power generation facilities (UPD, 2009, pp. 89-93).

Following the UPD's report, the provincial government began a public consultation process to understand Saskatchewan residents' attitudes towards the proposed strategic plan. Following consultations, which included a stakeholder conference, several hearings, numerous submissions from the public, and public consultation meetings in 14 towns and cities, the Chair released their findings in the *Future of Uranium Public Consultation Process* report. The consultations found a number of emerging themes, including an overwhelming opposition to nuclear power generation. Public reservations included fears about health, safety, and the environment. The consultation process also found major opposition to storage and disposal of nuclear waste, however, there was general support for pursuing alternative energy sources (Perrins, 2009, pp. 37-43, 45-53, 55-58, 67-73).

At the end of 2009, the Minister of Energy and Resources released a response to the UDP report and the public consultation report. The Minister rejected Bruce Power's proposal to construct a large-scale site, but did promote the idea to pursue alternative forms of nuclear energy development in the medium and long-term. The Minister also suggested working with the federal government to establish a nuclear enrichment facility. At the same time, the provincial government and the U of S submitted a joint proposal to the federal government's Expert Review Panel to establish a centre to produce medical isotopes and perform nuclear related research (Government of Saskatchewan, 2009, pp. 2, 11).

PUBLIC OPINION OF THE NUCLEAR INDUSTRY IN SASKATCHEWAN

While the *Future of Uranium Public Consultation Process* report found little public support for developing the nuclear industry in Saskatchewan, its results may not be representative of the provincial population because the submission process was self-selective. It is possible that residents who were very much opposed to the issue were overrepresented in the public process, while other residents might have chosen not to participate. To date there has been some study of public opinion towards the nuclear sector in Saskatchewan. A review of these studies is provided below in Table 1.

In 2006, 2008, and 2009, Sigma Analytics conducted telephone surveys to assess public opinion. Public support for a uranium enrichment refinery was 75% in 2006, 59% in 2008, and 57% in 2009 (Sigma Analytics, 2009, p. 3, 2008, p. 2). Support for a nuclear power plant was about 54% in 2006, 49% in 2008, and 48% in 2009 (Sigma Analytics, 2009, p. 5, 2008, p. 2). Insightrix's 2009 online poll found 62% of respondents were supportive of a policy to develop a nuclear reactor in the province; in 2008 support was over 66% (Warren, 2009, para 2).

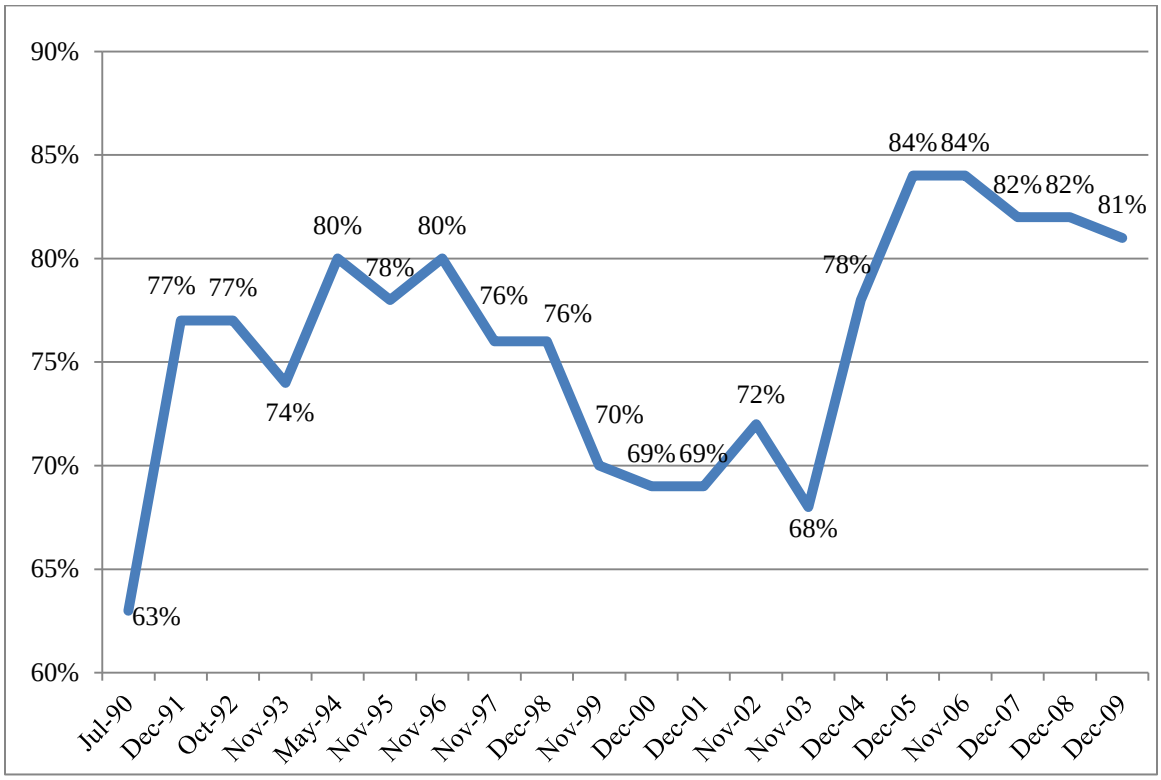
Each year, the Canadian Nuclear Association contracts out public opinion research to understand nuclear attitudes in Canada. The 2012 iteration, which surveyed Canadian residents by telephone, showed 45% of Saskatchewan residents supported nuclear power; about 42% supported building new nuclear plants in Canada (Innovative Research Group, 2012, p. 12). Since 1990, Cameco, a Saskatchewan based uranium mining company, has commissioned an annual public opinion study of Saskatchewan residents' attitudes. From 1990 to 2009 the level of support for the uranium mining industry ranged from 63% to 84% with an average of 74% over the time period (see Figure 1). In 2009, 72% supported building a nuclear power reactor in the province, 62% supported building a spent fuel repository, and 83% supported the establishment of a centre to produce medical isotopes (Fast Consulting, 2009, pp. 2-3). Bruce Power also commissioned public opinion polls of Saskatchewan residents before and after the release of their feasibility report. Almost 55% supported nuclear power and 41% opposed it before the release of the report, while 52% supported and 39% opposed it post-release (Bruce Power, 2009, p. 11).

Table 1: Previous Public Opinion Studies of the Nuclear Sector in Saskatchewan

Source(s)	Method	Sample size (MoE; CL)	Main Findings
Perrins, 2009	Non-random, self-selective submissions to the UPD (mail, email, in person, at a meeting, or at a hearing)	2,263 (NA)	Of the 2,263 submissions: • 1,401 opposed nuclear power • 945 showed concern about, health, safety, and the environment • 895 opposed nuclear waste storage • 797 were concerned about the costs of uranium development • 682 showed support for renewable energy sources • 519 viewed uranium mining and exploration unfavourably
Regina Leader-Post, 2006 & Sigma Analytics, 2009	Random telephone survey stratified by 10 provincial regions	809 (+/- 3.4%; 95%)	• 75.1% supported and 12.2% opposed the construction of a nuclear refinery; 53.2% were strongly supportive • 53.5% supported and 30.5% opposed the construction of a nuclear reactor to produce electricity • Men, those with higher income individuals, and Metis and non-aboriginals were more supportive than women, lower income individuals, and First Nations, respectively
Sigma Analytics, 2008	Random telephone survey stratified by 10 provincial regions	610 (+/- 4%; 95%)	• 58.5% supported and 19.1% opposed the construction of a nuclear refinery; men were more likely to be supportive than women • 48.8% supported and 29.0% opposed the construction of a nuclear reactor to produce electricity; those with less than Grade 12 education and those who graduated university were more likely to show support than other education groups; men were more supportive than women
Sigma Analytics, 2009	Random telephone survey stratified by 10 provincial regions	813 (+/- 3.44%; 95%)	• 57.2% supported and 22.9% opposed the construction of a nuclear refinery; higher income individuals were more likely to be supportive than lower income individuals and men were more likely to be supportive than women • 47.8% supported and 33.5% opposed the construction of a nuclear reactor to produce electricity; higher income individuals were more likely to be supportive than lower income individuals and men were more likely to be supportive than women • Of those who opposed the construction of a nuclear facility, the most cited reason was safety/ waste (48.5%) • Respondents believing they well informed about nuclear reactors were more likely to support them than those who felt misinformed; men were more likely to feel more informed than women
Insightrix	Online survey;	796 (Not	• 61.8% supported and opposed the development of a nuclear

Research, 2009 in Warren, 2009	respondents were randomly chosen from panel members	available)	reactor in Saskatchewan; 27.4% strongly supported, while 17.3% strongly opposed
Innovative Research Group, 2012	Random telephone survey	201 (+-6.9%; 95%)	• 45% of Saskatchewan residents supported and 46% opposed producing electricity form nuclear sources • 42% of Saskatchewan residents supported building nuclear power plants to meet Canada's future electricity demands
Fast Consulting, 2009	Method not stated	820 (+/-3.5%, 95%)	• 81% supported uranium mining in Saskatchewan • 82% of participants had some awareness of Cameco; participants that had higher levels of awareness of the uranium mining industry were more supportive of the industry • 72% support building a nuclear enrichment facility in the province; 82% of these supported such a facility being built near their community • 72% supported the construction of a nuclear power plant to generate electricity • 62% supported the establishment of a spent facility for spent fuel • From 1990-2009, support for uranium mining has ranged from 63% in 1990 to 84% in 2004 and 2005; average support was 74%
Bruce Power, 2009	2 polls (July, 2008 and February 2008); method not stated	July: size not available (+/-7.72%; 95%) February: ~800 (+/-3.4%; 95%)	• 52% supported and 39% opposed nuclear power in the July survey; 55% supported and 41% opposed in the February study • 66% agreed that nuclear energy is a reliable source of energy, 55% agreed that it is safe, and 45% agreed that nuclear power generation does not emit greenhouse gases

Figure 1: Times Series of Support for Saskatchewan's Uranium Mining Industry, 1990-2009



Source: Fast Consulting, 2009, p. 2

Previous public opinion research has revealed a wide range of support and opposition for nuclear technology in the province. Medical applications, nuclear enrichment facilities and uranium mining were viewed more positively than nuclear power generation or a spent fuel repository. The public appeared to be slightly more in favour of constructing a nuclear power facility than they were opposed. There was also significant opposition to a spent nuclear fuel repository. Although some of these studies assessed socio-demographics as predictors of attitudes, previous research has mostly focused on public opinion and has neglected to explore how other factors might predict attitudes. This project fills in this gap by hypothesizing and testing potential predictors of attitudes towards the nuclear sector and it makes a new contribution by assessing risk perceptions.

1.4. Argument and Major Findings

Attitudes towards nuclear sector applications and other scientific technologies are hypothesized as being related to a number of independent predictors. Commonly, scientific knowledge/factual awareness, social trust, emotions, and cultural worldviews have been shown to make independent contributions to attitudes. However, none of these have been assessed in the context of Saskatchewan, and rarely have all of these predictors been tested in the same study. Analyzing the role of these is important for knowing how the public understands scientific applications and is also important for the future of nuclear sector activities in Saskatchewan from a public policy perspective.

Key deliverables for this project include:

- A major research paper that contains a literature review, data analysis and findings, an assessment of survey measures and how they correspond/deviate to those in academic literature, and policy and research recommendations;
- An annotated bibliography of all literature consulted during the research stage;
- All SPSS and AMOS data sets and syntax files used during the analysis; and
- Other spreadsheet documents used during the analysis stage.

1.5 Organization of Report

The first major section of the report (2.0 Literature Review) is a literature review of determinants of attitudes and risk perceptions with respect to science, including sub-sections on scientific knowledge/awareness, emotions, trust, and worldviews. First, an overview of the theoretical link between knowledge and attitudes is presented before moving into a three part review of empirical literature, including: attitudes towards generalized science, differences in attitudes towards generalized science and specific scientific policies, and attitudes towards specific policies. After a discussion of heuristics, the review considers hypothetical and empirical evidence for emotions and trust as predictors. The literature review concludes with an overview of the cultural theory of risk perceptions and a summary of empirical literature that tested the link between worldviews and attitudes and risk perceptions.

A description of the project's methodology, including methods of analysis, telephone survey data collection method, and sample statistics, is presented in the proceeding section (3.0 Methodology). This is followed by the measure section (4.0 Measures), which contains a discussion of how the survey measures align and/or deviate from those used in academic literature, as well as a detailed explanation of how measures were operationalized for statistical analysis. Research questions and hypotheses are presented is the following section (5.0 Research Questions and Hypotheses).

The results section (6.0 Results) is structured to address each of the four research questions in order. The first part provides an overview of impressions, future support, and risk perceptions towards various nuclear activities. It also explains which socio-demographic variables were significantly related to each dependent measure. The second section contains the results of multiple regression models that test the independents effects of knowledge/awareness, emotions, trust, and worldviews. Building upon this, the third section assesses if the effects of knowledge on attitudes towards nuclear power generation were moderated through ethical concerns. After two final structure equation models (SEM) are presented, the results section concludes with an evaluation of the direct effects between hypothesized predictor variables and attitudes towards nuclear and the indirect effects as mediated through risk perceptions.

The discussion section (7.0 Discussion) considers the results of the analysis section in light of previous findings and the report's hypotheses. It also provides a macro-level overview of research implications and will note any limitations. Recommendations are made concerning future public engagement in Saskatchewan, as well as recommendations for research measures and future areas for research (8.0 Recommendations), before the report is concluded (9.0 Conclusion).

1.6 DEFINITIONS

Moderator variable – A variable that "affects the direction and/or strength of the relation between an independent or predictor variable and a dependent or criterion variable" (Baron & Kenny, 1986, p. 1174)

Mediator variable – A variable that "accounts for the relation between the predictor and the criterion [variables]. Mediators explain how external physical events take on internal psychological significance. Whereas moderator variables specify when certain effects will hold, mediators speak to how or why such effects occur" (Baron & Kenny, 1986, p. 1176)

Bootstrapping – A resampling method in AMOS. It creates a sampling distribution that can be used to estimate standard errors, estimate probability values, and create confidence intervals for mediation analysis (Hu, 2010, p. 2).

Kaiser-Meyer-Olkin (KMO) – A measure of sampling adequacy. It assesses if the sample size used for factor analysis is large enough. A high value is desired and indicates that "the proportion of variance in the variables is causes by underlying factors" (Rasli, 2006, pp. 14-15).

Cronbach's Alpha – A measure of internal consistency of a scale variable. "Internal consistency describes the extent to which all the items in a test measure the same concept or construct and hence it is connected to the inter-relatedness of the items within the test" (Tavakol & Dennick, 2011, p. 53).

Chi-square ($\chi 2$) – A measure of model fit that "assesses the magnitude of discrepancy between the sample and fitted covariances matrices" (Hu & Bentler, 1999, p. 2).

Steiger–Lind root mean square error of approximation (RMSEA) – A measure of model fit that says "how well the model, with unknown but optimally chosen parameter estimates would fit the population's covariance matrix" (Hooper, Coughlan, & Mullen, 2008, p. 54).

Jöreskog–Sörbom Adjusted Goodness of Fit Index (GFI) – An alternative measure of model to the $\chi 2$ statistic which "calculates the proportion of variance that is accounted for by the estimated population covariance" and "it shows how closely the model comes to replicating the observed covariance matrix". The adjusted GFI is adjusted based on degrees of freedom (Hooper, Coughlan, & Mullen, 2008, p. 54)

Bentler Comparative Fit Index (CFI) – A measure of model fit that accounts for sample size. It assesses the goodness of the model by comparing the hypothesized model $\chi 2$ statistic to the $\chi 2$ of the null model (Hooper, Coughlan, & Mullen, 2008, p. 55).

Standardized Root Mean Square Residual (SRMR) – A measure of model fit that calculates "the square root of the difference between the residuals of the sample covariance matrix and the hypothesized covariance model". It standardizes the scales of each variable in the model so that the results are easier to interpret (Hooper, Coughlan, & Mullen, 2008, pp. 54 – 55).

2.0 LITERATURE REVIEW

The development of attitudes and opinions towards science and scientific policy, known as the "public understanding of science", has been of much interest in public policy and scientific communities. The force behind this inquiry began to explain increasing public skepticism towards science as a driver for social good, explaining low levels of scientific understanding in adults, such a lack of basic textbook scientific knowledge, and for understanding risk perceptions (Allum, Sturgis, Tabourazi, & Brunton-Smith, 2008, p. 35). Later scholarship focused on attitudes as a function of declining of public trust in scientific experts and expert knowledge (Brunk, 2006, p. 178). More recently, research on attitudes towards scientific policy, such as nuclear power, has expanded to include the influence of other factors, such as emotions and worldviews.

Dependent measures used in the literature can be categorized as:

1. Attitudes to generalized science (e.g. support for scientific funding) or specific applications of scientific policy; and
2. Perceptions of risks and benefits (Lee, Scheufele, & Lewenstien, 2005, p. 243), which are sometimes assumed to be a proxy for or causally linked to attitudes.

2.1 SCIENTIFIC KNOWLEDGE

Public understanding of science has conventionally focused on studying the link between scientific knowledge and attitudes. "Public" refers to the non-scientific public (Bodmer, 1985, p. 7). "Understanding" refers to not only knowledge of basic scientific facts, but also an understanding of scientific inquiry and the nature of science itself (Bodmer, 1985, p. 7). "Science" is a broad concept that incorporates various facets of mathematics, technology, etc. used to evaluate the natural world, as well as the ability to apply knowledge derived from that evaluation (Bodmer, 1985, p. 7). This view has traditionally assumed that a scientifically knowledgeable public is important to a country's economic competiveness (Bauer, Durant, & Evans, 1994, p. 170), is essential for fostering a more involved citizenry in the science public policy process (Miller, 1983, p. 29), and is critical for making personal choices (Bodmer, 1985, p. 5). It is also tied to fears in the scientific community that declining support for science or trust in scientific knowledge will result in declining funding for research (Miller, 2004, p. 219).

This knowledge-attitude hypothesis proposes that the more knowledgeable one is about science, the more likely one is to support it. It is important to note that the direction of the causal relationship assumes that knowledge influences attitudes; however, it is possible that those with a more favourable attitude seek out additional sources of information. Scientific knowledge is thought to lead to more positive attitudes and preferences in a number of ways. Different theories, which attempt to explain how knowledge and attitudes are related, are explained below and summarized in Table 2.

The "knowledge deficit model" (Allum et al., 2008, pp. 35-36) assumes that low levels of public support for a scientific policy results from low levels of "scientific literacy" or understanding among the public (Laugksch, 2000, p. 85). A lack of support for science is the result of an uninformed and ignorant public. Public opposition to scientific policy, which is grounded in fear and misconceptions, would decline if people were more knowledgeable of the science behind it (Bodmer, 1985, pp. 9-10). In other words, a sound knowledge of science reduces fear and misconceptions, thereby resulting in a more favourable judgment. In the end, scientists would face less opposition when the public is more knowledgeable and scientists would have more impact on policy decisions because of greater public support.

Table 2: Summary of Knowledge-Attitude Theories

Model	Theory
Knowledge deficit model	Negative attitudes among the public results from misconceptions, fears, and a misunderstanding of the science behind an application. Greater knowledge would reduce these and would result in more positive attitudes.
Common sense linear assumption	More knowledgeable people have greater interest in science, which leads to a more favourable attitude. Negative perceptions of science result from a lack of interest that is caused by low levels of knowledge.
Knowledge-attitudes as cognitive schemes	Greater knowledge and exposure to science produces positive affect through a process of association with what one knows, thereby leading to a favourable judgment.
Knowledge theory of risk perception	When lacking in scientific knowledge, the public is unable to adequately perceive risks and benefits. As a result, the public may perceive greater risks than experts, which results in negative attitudes.

Another theory is the "common sense linear assumption", which contends that more scientific knowledge leads to more interest in science, which then results in a positive attitude (Bauer, Durant, & Evans, 1994, pp. 165-166). This assumes a causal, linear relationship between knowledge, interest, and attitude. Thus, more knowledgeable people seek out their interest in science, for example by consuming science related news or television programs, which then results in a more favourable attitude because of this interest. Increasing scientific knowledge among the public would result in a greater interest and involvement in science.

Einsiedel (1994) hypothesized that "cognitions about scientific concepts may trigger more generalized schemas relating to science, the scientific enterprise, roles associated with scientists, which may evoke some evaluative response" (p. 36). This view proposes that the knowledge one has about science leads the formation of an attitude through a process of association; high levels of scientific knowledge will result in favourable attitudes through positive affect and vice versa for low knowledge. For example, in her study Einsiedel (1994) found that more scientifically literate individuals had greater education, more exposer to science classes, and a more positive evaluation of science (p. 41-42). Thus, exposure to and knowledge of science and scientific methods may produce positive affect and a subsequent positive attitude (Einsiedel, 1994, p. 42).

The "knowledge theory of risk perception" implies that "people perceive technologies (and other things) to be dangerous because they *know* them to be dangerous" (Wildavsky & Dake, 1990, p. 42). It may be assumed that people perceive things to be safe because they have enough knowledge to know they are not dangerous. Thus, lacking in knowledge, the public may perceive something as more risky than it actually is (Gustafson, 1998, p. 806). The less knowledgeable the public is about science, the less likely they are to adequately perceive risks of science, and therefore the less likely they are to support science to the extent that the risk is lower than what the public perceives it to be.

According to these theories, knowledge and attitudes might be linked in a variety of ways. The proceeding section is a review of empirical literature that explored the knowledge-attitude relationship. The first section reviews generalized science attitudes. It then moves on to discuss studies that evaluated attitudes towards both generalized science and specific applications of science. This is useful for

understanding if the knowledge-attitude link is different between the two. Finally, a review of studies that assessed specific policies, including nanotechnology, biotechnology, and nuclear technology, is provided.

Knowledge and Attitudes Towards Science in General

Many studies have assessed knowledge and attitudes towards science in general. Attitudinal measures toward generalized science tend to include broad measures, such as attitudes towards funding for science, perceptions of the role of science in society, and interest and engagement in science.

Using SEM, Einsiedel (1994) found that those with higher levels of knowledge were more likely to show feelings of efficacy towards science (a measure of attitudes) and were more likely to trust science than the less knowledgeable (pp. 41-42). The efficacy-knowledge link was very weak, while the relationship between knowledge and trust was moderately stronger. Similarly, Sturgis & Allum (2004) found that scientific knowledge was weakly and positively correlated to general attitudes; the model accounted for about 21% of the variance (p. 15, 28). Inclusion of political knowledge increased the effect on attitudes (Sturgis & Allum, 2004, pp. 16, 28). This suggests that other types of knowledge may contextualize the influence of scientific knowledge.

Some studies have assessed differences in attitudes between genders. Hayes & Tariq's study (2000) found attitudes towards science in general in Canada, the United States, Great Britain, and New Zealand were weakly to moderately and positively related with knowledge (p. 440). While men had greater levels of knowledge and support for science, differences between genders could be attributed to education and religion, except for the United States where gender differences could be attributed to knowledge (p. 442). Von Roten (2004) replicated work by Hayes & Tariq (2004) in Switzerland and found similar results for gender differences in the knowledge-attitude relationship (pp. 194-196). However, the inclusion of an interaction effect between gender and knowledge in a separate model suggested that gender differences were the result of knowledge differences, not socio-demographics (Von Roten, 2004, p. 197). Despite these differences in gender, it appears that knowledge was positively related to attitudes in some capacity.

Bauer et al. (1994) evaluated attitudes in 12 European countries. Higher levels of scientific knowledge were moderately correlated with favourable attitudes towards science. More industrialized countries had higher levels of knowledge and showed greater levels of support for science than the less industrialized, except the most industrialized countries which showed a negative knowledge-attitudes relationship. When perceptions of research activities by the European Council (EC) were assessed, more knowledgeable countries reported less support, while less knowledgeable countries showed more support for scientific funding at the EC level (Bauer et al., 1994, pp. 170-172, 180). Taken as a whole, these findings show mixed support as the most informed countries did not show as much support as less knowledgeable countries.

The results of studies of generalized science attitudes evidence a positive relationship between knowledge and attitudes, thereby lending some support to the knowledge-attitude hypothesis. As the summarized findings in Table A1 (see Appendix A) suggest, scientific knowledge appears to be significantly related to general science attitudes. Considering science in general is rather abstract, it is possible that the link may be weaker for specific scientific applications.

Differences in Attitudes Towards Science in General and Specific Scientific Policy

Evan & Durant (1995) found that while knowledge had a moderate, positive correlation with favorable attitudes towards generalized science and a weak, positive correlation with support for research, it was negatively correlated with attitudes towards genetic engineering and embryotic research (Evans & Durant, 1995, pp. 64-65). Bak's (2001) contribution also found similar results. Knowledge accounted for 11% of the variance and was positively related to perceived benefits of general science (Bak, 2001, pp. 786-787). However, results were insignificant for the relationship between knowledge and perceived benefits of

nuclear power (p. 790). In other words, although those with more knowledge perceived more benefits with respect to general science, the author found no difference in risk perceptions of nuclear power between levels of scientific knowledge.

Allum et al.'s (2008) meta-analysis of 193 samples of data spanning 40 different countries provides an extensive assessment. General knowledge was positively correlated with general attitudes, albeit small with a weighted mean standardized regression coefficient of 0.08 (p. 47). The correlation between general knowledge was the same for nuclear power and genetic medicine as it was for general science attitudes, that is, very weak and positive (p. 48). No significant relationship existed for GM Foods, while a small negative relationship was found with environmental science (p. 48). In other words, both positive and negative relationships were found between knowledge and specific policies.

These studies, as Table A2 (see Appendix A) summarizes, suggest that while knowledge is positively related to generalized science attitudes, the correlation may be insignificant or negative for specific policies, depending on the application. These studies provide mixed support for the knowledge-attitude hypothesis.

Knowledge and Attitudes Towards Specific Science Policy

While there is some support that knowledge influences general attitudes towards science, there is also evidence to suggest that the relationship is much weaker, or occasionally negative, for specific applications of science. Variation in attitudes may be more than just a function of knowledge, especially if the policy is morally contentious (Evan & Durant, 1995, p. 59). To date, much literature has been published on the role of knowledge and attitudes towards contentious policies, such as biotechnology, nanotechnology, and nuclear power.

Biotechnology

Attitudes towards biotechnology have been the subject of recent study. Brossard & Nisbet (2007) found a weak, positive correlation between factual knowledge of biotechnology and support for agricultural biotechnology, however, deference to scientific authority and trust in biotechnology agents were stronger predictors (pp. 40 - 41). The heterogeneity of information sources and amount of attention to newspaper coverage were important sources of knowledge for respondents and both weakly and indirectly influenced support through factual knowledge (pp. 40-41). This suggests that the media mediates knowledge and attitudes. Such findings are consistent with Brossard & Shanahan (2003) who found that more attention one pays to agricultural biotechnology in the media, the more knowledgeable one was, and the less likely one was to perceive risk (p. 306). However, the link between levels of trust in science, industry, and government were better at reducing perceptions of risk and concerns that biotechnology has negative implications for society (Brossard & Shanahan, 2003, p. 303). Priest's (2001) work found similar results. While higher knowledge was weakly and positively correlated with support for medical and agriculture biotechnology, trust in institutional actors was better predictor of attitudes towards several applications of biotechnology (Priest, 2001, pp. 103-104).

Other studies provide mixed support. Higher levels of knowledge have been found to be significantly related to both high and low levels of encouragement for agricultural biotechnology applications (Martin & Tait, 1992 in Allum et al., 2008, p. 37). Such findings suggest that while knowledge is related to biotechnological attitudes, the direction of the relationship may be positive or negative. In contrast, some studies have found no relationship. Connor & Siegrist (2010) found knowledge, including knowledge of basic biology, gene technology, and legal regulations, had no impact on acceptance of medical or non-medical gene technology applications (p. 528). Basic biology knowledge was positively related to perceptions of risks and negatively related to perceptions of benefits of medical and non-medical applications which suggests that positive perceptions decrease when knowledge increases (Connor & Siegrist, 2010, p. 530). Gene technology knowledge was negatively related to perceived risks of non-medical applications, while knowledge of legal regulations in Switzerland was not related to any

risk/benefit perceptions (Connor & Siegrist, 2010, p. 530). Finally, Simon (2010) found that greater knowledge of biotechnology led to more favourable attitudes for men, but less favourable attitudes for women (p. 650).

In summary, higher levels of scientific knowledge appear to be linked to attitudes towards and risk perceptions of different biotechnology applications (see Table A3 in Appendix A). While knowledge is sometimes positively correlated to attitudes and negatively correlated to risk perceptions, a few studies have found significant relationships in the other direction, as well as no significant relations.

NANOTECHNOLOGY

Attitudes towards nanotechnology have also been evaluated extensively. Using hierarchal regression modeling, Brossard, Scheufele, Kim, & Lewenstein (2009) found that knowledge was positively, but very weakly, related to support for nanotechnology funding in general (p. 553) Other factors, such as perceptions of risks and benefits and use of science media (e.g. reading science sections in the newspaper and watching science news on television), also played a key role in attitude formation (pp. 554-555). After controlling for demographics, religiosity, and science media use, knowledge only accounted for an additional 1.1% of variation in support (p. 553). Interestingly, the knowledge-attitude link was moderated through religiosity (defined as how much of a role religion plays in one's life); religious denomination was not tested (Brossard et al., 2009, p. 554). Those reporting higher levels of religiosity were more likely to oppose funding even if they were more knowledgeable; those with lower levels of religiousness were more likely to support funding as their knowledge increased. This suggests that very religious people would not show greater support for nanotechnology even if they had a greater understanding of it.

Lee & Scheufele (2006) also found a very weak, but significantly positive link between knowledge and attitudes towards support and funding for nanotechnology. The relationship between deference towards scientific authority and attitudes, however, was stronger. Path analysis revealed that reading science literature on the Internet and in newspapers indirectly led to positive attitudes through knowledge. Although the link is weak, this suggests that greater exposure to media science can positively influence support for contentious policy issues (Lee & Scheufele, 2006, p. 827).

Knowledge appears to be positively correlated to attitudes towards nanotechnology (see Table A4 in Appendix A). However, this may not be true for very religious individuals, who were less likely to show support as levels of knowledge increased. The consumption of media may play a role in mediating the knowledge-attitude link.

NUCLEAR TECHNOLOGY

Considering the relationship between knowledge and attitudes may differ by policy issue, a review of literature on nuclear technology is essential. Indeed, many studies of nuclear technologies show evidence for such a relationship. For example, Mazur (1975) found that, for men in New York, the more knowledgeable they were about nuclear technology, the less likely they were to believe nuclear power was dangerous and the less opposition they showed (p. 66). One study of Idahoans' attitudes found factual knowledge of radiation was positively correlated with support for transporting spent nuclear waste (McBeth & Oakes, 1996, p. 424). Recent publications in Europe show that factual knowledge of nuclear issues and safety, as well as awareness of nuclear issues, such as the construction of a power plant in one's country, was positively linked with support for nuclear power (European Commission, 2007, p. 42, 2010, p. 11). With respect to risk perceptions, a study of 10 professional groups working in Swedish nuclear power plants revealed that knowledge of radiation and risks were negatively correlated to perceived job risk and risk of nuclear hazards (Sjöberg & Drottz-Sjöberg, 1991, p. 617). Similarly, Bassett, Jenkins-Smith & Silva (1996) showed that factual knowledge of radiation and institutions were related to decreased perception of nuclear risks for a spent fuel repository site (p. 317).

Kuklinski, Metlay, & Kay (1982) found a weak, positive correlation between knowledge and support for nuclear power (p. 621). Further analysis was performed to understand differences in decision-making between the informed and uniformed. Results showed that core values played a large role in understanding attitudes and that more knowledgeable people relied on different values than the less knowledgeable when perceiving risks (p. 633). Informed participants' risk perceptions, and subsequent attitudes, were influenced by their political ideology - measured as liberal, conservative, or "middle-of-the-road" (pp. 633, 639). Less knowledgeable respondents' attitudes, on the other hand, were influenced by their impression of technology and by the cues disseminated by groups that they trusted (p. 633). Knowledgeable peoples' attitudes were not influenced by cues from groups they trusted (p. 633), which suggests that they already have enough information to form an opinion and that they seek out reference groups to reaffirm their views after a decision has already been made. Further, uniformed people lack enough knowledge to form an opinion so they rely on their perceptions of technology and information from reference groups that they trust.

In assessing factual awareness items, such as the storage of spent nuclear fuel and the presence of nuclear power generation in one's state, Greenberg & Truelove (2010) found that more aware respondents were more supportive of nuclear power generation and had greater trust in nuclear industry actors (p. 137). Participants who gave no response to most of the survey knowledge questions were less trusting of actors and also showed less support for nuclear power generation (p. 137). Considering attitudes towards nuclear technology in space as an energy source, Maharik & Fischhoff (1993) found through three separate surveys that, for members of the general public, the more they knew about the risks of nuclear technology, the more they supported it (pp. 347, 349 351). The relationship was not significant for professional engineers or environmental activists (p. 347). A fourth survey in the study revealed that an experimental group, who were provided a NASA authored brochure on risk, had more knowledge and more favourable attitudes than the control group (p. 351). This suggests that information can be used to lower perceived risk and influence attitudes. On the other hand, Solomon, Tomaskovic-Devey, & Risman (1989) found that awareness of local nuclear issues was not significantly related with support for constructing a nuclear power plant in their community or with general support (p. 409). However, this study differed as it considered only factual awareness (similar to Greenberg & Truelove, 2010), such as awareness of a power plant in their region, instead of factual knowledge related to constructs of science. As noted earlier, Bak (2001) found no significant relationship between scientific knowledge and attitudes towards applications of nuclear technology (p. 790).

As Table A5 (see Appendix A) summarizes, the relationship between knowledge and attitudes towards nuclear technology appears to be significant and positive. A majority of these studies suggest that the more scientific knowledge one has, the more likely one is to perceive fewer risks and/or have a more favourable attitude towards the nuclear industry. On the other hand, there is mixed evidence to suggest that factual awareness is significant predictor.

Summary of Empirical Studies Assessing Knowledge and Attitudes

As this section has shown, empirical studies generally support the hypothesized relationship between knowledge and attitudes towards science. This correlation is often positive with those having more knowledge being more likely to support it, and those with less knowledge being less likely. The correlation seems to be more prevalent for science in the abstract, rather than for specific applications of science or technology. In some instances, the relationship was non-significant, weak, or negative for specific applications. The review also showed that many other factors seem to mediate the knowledge-attitude relationship, such as religiosity, sources of and consumption of news media, cues from trusted reference groups, and political ideology. While knowledge was significantly correlated, it was not the strongest predictor of attitudes, especially for specific applications of science and technology. For example, trust and media consumption were better predictors of attitudes or risk perceptions when

compared with knowledge. It seems that although those with more knowledge might be more supportive of science, many other factors might also play a role in attitude formation.

2.2 HEURISTICS

Although there is evidence that knowledge influence attitudes through a rational decision-making phase, others have looked to non-cognitive factors to explain attitude formation. Heuristics may serve as shortcuts for people to make decisions on complex issues. Heuristics, according to Simon (1990), are "methods for arriving at satisfactory solutions with modest amounts of computation" (p. 11). Abelson & Levi (1985) referred to heuristics as automatic or unconscious strategies that attempt to "keep the information processing demands of the task within bounds (p. 255). Early work on heuristics by Tversky & Kahneman (1974) showed people relied on a number of mental short-cuts when making decisions (p. 1130). This supports the idea that judgments are not formed on rational judgments of complete information, but through short-cuts of information. Lau (2003) notes that people use heuristics as "rules of thumb" to make judgments that do not require searching out complete information about all alternatives (p. 31). Taken together, it appears that heuristics, whether employed consciously or unconsciously, might be used to simplify the decision making process.

In their review of heuristics, Shah & Oppenheimer (2008) note how people are subject to operating within "bounded rationality", that is, bounded within their cognitive ability and environment (p. 207). As greater demand is placed on the limited resources available within one's bounded rationality, a person will begin to employ heuristics in an effort to simplify the decision making process. Similarly, individuals, according to Popkin (1991), cannot obtain enough knowledge about every policy issue because of competing demands for their attention and scarcity of time to seek out evidence (in Brossard & Nisbet, 2007, p. 26). Because of the complexity of scientific policy debate and their lack of knowledge, people seek out alternative routes to obtain and process information in order to form an opinion. As a result, the majority of citizens are likely to form attitudes towards a scientific policy issues based on heuristics when they lack enough information to make a judgment (Brossard & Nisbet, 2007, p. 26). Thus, people might employ mental short-cuts when they do not have enough information to make a judgment and/or when they do not have enough time to seek out information on alternatives.

A fair amount of literature has been written on how heuristics are employed when forming attitudes and risk perceptions towards complex scientific policy. Considering the complexity behind many scientific applications, such as nuclear technology, it might be expected that people rely on heuristics when making a judgment.

2.3 EMOTIONS AS HEURISTICS

Emotions may act as heuristics when forming attitudes or judgments of risk towards complex policies (Loewenstein et al, 2001, p. 274). The "affect heuristic" or the similar idea of "risk as feelings" state that emotions felt during the decision making process influence attitudes and risk perceptions (Lee, Scheufele, & Lewenstein, 2005, p. 244). Affect is defined as the "goodness" and "badness" that a person experiences consciously or unconsciously that then results in positive and negative feelings towards an item (Slovic, Finucane, Peters, & MacGregor, 2007, p. 1333). Risk as feelings, which refers to "individuals' fast, instinctive, and intuitive reactions to danger", differs substantially from conventional thought of "risk as analysis", whereby risk perceptions are a cognitive, purposeful and logical process (Slovic, Peters, Finucane, & MacGregor, 2005, p. s35).

The influence of affect on the decision making process has been summarized by Slovic, et al. (2004, p. 314) and Slovic et al. (2005, p. s36). Individuals react differently to affective processes and tend to rely upon previous experiences when making judgments. As such, individuals tend to map or interpret affective properties of images differently within their minds. The images that people hold are collected

into an "affect pool" that contains the positive and negative imagery associated with each item. This affect pool is relied on during the decision making process and results in a judgment process that is more efficient and effective than a cost-benefit analysis.

Much work on emotions and attitudes is grounded in risk perception literature. Those who perceive something as low risk and high benefit are seen as supportive or having a positive attitude, while a perception of high risk and low benefit corresponds to opposition. This assumption of causality is consistent with the automatic processing model proposed by Fazio (1986) that contends that people describe positive qualities of an object when they have a positive opinion of it and describe negative qualities when they have a negative opinion (p. 210).

The presence of the affect heuristic has been supported by a few studies. Alhakami & Slovic (1994) found that people who perceived applications, such as nuclear power, as beneficial were less likely to perceive risk, and vice versa for risk perceptions (p. 1094). Affective evaluation of a hazardous topic was the greatest predictor of this negative correlation between risks and benefits (p. 1095). The distance between perceived risks and benefits also widened when extremely positive or negative affect were reported, thus signifying that when developing attitudes towards hazards, people are prone to forming consistent judgments (viewing something as high risk/low benefit) (p. 1095). This supports the idea that people use the affect heuristic to underestimate risks and overestimate benefits when they perceive something as good, and overestimate risks and underestimate benefits when they oppose it. When time limits were placed on an experimental group, Finucane, Alhakami, Slovic, & Johnson (2000) found that the negative relationship between perceived risks and benefits of several hazards were greater than those for than the control group that did not face a time limit (p. 8). This study, which attempted to limit analytical thought, also provides evidence for the presence of the affect heuristic. Thus, when making a decision within time constraints, people tended to form attitudes that consistent with Fazio's (1986) processing model via affective short-cuts.

Empirical Studies of Emotions and Attitudes/Risk Perceptions

A number of empirical studies have found significant relationships between emotions and attitudes/risk perceptions. This supports the hypothesis that emotions can be invoked as heuristics. Savadori et al. (2004) found that harm and dread of hazards played a role in risk perceptions of two biotechnology applications for both experts and public participants (p. 1298). For both groups, the more harm and dread reported, the more likely an application was perceived to be high risk and low benefit (p. 1298). About 32% of the variance in risk perceptions towards biotechnological food applications was attributed to harm and dread (Savadori et al., 2004, p. 1293). Other factors, such as trust and perception of benefits were also correlated, however, the relationship was less pronounced (Savadori et al., 2004, p. 1298). Similarly, Cobb & Macoubrie (2004) showed that feelings of hope towards nanotechnology were correlated to perceptions that the benefits of nanotechnology outweighed the risks; feeling worrisome had the opposite effect (p. 402). Trust was less strongly correlated with risk-benefit perceptions, while knowledge was not (p. 402). Lee et al., (2005) also showed that negative emotions are negatively correlated with general support for nanotechnology. Those showing higher levels of negative emotions perceived nanotechnology as having more risks then benefits, while those with higher levels of trust and knowledge perceived more benefits than risk (pp. 254-255). However, the authors also did find that greater levels of knowledge and trust were also significant predictors of support (Lee et al., 2005, p. 255).

Sjöberg (2007) also looked at the role of negative and positive emotions in predicting risk perceptions and attitudes towards a spent fuel repository. Path analysis showed that negative emotions (an index consisting of anger, contempt, fear, sorrow, guilt, shame, worry, and pessimism) were negatively related to attitudes, while positive emotions (interest, satisfaction, and optimism) were positively related (Sjöberg, 2007, pp. 227-228). Emotions were stronger predators than measures of social trust, trust in science, municipal risk perceptions, and attitudes towards nuclear power (Sjöberg, 2007, p. 228). Anger

was the most important emotional predictor of attitudes towards the repository (Sjöberg, 2007, p. 227). Negative emotions were also positively correlated with risk perceptions, while positive emotions were negatively correlated; negative emotions were a much stronger determinant than positive emotions. Both emotional factors accounted for 29.6% of the variance in such perceptions (Sjöberg, 2007, p. 230).

Emotions have also been measured in other ways. Slovic, Flynn, & Lyman (1991) asked American participants to provide the first three images that came to mind when they thought about an underground nuclear waste repository (p. 1605). Over 90% of those who provided a negative image for their first response said they would not vote for the repository (p. 1605). Negative emotional imagery, in this regard, seems to relate to opposition to the waste facility. Peters & Slovic (1996) employed similar word association methods. Those reporting positive affect imagery with respect to nuclear power were more likely to support building a new nuclear power plant, while those reporting negative affect were much less likely (p. 1436). Despite these results, one's worldview was a better predictor than emotions (p. 1449).

Other studies have showed less strong support for the role of emotions. In another study (Sjöberg, 2003a), fear was weakly, negatively related to voting for the establishment of spent fuel facility (p. 114). Hierarchal multiple regression showed that fear only accounted for an incremental 5% of variance once perceptions of risk were controlled for (Sjöberg, 2003a, p. 114). Such findings suggest that, although emotions play a factor in policy attitudes, they are not as strong of a predictor as risk perceptions. Additional regression modeling showed that emotional risk reactions were insignificant predictors of attitudes towards a repository; severity of consequences, attitudes towards nuclear power, risk perceptions, and perceived economic consequences were better explanatory variables (Sjöberg, 2003a, pp. 114-115). Using path analysis, Sjöberg (1992) found that worry was a significant predictor of attitudes towards nuclear power, however general risk and economic aspects of nuclear power were greater determinants (pp. 3, 10). Perceived personal risk was a strong predictor of worry, perceived danger, and general risk, but not as strong of a predictor of attitudes. Unexpectedly, feelings of worry resulted in less favourable attitudes by increasing general risk perceptions, while worry led to more favourable attitudes directly.

Another study empirically tested the effect of negative emotions on risk perceptions of nuclear activities (Sjöberg, 1998a). Regression analysis showed that feelings of worry and pessimism were positively correlated with risk perceptions of several items, including: domestic and foreign nuclear power, natural background radiation, domestic nuclear waste, nuclear waste transportation, and a nuclear waste repository (Sjöberg, 1998a, p. 88). Although Sjöberg did not report which relationships were statistically significant, considering beta-coefficients ranged from 0.161 to 0.403, most, if not all, were significant predictors. Feelings of worry and pessimism were also very weakly and positively related to intentions to vote against the establishment of a spent nuclear fuel repository for both men (β= 0.041 and β= 0.070) and women (β= 0.048 and β= 0.086), respectively (Sjöberg, 1998a, p. 88). Once again, significance was not reported; it seems that these negative feelings were insignificant or, at best, poor predictors of attitudes. On the other hand, not all studies showed support for emotions. For example, Sjöberg (1998b) found negative affect, which included items measuring dissatisfaction with various things of life, was not related to 36 measures of societal concern or risk perceptions (p. 145). Although statistical significance was not reported for individual measures of societal concerns, the correlation between affect and dangers associated with nuclear power was low (Sjöberg, 1998b, p. 143).

As this section has shown, emotions appear to be significantly related to attitudes (see Table A6 in Appendix A); this relationship may be the result of the affect heuristic. Two of these studies showed that, after being provoked to think about nuclear applications, those who held negative imagery showed less favorable attitudes, while those reporting positive imagery had more positive attitudes. Most studies employed different methodologies and found that positive emotions, such as feelings of hope, were positively correlated to perceptions of benefits, while negative emotions, such as dread and harm, were

positively related to risk perceptions. Negative emotions seem to be greater predictors or attitudes than positive emotions.

2.4 TRUST

Trust may also act as a heuristic when forming perceptions of risks and benefits, as well as attitudes. People may use trust in actors, based on social relations, to eliminate feelings of uncertainty (Siegrist, Gutscher, & Earle, 2005, p. 151) Therefore, trust may be used to simplify the decision making process by reducing uncertainty when areas are too complex or ambiguous to weigh alternatives. Trust is argued to be an important factor that moderates the inverse relationship between perceived risks and benefits (Siegrist, Cvetkovich, & Roth, 2000, pp. 354-355), a link that is often thought to support the presence of heuristics. Because risks and benefits of science are not always tangible or known, people tend to rely on cues disseminated from groups that they trust, such as scientists or the government. Considering the importance of trust in opinion formation, Robins (2001) also notes that trust in those regulating or operating technologies, for example a nuclear power plant, is important for knowing that management of risk is adequate and that said management will result in safer circumstances (p. 20). This suggests that people perceive something to be safe, not because of a lack of real risk, but because they trust institutions to manage potential risks. At the same time, risk managers might face distrust if risks have been poorly managed in the past (Kasperson, 1986, p. 277). This suggests that trust is harder to gain back once it is lost. Perceptions of risks, according to Wynne (1987), will be exponentially greater if those responsible for managing potential hazards are perceived as untrustworthy (in Robins, 2001, pp. 20-21). In this sense, although risk perceptions of actual hazards themselves might be subjective, objective perceptions of risks will increase when views of regulators are unfavourable.

Others contend that trust is employed in the absence of knowledge of risks and benefits. Siegrist & Cvetkovich (2000) have argued that trust in social actors responsible for a hazard is negatively related to perceptions of hazardous risks and positively related to perceptions of benefits when knowledge of risks and benefits are lacking (p. 715). This assumes that the public might defer to experts when forming attitudes because they lack sufficient knowledge to make judgments. Trust therefore reduces anxieties and simplifies the decision making process for the uninformed as they rely on cues from relevant actors deemed to be reliable and accurate (p. 714). Others propose that people may seek out the opinions of actors they have faith in or who share their same values (Earle & Cvetkovich, 1995 in Siegrist & Cvetkovich, 2000, p. 714). It is possible that people who identify with and trust institutions that oppose nuclear power, such as environmental groups, may have less favourable attitudes.

Trust is often categorized in two different ways in the empirical literature: specific trust and general trust. Specific trust measures trust in relevant actors to regulate a specific type of hazard, for example trust in nuclear power regulators, while general trust refers to trust in general institutions or actors that are not specifically tied to a hazard, for example scientists or government officials (Sjöberg, 2001, p. 192). The following section explores empirical studies that employed general trust measures before moving onto a review of specific trust measures. Before summarizing the role of trust, it will consider how trust may directly and indirectly influence the formation of attitudes through perceptions of risk.

GENERAL TRUST MEASURES

Bord & O'Connor (1992) found levels of concern regarding cleanup of nuclear waste facilities to be higher for those who perceived greater health risks (p. 413). General trust in government and industry reduced concern, while trust in science and knowledge of chemical risks had no effect (p. 414). Between six to eight percent of the variance in risk was explained by trust in government, although education accounted for more than twice that variance (p. 414). Such results were similar to Sjöberg (1999) who found general trust dimension to account for 10% of the variation in risk perception for 35 hazards as an average; the direction of the relationship varied by type of hazard (p. 98). Only two of four trust dimensions – trust in corporations and beliefs in social harmony - were significantly correlated with these

perceived risks; trust in politicians and general honesty were not (Sjöberg, 1999, p. 98). Looking at risk perceptions of nuclear waste, only trust in corporations was significantly (negatively) related to perceived general risk; it was not related to demand for risk reduction (Sjöberg, 1999, p. 97). The other three general trust scales were not related to either general risk of demand for risk reduction. Sjöberg (1999) interpreted his findings to mean that general trust plays a modest role in risk perception (p. 98).

Sjöberg's (2001) study of attitudes towards 43 various hazards, including nuclear power and a repository, found a weak relationship between low levels of general trust and perceptions of risk (p. 193). In other words, those who had less trust in politicians, corporations, general societal honesty and those with high levels of cynical suspiciousness and those who perceived high levels of societal conflict, were more likely to perceive risks. General trust accounted for 10% of the variance in perceived risk (p. 193). Considering general trust measures and attitudes towards gene technology and energy consumption, Sparks, Shepherd, & Frewer (1994) found that greater trust in environmental groups, such as Greenpeace and Friends of the Earth, were negatively correlated with attitudes, while trust in government institutions was positively associated with attitudes (p. 24). Bassett, Jenkins-Smith, & Silva (1996) found similar results. While trust in the Department of Energy, the Environmental Protection Agency (EPA), and the Nuclear Regulatory Commission led to greater support for a nuclear repository, trust in environmental groups did not (p. 315).

Pijawka & Mushkatel (1992) found general trust in the United States federal government and relevant agencies were negatively related to several measures of risk, such as health and safety threats and risks during transportation, of a nuclear waste repository (p. 191). Unexpectedly, trust in state and local government was positively related to risk perception, albeit the relationship was weaker (p. 191). This suggests that participants might not trust state or municipal government to adequately manage risks. Similarly, Siegrist et al. (2005) found that while general trust measures related to society reduced risk perceptions of technological and non-technological hazards, general confidence (the perception that situations are manageable and unambiguous) were a more important predictor for both hazards; age and gender were also better predictors than trust (p. 151). Despite these reservations, trust still appears to have an influence on perception of risks and on attitudes.

In summary, general measures of trust seem to be negatively related to risk perceptions for various hazards and concerns and positively related to attitudes, although the strength of the relationship is somewhat low (see Table A7 in Appendix A). The exception is fringe groups (e.g. environmental groups) where the direction of the relationship was reversed. For the two studies that looked at the negative relationship between risks and benefits, controlling for trust eliminated or reduced the relationship. This provides evidence that trust might moderate the relationship between risks and benefits (perhaps through heuristics).

Specific Trust Measures

While Sjöberg (2001) found a significant relationship with general trust measures, further analysis showed that specific trust measures were better predictors of risk perceptions, and other related variables, than general trust measures (p. 196). A separate data set in Sjöberg (2001) showed that specific trust in 22 hazards (as a whole) was moderately and negatively correlated to risk perceptions for both the public and experts (p. 192). The relationship with general risk for the public was strongest for nuclear power plants in the respondents' country, a high-level nuclear waste from Swedish nuclear power plants, transportation of nuclear waste, and radiation from a nuclear repository (p. 192). While specific dimensions of trust explained between 14% to 20% of personal and general perceptions of risk with respect to domestic nuclear power and a nuclear waste repository, the addition of respondents' beliefs of unknown effects of the technology in the model increased the amount of explained variance by between six and 11 percentage points (Sjöberg, 2001, p. 195). Additional analysis using a third separate data set revealed similar results for the general public. Trust accounted for about 22% and 20% of the variance in perceptions of domestic nuclear power and a nuclear waste repository, respectively (p. 197). Adding perceptions of unknown

effects in a second regression block increased the explainable variance to about 24% for domestic nuclear power and 25% for the repository (p. 197). Controlling for unknown effects increased the explained variance, which the author interpreted as it being a stronger explanatory variable than trust for the general public (Sjöberg, 2001, p. 189). That being said, these findings propose that specific measures of trust are more strongly correlated to perceptions of risk than general trust, and that trust plays a role in perceptions of risk, especially for nuclear applications. A similar study (Sjöberg, 2006) found that greater trust in experts, including the Swedish Nuclear Fuel and Waste Management Company, the Nuclear Power Inspectorate and the Radiation Protection Institute, and trust in science were both positively related to voting for a spent nuclear facility (p. 459). After controlling for demographics and risk perceptions in two previous blocks, trust in experts and in science accounted for an additional 20% of the variance (Sjöberg, 2006, p. 459).

A few empirical studies by Siegrist and colleagues support the idea that specific trust are predictors of perceptions of risks and benefits. Siegrist et al.'s (2000) SEM revealed that specific trust measures in business, government, and scientists led to substantially higher perceptions of benefits and lower perceptions of risk for pesticides, artificial sweeteners, and nuclear power; trust was influenced by one's values (pp. 358-359). When trust was controlled for, the relationship between values and risks and benefits became statistically insignificant for pesticides and was reduced for the other two factors (p. 360). These diminished correlations suggest that trust in societal actors is an important predictor of perceptions in terms of one's values. Looking at perceptions towards 25 different hazards, including nuclear power, Siegrist & Cvetkovich's (2000) analysis also revealed strong correlations between specific levels of trust and risk-benefit perceptions in the directions expected (p. 717). Similar to previous studies, controlling for trust significantly reduced the strength of the relationship between perceived risks and benefits (p. 718).

Other empirical studies have also found a negative link between specific trust measures and risk perceptions. For example, Hallman & Wandersman's study (1995) found a moderately strong and negative relationship with specific levels trust explaining over 16% of the variance in perceptions of risk towards a nuclear waste repository (in Sjöberg, 2001, pp. 189- 190). Another study showed that greater trust in experts related to a nuclear repository was related to lower perceived risks, negative feelings of consequences, and higher approval of a proposed site (Biel & Dahlstrand, 1995, pp. 31, 34). Self-reported levels of knowledge as well as objective measures of knowledge were not related to risk perceptions (p. 30). Bord & O'Connor (1990) found specific and general measures of trust in government agencies and the food irradiation industry to be the best predictors of willingness to try irradiation foods and being comfortable with serving them to one's family (p. 504). Trust measures accounted for 36% and 40% of the variance, respectively (Bord & O'Connor, 1990, p. 504).

As this section has shown, trust appears to be a strong predictor of attitudes and risk perceptions (see Table A8 in Appendix A). General trust in government and industry reduced risk perceptions and increased attitudes, while trust in non-governmental environmental groups had the opposite effect. Greater specific trust also reduced risk perceptions and increased attitudes. Studies that operationalized specific measures reported stronger correlations and explained more variance than general measures. This suggests that trust in actors responsible for regulating risks of a hazard can better explain how attitudes are formed as there is a stronger connection between the actor and the hazard.

Trust as Mediated Through Risk Perceptions

A number of studies suggest that trust influences attitudes through risk and benefit perceptions. Flynn, Burns, Mertz, & Slovic (1992) found trust and risk perception to be the main determinants of attitudes towards a nuclear repository (p. 425). Covariance structure analysis showed that trust in management of a nuclear repository site indirectly influenced one's opinion towards the repository through perceptions of risk (p. 426). In other words, those who trusted managers of risk were less likely to perceive risks and as a

result supported the initiative. Siegrist (2000) found similar results with respect to attitudes towards gene technologies in his causal model. Higher levels of trust indirectly influenced willingness to purchase genetically modified foods through perceptions of benefits and risks (p. 200). A similar study by Siegrist (1999) replicated results for acceptance of applications of gene technology (p. 2102). Worldviews also directly and indirectly influenced acceptance through perceptions of risks and benefits, however, the relationship with trust was stronger (Siegrist, 1999, p. 2102). Looking at attitudes towards food technologies, Eiser, Miles, & Frewer (2002) found that trust influenced attitudes towards food technologies through risk perceptions; trust was a measure of information being "trustworthy", rather than trust in actors (pp. 2430). When attitudinal measures were controlled for, the relationship between trust and risk perceptions remained significant, albeit reduced (p. 2430). This suggests that trust directly influenced attitudes and indirectly through perceptions of risk. With respect to nuclear power, Whitfield, Rosa, Dan, & Dietz's (2009) SEM showed that trust in nuclear organizations was moderate-strongly related to both attitudes and risk perceptions (p. 432). Greater trust directly increased attitudes and indirectly increased attitudes by lowering perceived risk (Whitfield et al., 2009, p. 433). Trust in environmental groups, which included the EPA, national environmental groups, and university scientists, did not have any direct or indirect effects on attitudes or risk perceptions (p. 432).

As Table A9 (see Appendix A) summarizes, trust seems to influence attitudes through perceptions of risks and benefits. This provides evidence that attitudes towards complex scientific policy are a function of trust. Furthermore, the relationship appears to be moderated by perceived risks and benefits.

Summary of Empirical Studies of Trust and Attitudes/Risk Perceptions

Trust seems to be a significant predictor of attitudes and risk perceptions. There is some evidence to suggest that trust can be employed as a heuristic during the decision making stage or used in absence of knowledge. Trust in government, government agencies, industry, university scientists, were positively related to attitudes and negatively related to risk perceptions. Trust in fringe groups, such as non-governmental environmental groups, was linked to less positive attitudes and greater risk perceptions. A number of studies also showed that risk perceptions moderated the relationship between trust and attitudes. Studies that employed specific measures of trust often found stronger correlations than those that used general trust measures. Specific measures link management of hazards to those actors responsible for regulation, which could explain the increased strength of the trust-attitude relationship. General measures only measure trust in social actors and do not relate them to management of a hazard. When general measures are employed, it may be hard to tell if a significant relationship is due to trust in social groups one identifies with, or if they trust them as managers.

2.5 Worldviews: Cultural Biases and Social Relations

Culture shapes the way people think and act. Therefore, it could be expected that one's worldview is a predictor of attitudes and risk perceptions. Worldviews, according to Slovic (1999) are "general social, cultural, and political attitudes that appear to have an influence over people's judgments about complex issues" (p. 693). Rippl (2002) argues that, in terms of risk perception, people choose to dread something in terms of their relative culture (p. 149). Worldviews, in this sense, may influence perceptions of risk and attitudes through perceptions of risk.

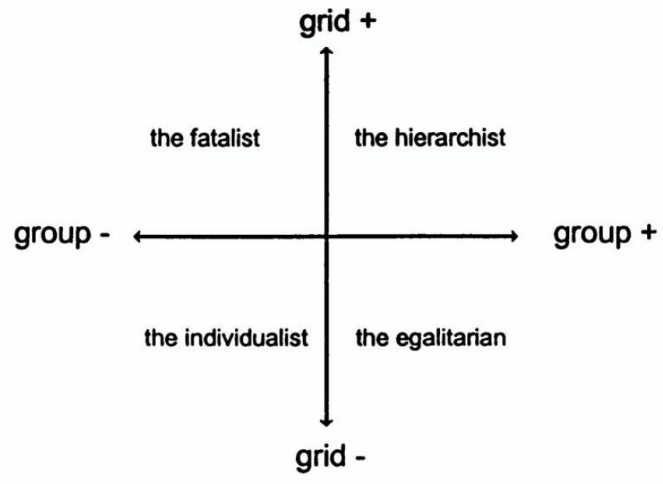
Some scholarship has examined worldviews as two opposing paradigms. For example, Buss & Craik (1983) measured worldviews across several different social, political, and environmental dimensions (p. 263). "Worldview A" reflected values that emphasized high economic growth, high reliance on technology, a centralized capitalist society, opposition to regulation on business, achieving societal goals through materialistic motivation, and a decision-making process based on rationality and logic (Buss & Craik, 1983, p. 268). On the other hand, those subscribing to "Worldview B" show concern for social and environmental costs of technologic growth, have greater interest in participatory democracy, place

emphasis on reducing consumption and redistributing resources, promoted a decentralized society, and other post-materialist qualities that are skeptical of a society based on productivity and technological growth (Buss & Craik, 1983, p. 269). Looking at differences in risk perceptions, those holding a Worldview B perceived relatively more dread and feelings of fatalism than Worldview A (p. 271). Worldviews also impacted risk perceptions for some applications, but not others (Buss & Craik, 1983, p. 271). For example, those holding Worldview A perceived the risks of nuclear power to be more acceptable, perceived less severity of risk, and reported less feelings of personal risk than Worldview B respondents. Oppositely, there were no significant differences for more conventional items, such as power motors. Therefore, worldviews might influence risk perceptions for more dreadful activities.

Other scholarship on worldviews incorporates aspects of the cultural theory of risk perception. According to this theory, people choose what they perceive to be risky and what level of acceptable risk they will tolerate in order to justify their lifestyle. Attitudes towards contentious scientific policy issues are not just based on perceptions of risk, but also the political and social stigma associated within their relative cultural framework (Buss, Craik, & Dake, 1986, p. 97). Thus, individuals choose not only what to fear, but how much fear is acceptable. Cultural theorists argue that judgments are shaped by a combination of cultural biases (shared values and beliefs) and social relations (various patterns of interpersonal relationships) (Dake, 1991, p. 65). Social relations influence our behaviours and cultural bias provides a justification for those behaviours (Rippl, 2002, p. 149). Combinations of cultural biases and social relations, which constitute a worldview, interact together in a mutually enforcing and non-hierarchal manner (Wildavsky & Dake, 1990, p. 44). In other words, social relations and cultural biases work together to form a worldview that shapes attitudes in consideration of perceived risk and how much risk is bearable; this relationship exists without primary causal significance being assigned to either of the two.

Most studies of worldviews and risk perceptions are built upon work by Douglas (2011) and Douglas & Wildavsky (1983), who proposed that social relations emerge from two societal dimensions: group and grid. Group is the degree to which one is embedded in or controlled by the cultural group they subscribed to (Douglas, 1978, p.7) where "an individual needs to accept constraints on his/her behaviour by the mere fact of belonging to a group" (Douglas, 2007, p.3). Group is high when they are strongly attached to a group and low when they do not belong to it (Mamadouh, 1999, p. 397). Grid refers to "all the other social distinctions and delegations of authority that [groups] use to limit how people behave to one another" (Douglas & Wildavsky, 1983, p. 138). Grid is high when individuals are subject to many rules or regulations within their group and low when a person lives free of group pressure and constraints (Douglas, 2007, p.3). Four distinct social relations, including fatalism, hierarchy, individualism, and egalitarianism, emerge from the group-grid system (see Figure 2).

Figure 2: Grid-Group Theory of Social Relations



Source: Schwarz & Thompson, 1990, p.7

Hierarchists are high group-oriented and prefer a large degree of socially controlled rules (high grid). As such, they fear social deviance, such as political protests, as those activities challenge the hierarchal structure of social relations (Dake, 1991, p. 66). They also have less concern for technological risks because of a high trust in experts regulating them; technology or science applications are seen favourably as they increase the social good (Dake, 1991, p. 67). Hierarchists are also less concerned about environmental risks because they trust experts to mitigate those risks for society (Dake, 1991, p. 67). Egalitarians are strongly group-oriented, but low on the grid dimension. They oppose social hierarchy and are therefore less concerned about socially deviant behaviour (Dake, 1991, p. 66). As group-oriented individuals, egalitarians fear technological risks as they increase disparities between classes, genders, and authority (Dake, 1991, p. 66). Similarly, they fear environmental risks because those risks threaten the equal distribution of the planet's finite resources (Dake, 1991, p. 67). Individualists, characterized as low-grid and low-group, oppose social deviance because it threatens individual liberty and upsets free-markets (Dake, 1991, p. 66). They are less concerned with environmental risks as unregulated markets increase social and economic benefits for all (Dake, 1991, p. 67). Individualists generally support scientific applications as they promote growth through an unfettered market (Dake, 1991, p. 67). Individualists are less risk averse as they view risk as an economic opportunity. Fatalists support social rules, but at an individual level. They show less concern for technological and environmental risks because they feel they have no influence over those risks (Peters & Slovic, 1996, pp. 1437, 1439).

Empirical Studies of Worldviews

A variety of studies have analyzed the link between worldviews emerging from the grid-group dimension and attitudes/risk perceptions. Most did not consider the fatalist worldview or it was grouped with another worldview. Jenkins-Smith (1994) evaluated if imagery of a nuclear repository site could be predicted by worldviews. While a majority of respondents reported negative imagery, analysis of variance of worldview mean scores showed that egalitarians had significantly higher negative valence imagery towards the repository, while hierarchists and individualists had lower negative valence (Jenkins-Smith, 1994, pp. 35-36, 38). When they thought about the repository, egalitarians were more likely to conjure negative imagery, while the other two invoked more positive (or less negative) imagery. Differences between egalitarians and hierarchists, as well as between egalitarians and individualists were significant.

Wildavsky & Dake (1990) found that worldviews were better predictors of risk and benefit perceptions and acceptability of risks than personality traits or self-perceived knowledge (pp. 49-50). Considering 25

applications of technology, egalitarians were more likely to believe technology posed greater risks and showed less preference for taking risks that could affect society (p. 50). Individualists and hierarchists saw relatively greater benefits, fewer risks, and were more willing to take risks that could affect society (pp. 50-51). Consistent with cultural theory, perceptions of danger for different items diverged among the three. Egalitarians perceived greater danger in technological and environmental risks, social deviance risks ranked highest for hierarchists, and the idea of war was the greatest threat for individualists (p. 51). Political orientation, which measured both political party membership and liberal-conservative ideology, also predicted perceptions of risk and was related to worldviews (p. 50).

Dake (1991) found similar results, although the sample (n=134) was notably small. Looking at technological and environmental concerns, egalitarians showed more concern than individualists or hierarchists (p. 71). On the other hand, the latter two showed greater concerns for social deviance when compared to egalitarians (pp. 71, 73). Individualist perceptions were similar to those of hierarchists, except for issues related to the free market (p. 72). With respect to dangers associated with nuclear power, hierarchists showed less concern and egalitarians showed more; the relationship for individualists was not statistically significant (p. 71). In terms of societal risk taking, Dake (1991) also found that hierarchists and individualists were pro-risk oriented, while egalitarians were more risk averse (p. 76). These findings suggest that attitudes are shaped by one's worldview.

Building upon work by Dake (1991), Peters & Slovic (1996) hypothesized that worldviews would be a predictor of attitudes towards nuclear power and perceptions of risks (see Table 3). Worldview measures were good predictors and accounted for 37% of the variance in nuclear power attitude items (p. 1437). Fatalist/hierarchists and individualists showed more favourable attitudes towards five measures of nuclear power, while egalitarians were less supportive (p. 1435). Egalitarians perceived greater health risks for several items, including nuclear power plants, nuclear waste, and food irradiation (p. 1441). Risk perceptions for the other worldviews were less pronounced; individualists viewed power plants as less risky and fatalist/ hierarchists perceived less risk in management of nuclear waste (p. 1441). Egalitarians believed the public should have greater control over decisions regarding the establishment of a nuclear power plant in their region (p. 1442). Fatalist/ hierarchists tended to hold the opposite view (p. 1442).

Table 3: Hypothesized Relationship Between Worldviews and Support for Nuclear Power

Fatalists • Tend to be less concerned about technological and environmental dangers • Do not trust experts, but support experts' authority and the technologies that they approve of • Expected to support nuclear power	**Hierarchists** • Less concerned about technological dangers and the free market, and are more concerned about social deviance • Support nuclear technology as it results in increased stratification of wealth and power.
Individualists • Show more concern for risks that infringe on rights or liberties and less concern for technological dangers • Support nuclear technology as it results in greater economic growth through a free-market, but oppose it if it infringes on liberty	**Egalitarians** • Show greater concern for technological and environmental dangers • Oppose nuclear technology because it increases societal disparities of wealth and power

Adapted from: Peters & Slovic, 1996, pp. 1430-1432

Other empirical research has found less supportive evidence. Palmer (1996) employed Dake's (1991) worldview constructs and found the risk model, which incorporated different measures of benefits and harms, accounted for a significant amount of variance in risk perceptions for hierarchists, individualists, and egalitarians at 67%, 55%, and 62% respectively (p. 721). However, many of the risk construct coefficients were statistically insignificant for each worldview; Palmer (1996) suggested this is the result

of the small sample size (n=115 students) (p. 720). Looking at differences in perceptions of 10 items, including nuclear power, there were no significant differences between worldviews (p. 721). While possibly the result of the small sample, it does not suggest that worldviews differed in their risk perceptions. Marris, Langford, & O'Riodan (1998) also employed Dake's (1991) constructs and were only able to categorize 32% of their 129 person sample to his worldview measures (p. 639). Worldviews could only be operationalized at the collective level (eg: high egalitarianism scores versus low egalitarianism scores). Individualists and hierarchists perceived less risk for nuclear power while egalitarians perceived more risk; the relationship was not significant for fatalists (p. 641). Correlations between worldviews and risk perceptions were small and insignificant, except for a few applications (p. 641).) Such findings suggest that the grid-group worldview measures might not be an appropriate method because they are "four extreme views", rather than four categories (Marris et al., 1998, p. 635).

Work by Sjöberg (1997), which compared risk perceptions between 102 teachers in Brazil and 94 teachers in Sweden, showed the two samples made similar judgments of risk (in Oltedal, Moen, Klempe, & Rundmo, 2004, p. 24-25). The relationships between worldviews and perceptions of risk were also weak (in Oltedal et al., 2004, p. 25) and only accounted for five percent of the variance in perceptions (in Sjöberg, 1998b, p. 138). This suggests that perceptions of judgment emerge, not from worldviews, but from actual risks that are constant across cultures (Sjöberg, 1997 in Oltedal et al., 2004, p. 25). Operationalizing Dake's (1991) worldview measures, Sjöberg (1998b) evaluated how worldviews, as well as trust, affect, and political orientation, influence 36 types of societal concerns and risk perceptions. While trust had the strongest correlation with concerns, about 58% of the relationships between the 36 concerns and worldviews were significant; Sjöberg (1998b) did not report which ones were significant (pp. 143-145). Egalitarians showed more concerns for dangers associated with nuclear energy, while individualists and hierarchists showed significantly less (p. 143)[2]. Trust, accounting for 23% of the variance, better explained societal concerns than worldviews (9% variance) and political orientation (7% variance) (p. 148). Worldviews accounted for a small amount of variance in risk perception at 4% for fatalist/ hierarchists, 2% for individualists, and 4% for egalitarians (Sjöberg, 1998b, p. 151). Trust and political attitudes each only accounted for 3% of risk perceptions (p. 148). This study suggests that worldviews are not significant predictors of societal concerns or risk perceptions, as an aggregate. However, concern over nuclear power did appear to vary significantly by worldview.

Summary of Empirical Literature on Worldviews and Attitudes/Risk Perceptions

Scholarship on worldviews tended to only evaluate three worldviews: egalitarians, hierarchists, and individualists. Empirical evidence for the notion that worldviews shape attitudes is mixed, but mostly supportive. Of all the studies that found significant correlations, the direction of the relationships were as expected; egalitarians were more likely to have higher environmental and technological risk perceptions, more concerns, and less supportive attitudes than individualists and/or hierarchists (see Table A10 in Appendix A). Interestingly, a few studies that employed Dake's (1991) constructs were unable to replicate his findings, however, this could be the result of small sample sizes. To summarize, the review of worldview literature suggests that cultural worldviews may shape risk perceptions as well as attitudes.

2.6 Literature Review Summary

Knowledge, trust, emotions, and worldviews appear to be correlated with attitudes and risk perceptions. The effect of knowledge on attitudes is the most widely studied predictor. This theory has been supported and challenged by different studies with respect to generalized science and specific technological applications. The role of trust and emotions seem to be well supported in the literature. Worldviews, while supported by some early studies, are challenged by others. Additionally, the validity of worldview

[2] Correlation coefficients were 0.29 for egalitarians, -0.23 for individualists, and -0.17 for hierarchists. Affect had a coefficient of -0.08 and trust was 0.34. Although Sjöberg (1998) did not report which correlations were significant, it would appear that, according to these coefficients, worldviews and concerns for nuclear power were significantly related.

measures has been subject of criticism, which warrants further study in this report. There is also substantial empirical and hypothetical evidence to suggest that these predictors may influence attitudes through risk perceptions.

Theories relating to knowledge assume that knowing more about science leads to more favourable attitudes, whether it is through greater understanding, more interest, less perceived risk, etc. Trust in those managing hazards could be employed in the absence of knowledge or through heuristics to simplify the decision making process. Emotional reactions to scientific items, such as nuclear power, are thought to influence attitudes in a non-cognitive way, such as the affect heuristic or risk as feelings, before a cost-benefit analysis is made. Each of these predictors assessed in the literature review is thought influence the decision making process in unique ways and there is sufficient amount of empirical evidence to support them.

3.0 METHODOLOGY

This research project's objectives were to analyze attitudes and risk perceptions of the nuclear industry in Saskatchewan and to test if they can be explained as a function of knowledge/awareness of the nuclear topics, trust, emotions, and/or worldviews. These four predictors had never been evaluated with respect to the nuclear sector in Saskatchewan.

In order to achieve these objectives, the researcher performed quantitative statistical analysis of telephone survey data using Statistical Package for the Social Sciences (SPSS) software, the Analysis of Moment Structures (AMOS) add-on, and Microsoft Excel. Methods of analysis included cross-tabulation, bivariate analysis, multiple linear regression, and SEM. Except for SEM, the findings of this quantitative analysis can be inferred upon the population of Saskatchewan (18 years and older) as a whole within a certain margin of error. It also allowed the researcher to test for statistical significance. Regression modeling was used to test relationships between independent and dependent variables and to explain how much variance in our dependent measures were accounted for, while controlling for other variables, such as socio-demographics. SEM was used to test the strength of direct effects of predictor variables on attitudes towards nuclear power and indirect effects as mediated through risk perceptions.

To perform such analyses, the researcher obtained secondary, anonymous data from the 2013 Saskatchewan Nuclear Attitudes telephone survey; the client provided the data set to the project researcher for this project. The survey was designed by Dr. Loleen Berdahl, Dr. Scott Bell, and Dr. Maureen Bourassa, all faculty at the U of S, and Dr. Jana Fried, Postdoctoral Fellow, It received approval from the U of S Research Ethics Board. The survey questionnaire contained six sections that assessed: knowledge of the nuclear industry, perceptions of nuclear sectors, Saskatchewan's nuclear sector future, trust in groups surrounding the nuclear sector, worldviews and political factors, and socio-demographics. The primary researcher for this project obtained ethics clearance from the University of Victoria Human Research Ethics Board before obtaining the survey data (see Figure B1 in Appendix B).

3.1 DATA COLLECTION

Survey data were collected using a computer-assisted telephone interviewing system (WinCATI) at the SSRL by student researchers over a two-week period from September 27, 2013 to October 11, 2013. In order to obtain a random sample of participants, WinCATI employed random digit dialing. When a call was answered by a resident, the student interview researcher asked to speak to the person in their household who is 18 years of age or older and is having the next upcoming birthday. The latter qualifier was done to ensure a more random representation of participants, as certain demographics are more likely to answer the phone within a household. If the participant of interest was not home or did not want to participate at that time, then a call back was arranged for the next day or a specific time identified by the participant. A telephone number was contacted up to a maximum of six times before it was considered to be a refusal and removed from the sample.

Once the participant of interest was on the phone, the researcher informed them of the purpose of the study and asked for their participation. In addition, the participant was read an ethics statement about the use of the data and was informed that their participation is voluntary and that all information is anonymous and stored securely. If consent was given, then the participant was prompted to provide their postal code to ensure that they were a resident of the Saskatchewan. If they could not provide a Saskatchewan postal code, they did not qualify as an eligible participant and were removed from the sample. WinCATI captures and stores the participants' responses into an electronic database. Once collection was completed, data was weighted by the SSRL by region, age, and gender. The weighted data set was then stripped of any personal identifiers before being provided to this report's researcher via Dropbox.

3.2 PARTICIPANTS

In total, 1,355 randomly selected Saskatchewan residents, 18 year of age or older, completed the telephone survey. The generalized response rate was 21% and the results of the survey are generalizable to the Saskatchewan population (18 years of age and above) with a margin of error +/- 2.66% 19 times out of 20 (95% confidence interval). Table 4 provides a comparison of gender, age, and area of residence sample statistics with 2011 Canadian Census population parameters for Saskatchewan residents, 18 years of age or older. Females and older individuals were over-sampled, while males and younger individuals were under-sampled. In the analyses, the data was weighted to reflect the population parameters.

Table 4: Comparison of NPRI Sample Statistics with Provincial Population Parameters

	NPRI sample statistics	2011 Census population parameters (18+)	Deviation from population parameters (% points)
Male	44.6%	49.0%	-4.4%
Female	55.4%	51.0%	4.4%
Saskatoon CMA	28.6%	25.7%	2.9%
Regina CMA	18.3%	20.9%	-2.6%
Other Sask. Cities	15.4%	15.9%	-0.5%
Rural areas	37.6%	37.5%	0.1%
18-34	14.8%	29.9%	-15.1%
35-54	35.9%	34.7%	1.2%
55+	47.7%	35.4%	12.3%

Source: Statistics Canada, 2011

4.0 MEASURES

The following is a general overview of the measures that were used to assess attitudes and risk perceptions towards the nuclear sector in Saskatchewan. A more detailed account of methods, including the NPRI telephone survey questions, their operationalization, factor and reliability analysis, coding, and measures of central tendency, are presented in Appendix C. An assessment of how the NPRI measures relate to conceptual definitions in the literature and how said measures correspond to or deviate from those in the literature are also covered in Appendix C.

Three separate dependent measures were used in this research report: impressions of nuclear sector applications (impressions), support for future involvement of the nuclear sector in Saskatchewan (future support), and risks and benefit perceptions of nuclear power (risk perceptions) (see Table 5). The first two measures were average scales that consisted of four constructs each. The risk perception measure was one variable. The Cronbach's alphas (a measure of internal consistency of a scale variable) for impressions (0.793) and support (0.825) measures were moderately high, which means there was a good degree of internal consistency among the four variables in each scale.

Table 5: NPRI Dependent Attitudinal Measures

Dependent Measures	Number of constructs	Cronbach's Alpha (if applicable)
Impressions of nuclear sector applications: • Nuclear medicine • Nuclear fuel waste management practices • Uranium mining • Nuclear power generation	4	0.793
Support for Future Involvement of the nuclear sector in Saskatchewan: • Continuing nuclear medicine research funding • Storing nuclear fuel waste • Continuing uranium mining • Generating power form nuclear sources	4	0.825
Risk/benefit perceptions of nuclear power	1	

A variety of independent variables, including knowledge/awareness, trust, emotions, and worldviews, = were used to test the hypothesized predictors (see Table 6). Knowledge was measured in two ways: how much factual knowledge one had about nuclear topics and nuclear related activities in Saskatchewan (objective knowledge/awareness) and how much they thought they knew about nuclear topics (subjective knowledge). The objective knowledge measure was a summed scale that consisted of four factual knowledge/awareness items. Trust was assessed by six variables that included trust in government/industry (average scale of four variables), trust in university scientists (single variable), and trust in environmental groups (single variable). Two different types of emotional measurements were employed. The first assessed the respondent's initial reaction to the word "nuclear", ranging from very negative to very positive. The second type measured specific negative and positive emotions towards nuclear power including, fright, anger, and excitement. This study employed nine measures to construct hierarchist, individualist, and egalitarian worldview scales; each was an average scale that consisted of three different variables. A variable that assessed ethical concerns of nuclear power was also used.

The Cronbach's alpha for the trust in government/industry scale was moderately high (0.802) which suggested a good level of internal consistency among the four trust variables. The level of internal consistency among the objective knowledge/awareness variables was moderate (Cronbach's alpha = 0.601). Additional analysis showed that individually deleting any of the items in that scale reduced its internal consistency. Therefore, the objective knowledge/awareness scale had the highest amount of internal consistency when all four measures were included. Each of the three worldview scales had moderately low levels of internal consistency. Individually deleting any of the three variables from the hierarchist scale reduced its internal constancy; the level of internal consistency for this worldview was the strongest when all three variables were included. For the individualist scale, deleting variable E8 (The environment is very adaptable and will recover from any harm caused by people recode) increased the Cronbach's alpha to 0.591, while individually deleting the other two variables (E5 and E6) lead to significantly lower alphas (0.338 and 0.362, respectively). E8 was therefore a less consistent measure of the individualist worldview when compared to E5 and E6 variables. However, E8 was included in the individualist scale because its removal only marginally increased the internal constancy and also because of other theoretical justifications from the literature. When any of the three measures were individually deleted from the egalitarian scale, the Cronbach's alpha was reduced. Therefore, internal consistency for the egalitarian scale was strongest when all three were included in that scale.

Table 6: NPRI Independent Predictor Measures

Independent Measures	Number of constructs	Cronbach's alpha (if applicable)
Subjective knowledge	1	
Objective knowledge/awareness	4	0.601
Trust in government/industry	4	0.802
Trust in scientists	1	
Trust in environmental groups	1	
Initial reaction to the word "nuclear"	1	
Frightened by nuclear power	1	
Angered by nuclear power	1	
Excited by nuclear power	1	
Hierarchal worldview	3	0.549
Individualist worldview	3	0.539
Egalitarian worldview	3	0.503
Ethics of nuclear power	1	

Finally, a number of socio-demographic variables were used as independent measures of attitudes and as control variables during regression analysis. These variables included: gender, area of residence, age, education, employment status, a household member having worked in the uranium mining sector, nuclear industry near one's community, religion, Aboriginal status, country of birth, and annual household income.

5.0 RESEARCH QUESTIONS AND HYPOTHESES

The literature review revealed several potential research questions. The measures operationalized from the NPRI survey were used to address if commonly supported theories of attitude and risk perception development are supported with regard to the nuclear sector in Saskatchewan. Empirical studies that tested predictors have varied in their methodologies, measures, and methods of analysis; however, supportive findings in the literature review permitted further study for the purpose of this report. This project attempted to understand attitudes and risk perceptions towards the nuclear sector by addressing the following research questions and hypotheses:

Research question 1: What are Saskatchewan residents' attitudes and risk perceptions towards nuclear sector applications?

Research question 2: What is the role of knowledge/awareness, trust, emotions, and worldviews in explaining attitudes and risk/benefit perceptions?

> H1: Greater objective knowledge/awareness and subjective knowledge of the nuclear industry in Saskatchewan and of nuclear topics is positively related to: a) favourable impressions of nuclear sector applications, b) support for future nuclear activities in Saskatchewan; and c) benefits of nuclear power generation outweighing the risks.
>
> H2: Levels of trust in government, industry, and university scientists are positively correlated with: a) favourable impressions of nuclear sector applications, b) support for future nuclear activities in Saskatchewan; and c) benefits of nuclear power generation outweighing the risks.
>
> H3: Levels of trust in environmental groups are negatively correlated with a) favourable impressions of nuclear sector applications, b) support for future nuclear activities in Saskatchewan; and c) benefits of nuclear power generation outweighing the risks.
>
> H4: Negative emotions and feelings towards nuclear power generation are negatively related to: a) favourable impressions of nuclear sector applications, b) support for future nuclear activities in Saskatchewan; and c) benefits of nuclear power generation outweighing the risks.
>
> H5: Positive emotions and feelings towards nuclear power generation are positively related to: a) favourable impressions of nuclear sector applications, b) support for future nuclear activities in Saskatchewan; and c) benefits of nuclear power generation outweighing the risks.
>
> H6: Hierarchal and individualist worldviews are positively correlated with: a) favourable impressions of nuclear sector applications, b) support for future nuclear activities in Saskatchewan; and c) benefits of nuclear power generation outweighing the risks.
>
> H7: Egalitarian worldviews are negatively correlated with: a) favourable impressions of nuclear sector applications, b) support for future nuclear activities in Saskatchewan; and c) benefits of nuclear power generation outweighing the risks.

Research question 3: Do ethical concerns about nuclear power generation moderate the hypothesized link between knowledge/awareness and attitudes towards nuclear power generation?

Research question 4: Do perceptions of risks and benefits of nuclear power generation mediate the relationship between knowledge/awareness, trust, emotion, and worldviews and attitudes towards nuclear power generation?

H8: Perception of the benefits outweighing the risks for nuclear power generation are positively related to: a) impressions of nuclear power generation, and b) support for the future of nuclear power generation.

H9: Knowledge/awareness increases: a) favourable impressions and b) future support for nuclear power generation directly and indirectly through lower risk perceptions of nuclear power generation.

H10: Trust in government/industry and university scientists increases: a) favourable impressions and b) future support for nuclear power generation directly and indirectly through lower risk perceptions of nuclear power generation.

H11: Trust in environmental groups decreases a) favourable impressions and b) future support for nuclear power generation directly and indirectly through higher risk perceptions of nuclear power generation.

H12: Negative emotions and feelings decrease a) favourable impressions and b) future support for nuclear power generation directly and indirectly through higher risk perceptions of nuclear power generation.

H13: Positive emotions and feelings increase a) favourable impressions and b) future support for nuclear power generation directly and indirectly through lower risk perceptions of nuclear power generation.

H14: Hierarchal and individualist worldviews increase a) favourable impressions and b) future support for nuclear power generation directly and indirectly through lower risk perceptions of nuclear power generation.

H15: Egalitarian worldviews decrease a) favourable impressions and b) future support for nuclear power generation directly and indirectly through higher risk perceptions of nuclear power generation.

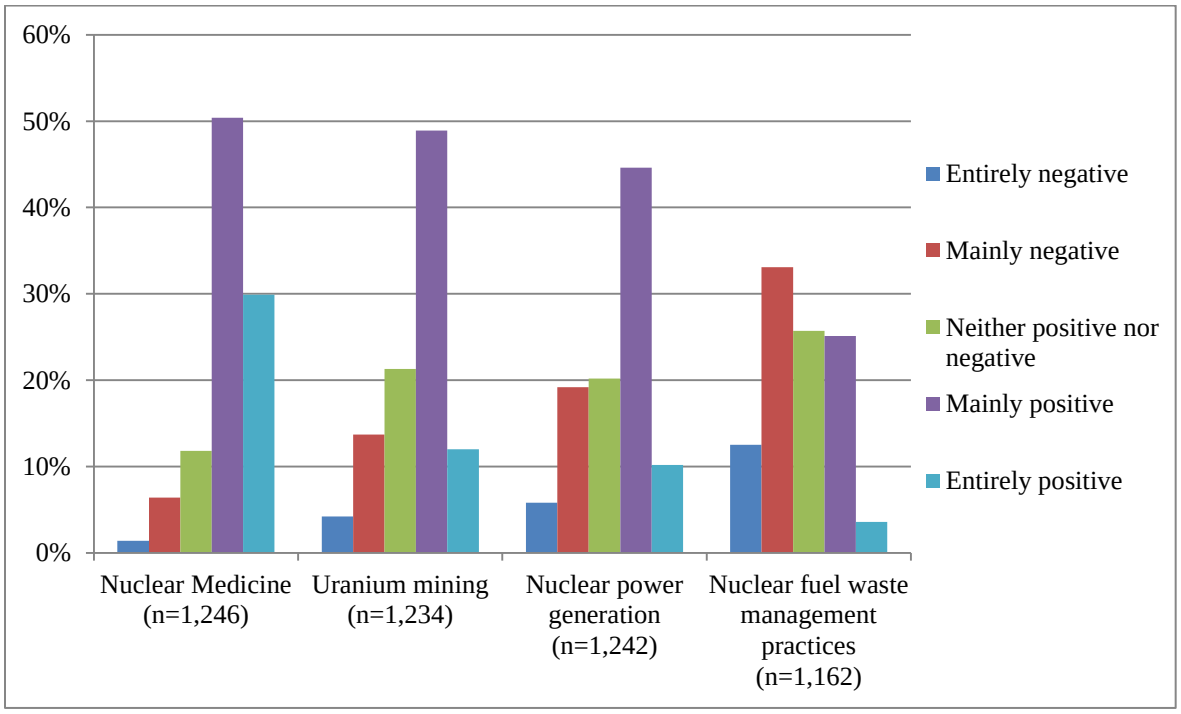
6.0 RESULTS

This section presents the findings of the statistical analysis of the survey data. It will begin will an overview of impressions and future support for four nuclear activities, as well as perceived risk perceptions of nuclear power generation (research question 1). It also includes a discussion of significant relationships between socio-demographic variables and the dependent measures. The correlation matrix for the bivariate analysis is available in Table D1 in Appendix D. The findings of several multiple regression models relating to research question 2 are then presented. Results of hierarchal multiple regression models that were used to test if ethical concerns of nuclear power moderated the hypothesized knowledge-attitudes relationship (research question 3) follow. The remainder of the results section is dedicated to research questions 4, which assesses if and how risk perceptions mediate the relationship between predictor variables and attitudes.

6.1 IMPRESSIONS OF NUCLEAR SECTOR APPLICATIONS

Saskatchewan residents hold generally positive impressions of nuclear sector applications (see Figure 3). Nuclear medicine, uranium mining, and nuclear power generation, were viewed favourably with 80%, 61%, and 55% of residents' having a positive impression. Nuclear fuel waste management practices were viewed less favourably; 28% viewed waste management practices positively, while 46% viewed it negatively.

Figure 3: Impressions of Four Nuclear Sector Activities



Males were significantly more likely than females to hold positive impressions for all four activities, as were non-Aboriginals than Aboriginals. This means that males and non-Aboriginals were more likely to view nuclear medicine, uranium mining, nuclear power generation, and nuclear fuel waste management practices more positively than their respective counterparts.

Age was positively correlated to impressions of nuclear medicine, but was negative related to the other three non-medical applications. In other words, as one's age increased they held a more positive attitude

towards medical applications, but a more negative attitude towards uranium mining, nuclear power generation, and fuel management practices.

Those who lived in the Saskatoon CMA and the Regina CMA were more likely to have a positive impression of nuclear medicine, while those who resided in a smaller city held more negative impressions of medical applications. Differences in impressions did not vary in the city regions with respect to the other three non-medical applications. In terms of area of residence, impressions of nuclear activities only varied for medical applications and only for those who lived in the CMA regions and smaller cities.

Education levels were positively correlated with support for nuclear medicine, which suggests that as education increased, the more likely one was to view medical applications more favourably. Impressions of uranium mining, nuclear power generation, and spent fuel management practices did not vary amongst levels of education.

Living in a community with a nuclear industry was also related to support for nuclear medicine. There were no significant differences in perceptions of uranium mining, nuclear power generation, and spent fuel management practices between those with a nuclear industry in their community and those without such an industry.

Employed residents were more likely to hold positive impressions of nuclear power generation and nuclear fuel waste management practices than the unemployed. Differences in impressions did not vary significantly between levels of employment for the other two sector activities.

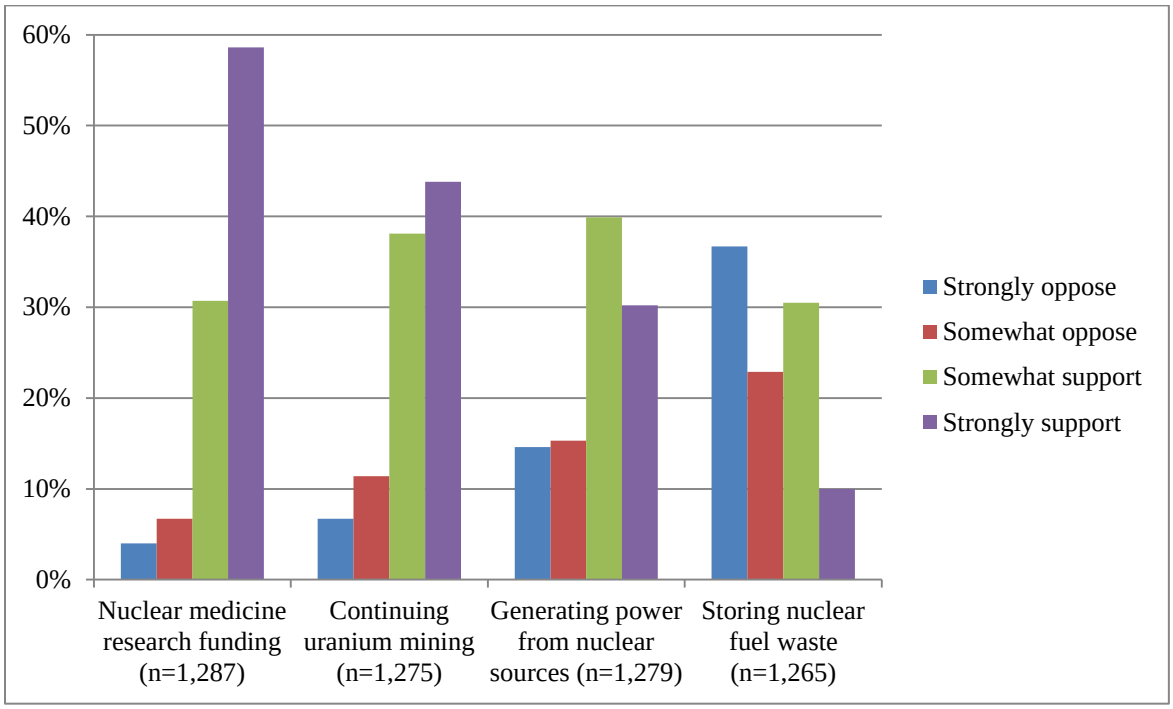
Household income was negatively correlated to impressions of spent fuel management practices, which suggests that attitudes became less favourable as income increases. Attitudes were not significantly different for the other three nuclear activities across income levels.

Those who reported having someone in their household who worked previously in the uranium mining industry were more likely to have a positive impression of uranium mining and nuclear power generation than those who did not. Attitudes towards spent nuclear fuel practices or nuclear applications did not differ between the two groups.

6.2 Support for Future of the Nuclear Sector in Saskatchewan

Respondents also showed generally high levels of support for the future of the nuclear sector in Saskatchewan (see Figure 4). Nuclear medical research was the most supported nuclear item with over 89% of respondents supporting it. Continuing uranium mining was the second most supported activity with over 82% support. More than 70% supported the idea of generating power from nuclear sources. Attitudes towards storing spent nuclear fuel were less positive; almost 60% opposed the idea of storing spent fuel in Saskatchewan.

Figure 4: Support for Saskatchewan's Future Involvement in Four Nuclear Sector Activities



Males were more likely than females to show support for all four activities, while Aboriginal were more likely than non-aboriginals to show opposition for all four activities. In other words, males and non-Aboriginals were more supportive of future activities related to nuclear medicine research funding, continuing uranium mining, generating power from nuclear sources, and storing nuclear fuel waste.

Those who lived the Saskatoon or Regina CMA regions were more likely to support funding for nuclear medicine research, while those in the rural south were more opposed to it. Attitudes towards continuing uranium mining, generating power from nuclear sources, and storing nuclear fuel waste did not differ between areas of residence.

Education was positively correlated with support for nuclear medicine research funding; no significant relationship existed for the other three non-medical activities. This suggests that support for medical research funding increased as education levels increased.

Those who lived in a community with a nuclear industry were more likely to support activities related to nuclear medicine funding, storing nuclear fuel, and continuing uranium mining than people in a community without a nuclear industry. Differences in attitudes towards nuclear generation did not vary according to the presence or absence of a nuclear industry.

Respondents reporting a household member having worked in the uranium industry were more likely than those who did not to support storing nuclear fuel, continuing uranium mining, and generating power from nuclear sources.

Employed residents were more likely to support continuing uranium mining and storage of nuclear waste than the unemployed. While attitudes did vary for these two applications between employment status, they did not significantly vary with respect to nuclear medicine research and nuclear power generation.

Age was negatively correlated to support for the continuation of uranium mining in Saskatchewan, as well as support for generating power from nuclear sources. This means that as age increased, the likelihood of

supporting those activities decreased. No significant difference existed between age and support for the future of medical applications or storing spent fuel.

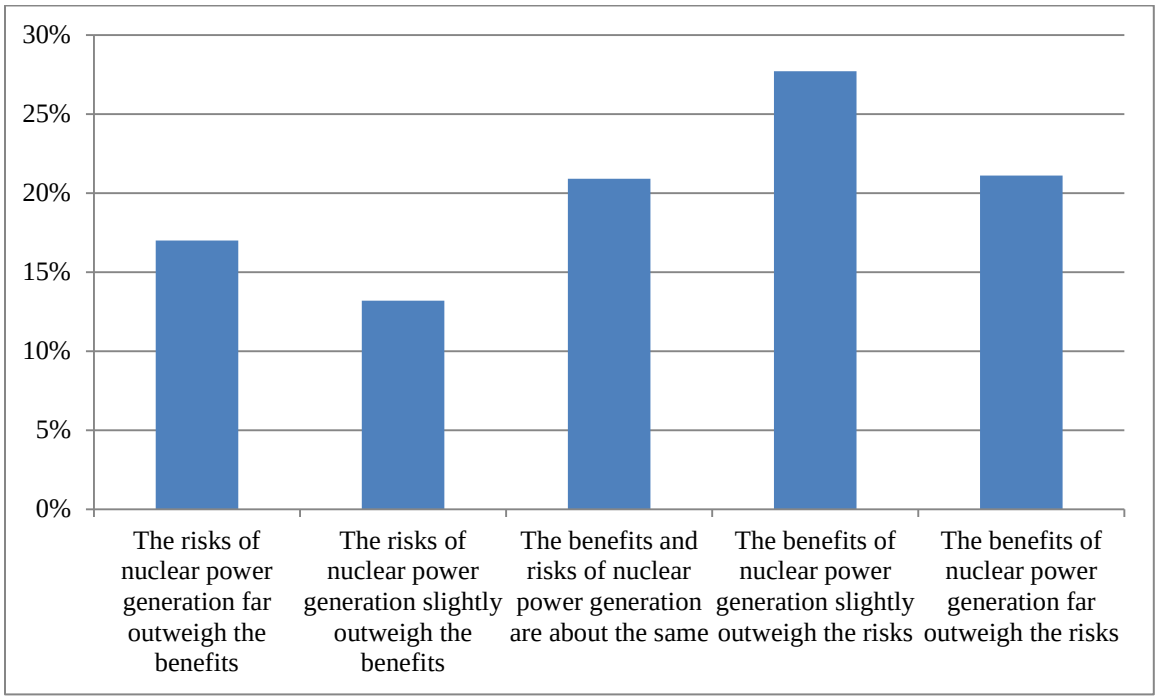
In terms of religion, Protestants were more likely to support nuclear waste storage than the other religions. Attitudes did not vary for the other three applications with respect to religious affiliation.

Persons born outside of Canada were more opposed to the idea of continuing uranium mining than those born in Canada. Attitudinal differences were not present amongst country of origin and the other three nuclear related activities.

6.3 Risk and Benefit Perceptions of Nuclear Power Generation

Slightly less than half of respondents (48.8%) believed that the benefits of nuclear power generation were greater than the risks, while 30.2% felt that the risks outweighed the benefits in some capacity; about 21% perceived risks and benefits to be about the same (see Figure 5) (n= 1,237). The only socio-demographic significantly related to risk perceptions was gender; males were more likely than females to perceive the benefits as outweighing the risks (r = 0.171). In other words, risk perceptions varied amongst gender and none of the other socio-demographics

Figure 5: Risk/Benefit Perceptions of Nuclear Power Generation



In summary, Saskatchewan residents hold generally positive attitudes towards nuclear medicine, as well as uranium mining and, to a lesser extent, nuclear power generation. Attitudes towards storing nuclear fuel and related practices were much more negative. Almost half thought that the benefits of nuclear power generation outweighed the risks. Gender was the most significant and constant predictor of attitudes and risk perceptions as males were much more likely than females to show positive attitudes and less risk perceptions. Aboriginal status was also an important predictor as they had much more negative attitudes than non-Aboriginals. Area of residence, education levels, living in a community with a nuclear industry, residing in household with someone who had worked in the uranium industry, employment, age, subscribing to the Protestant religion, country of origin, employment status, and household income were also significantly correlated to one or more nuclear sector activities.

6.4 Testing the Role of Knowledge, Trust, Emotions, and Worldviews

In addition to socio-demographics (Model 1), multiple regressions models were constructed for each of the four hypothesized predictors, including knowledge/awareness (Model 2), trust (Model 3), emotions (Model 4), and worldviews (Model 5). Model 6 included all predictors and models 2-6 also controlled for socio-demographics.

Predicting Impressions Towards Nuclear Sector Applications

As Table 7 shows, most of the models performed well in predicting impressions of the nuclear sector. Socio-demographics accounted for 11.4% of the variance in the dependent scale. The knowledge/awareness measures accounted for a small, incremental amount of variance when included with the socio-demographic measures (Model 2). This model only predicted 12.8% of the variance in impressions of nuclear sector applications and objective knowledge/awareness was insignificant, which suggests that impressions did not vary according to how much one knew about nuclear topics. Subjective knowledge was weakly, positively correlated (β= 0.136) with impressions, which suggests that favourable impressions increased as one thought they were more knowledgeable about nuclear topics.

The three trust measures (Model 3), on the other hand, were all significantly related to the nuclear impressions scale and predicted almost 39% of the variance of impressions towards nuclear sector applications. The strength of the relationship was greatest for trust in government/industry (β= 0.368); those with higher levels of trust in government/industry showed more favourable impressions. The relationship between trust in university scientists was slightly weaker (β= 0.197), but also suggests that greater trust in scientists led to more positive views. Trust in environmental groups was negatively related to impressions, as expected (β= -0.288). These findings suggest that trust was a significant predictor of impressions and that trust in government/industry and university scientists increased favourable impressions, while greater trust in environmental groups led to less favourable impressions.

Emotions (Model 4) were a very strong determinant and this model explained 63.3% of the variance. The relationship between one's reaction to the word "nuclear" was positively correlated with favourable impressions (β= 0.281), which reveals that positive affect was positively related to impressions, and opposite was true for negative affect. The three emotions were also significantly related to the dependent scale. Negative emotions, including fright (β= 0.135) and anger (β= 0.158), were positively correlated, while excitement, the strongest predictor in the model (β= -0.332), was negatively correlated. This supports the idea that greater negative feelings of nuclear power resulted in less positive attitudes for nuclear sector applications and positive feelings led to more positive attitudes.

Results for Model 5 showed that worldviews were also significant predictors of impressions; this model accounted for 40.5% of the variance. As expected, the hierarchist worldview (β= 0.222) and the individualist worldview (β= 0.319) were both significantly and positively related to the dependent measure. Alternatively, the egalitarian worldview was significantly and negatively correlated (β= -0.189). In other words, hierarchists and individualists had more favourable impressions, while egalitarians had less favourable impressions.

Inclusion of all the variables in Model 6 accounted for 65.3% of the variance in the impressions scale. This was only slightly more than what emotions (Model 4) accounted for on their own. Trust in government/industry (β= 0.065) and the individualist worldview (β= 0.129) remained significant, however, their strength was significantly reduced. The remaining trust and worldview measures were rendered insignificant. None of the knowledge measures were important predictors. Three of the four emotions variables, including reaction to "nuclear" (β= 0.257), anger (β= 0.156), and excitement (β= -0.261), were significant. These were the strongest predictors in Model 6 and their strength was only marginally reduced when compared to Model 4. Thus, when all predictor variables were included, emotions remained the strongest predictors when compared to knowledge, trust, and worldviews.

Table 7: Predicting Impressions of Nuclear Sector Applications

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Male dummy	0.185*	0.158*	0.079*	0.009	0.130*	0.009
Age	0.027	0.013	0.049	0.044	0.056	0.048
Education	0.066	0.047	0.038	0.041	0.112*	0.060*
Employment dummy	-0.004	0.003	0.028	-0.011	0.037	0.023
Household mining dummy	0.069*	0.056	0.076*	0.005	0.062*	0.020
Nuclear community dummy	0.035	0.020	0.030	0.011	0.037	0.027
Catholic dummy	0.064	0.074	0.042	0.085*	0.037	0.076*
Protestant dummy	0.117*	0.123*	0.041	0.029	0.046	0.027
Other religion dummy	0.068	0.072	0.054	0.061*	0.083*	0.083*
Aboriginal dummy	-0.078*	-0.082*	-0.033	-0.003	-0.035	0.001
Foreign born dummy	-0.030	-0.041	-0.025	0.030	-0.024	0.025
Income	0.191*	0.183*	0.020	0.049	0.077*	0.001
CMA dummy	-0.013	-0.018	-0.068	-0.038	-0.034	-0.050
Smaller city dummy	-0.030	-0.033	-0.045	-0.018	-0.021	-0.003
Rural south dummy	-0.026	-0.035	-0.077	-0.053	-0.057	-0.049
Objective knowledge		-0.040				0.042
Subjective knowledge		0.136*				-0.008
Trust in gov/industry			0.368*			0.065*
Trust in scientists			0.197*			0.052
Trust in environmental			-0.288*			0.003
Reaction to "nuclear"				0.281*		0.257*
Fright				0.135*		0.043
Anger				0.158*		0.156*
Excitement				-0.332*		-0.261*
Hierarchy					0.222*	0.057
Individualism					0.319*	0.129*
Egalitarian					-0.189*	-0.030
R	0.337	0.358	0.623	0.795	0.636	0.808
R Square	0.114	0.128	0.389	0.633	0.405	0.653
Adjusted R Square	0.097	0.109	0.373	0.623	0.390	0.637

Table includes standardized beta coefficients

*. Correlation is significant at the 0.05 level (2-tailed).

A number of socio-demographic variables were significantly related to impressions when included in the various models. Being male led to more positive impressions, except when emotions were controlled for. Having a family member who worked in the uranium mining industry was also a significant predictor. Income and education were also positively correlated to impressions in a few of the models. In two of the models, those subscribing to the Protestant faith showed more favorable impressions, while Aboriginals showed less favourable impressions. Belonging to the other religion category resulted in greater impressions in half of the models that were tested.

Predicting Support for Saskatchewan's Future Involvement

Results for support for future involvement of nuclear sector activities in Saskatchewan (see Table 8) were similar to results for impressions of the nuclear sector. The socio-demographic variables (Model 1) explained 14.8% of the variance. Knowledge/awareness (Model 2) barely increased the amount of explained variance (15.6%). Objective knowledge was not a significant predictor of attitudes, while subjective knowledge was (β= 0.100). Those believing they knew more about nuclear topics were more likely to show support, while attitudes did not vary amongst different levels of objective knowledge.

The trust model (Model 3) explained 43.7% of the variance in future support. Once again, trust in government/industry was the strongest predictor (β= 0.389) in the model and was positively linked to support. Trust in university scientists was also significantly and positively correlated to the dependent scale (β= 0.162), while trust in environmental groups was negatively related (β= -0.317). Similar to the findings for the impressions of nuclear activities scale, those who trusted government/industry and university scientists more were more likely to show support for the future of the sector, while those who trusted environmental groups more were more likely to show opposition.

Emotions (Model 4) predicted future support exceptionally well and this model explained 72.6% of the variance in this measure. Reactions to the word "nuclear" were significantly correlated to support for the future of the nuclear industry in Saskatchewan (β= 0.241). Viewing "nuclear" as positive was related to greater support for nuclear activities. Fright (β= 0.187) and anger (β= 0.205) were also significantly correlated; those who reported these negative emotions more were less likely to show support. The more excited respondents were about nuclear power, the more support they showed (β= -0.334). Therefore, greater negative emotions were negatively related to support; the opposite was true for greater positive emotions. The three worldviews (Model 5) also performed well as expected and accounted for 49.8% of the variance in support for the future nuclear activities. Hierarchists (β= 0.248) and individualists (β= 0.332) showed more support, while egalitarians were more likely to show opposition (β= -0.236).

When all variables were included (Model 6), 75.0% of the variance in the support for future activities scale was accounted for. This was about two percentage points more than what emotions accounted for on their own (Model 4). Neither of the knowledge measures were significant predictors. Trust in government/industry (β= 0.054) was the only trust measure that had significant effects, however, these effects were greatly reduced in the presence of other variables. Similarly, the hierarchy (β= 0.080) and individualist (β= 0.097) worldviews remained significant, albeit their strengths were also significantly reduced. All four emotion variables remained significant and their effects were only marginally reduced when compared to Model 4. Reactions to "nuclear" (β= 0.181), fright (β= 0.116), anger (β= 0.201), and excitement (β= -0.281) were the strongest predictors in Model 6.

Aboriginals were more likely to show opposition in all six models. Being male, on the other hand, increased the likelihood of support, except when emotions were included. Being Protestant and living in a community with a nuclear industry were also significant predictors of support. Income was also positively correlated with support in two-thirds of the models that were tested.

Table 8: Predicting Support for Future Involvement in the Nuclear Industry in Saskatchewan

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Male dummy	0.188*	0.162*	0.068*	0.000	0.120*	-0.011
Age	0.016	0.000	0.02	0.025	0.049	0.042
Education	0.043	0.018	0.02	-0.010	0.105*	0.009
Employment dummy	-0.038	-0.033	-0.011	-0.020	0.016	-0.013
Household mining dummy	0.045	0.034	0.063*	-0.013	0.047	0.000
Nuclear community dummy	0.088*	0.078*	0.058	0.041	0.087*	0.046*
Catholic dummy	0.031	0.035	-0.022	0.028	0.006	0.011
Protestant dummy	0.119*	0.117*	0.046	0.033	0.063*	0.026
Other religion dummy	0.034	0.035	-0.008	0.013	0.059*	0.021
Aboriginal dummy	-0.143*	-0.146*	-0.083*	-0.054*	-0.102*	-0.053*
Foreign born dummy	-0.031	-0.033	-0.011	0.013	-0.037	-0.008
Income	0.221*	0.215*	0.061	0.049*	0.067*	0.024
CMA dummy	-0.118	-0.122	-0.11	-0.031	-0.094	-0.019
Smaller city dummy	-0.138	-0.132	-0.12	-0.016	-0.114	-0.02
Rural south dummy	-0.102	-0.105	-0.117	-0.038	-0.090	-0.035
Objective knowledge		0.003				0.029
Subjective knowledge		0.100*				-0.002
Trust in gov/industry			0.389*			0.054*
Trust in scientists			0.162*			0.026
Trust in environmental			-0.317*			-0.032
Reaction to "nuclear"				0.241*		0.181*
Fright				0.187*		0.116*
Anger				0.205*		0.201*
Excitement				-0.334*		-0.281*
Hierarchy					0.248*	0.080*
Individualism					0.332*	0.097*
Egalitarian					-0.236*	-0.046
R	0.385	0.395	0.661	0.852	0.706	0.866
R Square	0.148	0.156	0.437	0.726	0.498	0.750
Adjusted R Square	0.132	0.139	0.423	0.719	0.487	0.739

Table includes standardized beta coefficients

*. Correlation is significant at the 0.05 level (2-tailed).

Predicting Risk/Benefit Perceptions of Nuclear Power

The models did not predict risk/benefit perceptions of nuclear power as well as they did for the two previous dependent scales (see Table 9); however, most of the predictors were significant and behaved as expected. The socio-demographic variables (Model 1) accounted for 7.2% of the variance in risk/benefit perceptions. Including the two knowledge measures (Model 2) only slightly increased the amount of explained variance (7.5%). Neither the objective nor the subjective knowledge scales were significantly related, which suggests that perceptions did not vary among levels of knowledge or awareness.

The trust measures (Model 3) accounted for 26.8% of the variance in risk/benefit perceptions of nuclear power. Trust in government/industry (β= 0.296) and trust in university scientists (β= 0.163) was positively related to the risk/benefit measure, while trust in environmental groups was negatively correlated (β= -0.251). In other words, those who trusted government/industry and university scientists were more likely to perceive the benefits of nuclear power as outweighing the risks, while those trusting environmental groups viewed the risks as greater than the benefits.

Explaining 45% of the variance, the emotions model (Model 4) predicted risk/benefit perceptions quite well. Initial reactions to the word "nuclear" were positively and significantly related to this measure (β= 0.259). This means that the more positive affect reported after thinking of "nuclear", the more likely the benefits were perceived to outweigh the risks. Similarly, the more one reported being angered by nuclear power, the greater the likelihood of perceiving more risks (β= 0.095), while the more excitement one reported about nuclear power, the greater the likelihood of perceives benefits (β= -0.345). Being frightened by nuclear power was not significantly related to risk perceptions.

Model 5, which assessed worldviews, accounted for 24.2% of the variance in risk/benefit perceptions of nuclear power. Hierarchists (β= 0.205) and individualists (β= 0.130) perceived the benefits of nuclear power generation to be greater than the risks, while egalitarians (β= -0.243) perceived risks as outweighing the benefits. Egalitarians, in this sense, were much more risk averse than the other two.

Model 6, which included all of the predictor variables, accounted for 45.6% of the variance in risk/benefit perceptions. This was less than a one percentage point increase in the amount of variance that emotions accounted for in Model 4. Knowledge was not significantly related to such perceptions. Trust in environmental groups (β= -0.078) was the only trust measure significantly related to risk/benefit perceptions and its effects were greatly reduced from Model 3. None of the worldview measures were significant predictors when included in this model, which was interesting considering all three were strong predictors in Model 5. Reaction to "nuclear" (β= 0.235) and excitement (β= -0.325) were the only two emotions variables that remained significantly related to risk/benefit perceptions. These two were the strongest predictors in the model and their effects were only marginally reduced from Model 4.

Age and income were positively correlated to risk perceptions; as age and income increased one was more likely to perceive the benefits as outweighing the risks. In most of the models, men were less risk averse than women. In two of the models, those born outside of Canada were more likely to perceive the risks as being greater than the benefits, when compared to those born in Canada.

Summary of Regression Models

Emotions explained the greatest amount of variance in all three dependent measures and were also the strongest predictors. Feeling excited about nuclear power was the strongest of the emotional variables, followed by reactions to "nuclear". When all predictor variables were included in a final model for each dependent measure, the variance only marginally increased. Knowledge had no effects in this final model. The effects of trust and worldview measures were also greatly reduced. The effects of the emotion variables were only moderately reduced in the presence of the other variables. Gender, Aboriginal status, and to a lesser extent, income, were the best socio-demographics predictors for the impressions and future support scales, while age, income, and gender were the best predictors of risk perceptions.

Table 9: Predicting Benefits of Nuclear Power Outweighing the Risks

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Male dummy	0.143*	0.148*	0.051	0.004	0.098*	0.021
Age	0.080*	0.082*	0.092*	0.066*	0.076*	0.060
Education	0.026	0.031	0.026	-0.011	0.039	-0.011
Employment dummy	-0.013	-0.006	-0.009	-0.003	0.025	-0.016
Household mining dummy	-0.036	-0.036	-0.032	-0.092*	-0.029	-0.086
Nuclear community dummy	0.008	0.006	-0.02	-0.023	0.004	-0.02
Catholic dummy	-0.020	-0.024	-0.061	-0.033	-0.040	-0.062
Protestant dummy	0.026	0.023	-0.048	-0.045	-0.023	-0.071*
Other religion dummy	-0.010	-0.009	-0.05	-0.042	0.007	-0.073*
Aboriginal dummy	-0.041	-0.042	-0.005	0.016	-0.012	0.022
Foreign born dummy	-0.060	-0.069*	-0.069*	-0.042	-0.044	-0.031
Income	0.193*	0.198*	0.094*	0.067*	0.082*	0.069*
CMA dummy	-0.129	-0.137	-0.186	-0.119	-0.121	-0.135
Smaller city dummy	-0.109	-0.112	-0.147	-0.087	-0.086	-0.077
Rural south dummy	-0.156	-0.163	-0.228	-0.13	-0.151	-0.161
Objective knowledge		-0.053				-0.050
Subjective knowledge		0.037				-0.057
Trust in gov/industry			0.296*			0.072
Trust in scientists			0.163*			0.052
Trust in environmental			-0.251*			-0.078*
Reaction to "nuclear"				0.259*		0.235*
Fright				0.053		0.067
Anger				0.095*		0.051
Excitement				-0.345*		-0.325*
Hierarchy					0.205*	0.007
Individualism					0.130*	-0.070
Egalitarian					-0.243*	-0.054
R	0.268	0.274	0.518	0.671	0.492	0.676
R Square	0.072	0.075	0.268	0.450	0.242	0.456
Adjusted R Square	0.057	0.058	0.252	0.437	0.226	0.434

Table includes standardized beta coefficients

*. Correlation is significant at the 0.05 level (2-tailed).

6.5 Nuclear Power Generation as an Ethical Concern

Some studies suggested that attitudes might be more than a function of knowledge when the application is morally contentious. Thus, while persons might be very knowledgeable about nuclear topics, they might not have a positive attitude towards nuclear applications because of other ethical concerns. Ethical concerns of nuclear power generation in Saskatchewan were mixed: 30.8% had low concerns, 36.1% had medium concerns, and 38.2% had high ethical concerns.

Similar to Brossard et al. (2009, p. 552), hierarchal multiple regression was used to see if the hypothesized knowledge-attitude link was moderated by ethical concerns. For this project, interaction terms were created between ethical concerns and both measures of knowledge. Although objective knowledge was not a significant predictor of attitudes/risk perceptions in the previous section, it was still possible that objective knowledge might have indirectly influenced attitudes through ethical concerns. Socio-demographics and the two knowledge measures were entered in the first block. Ethical concerns were in the second block, followed by the interaction terms in the third block. A significant relationship for an interaction term signified that the knowledge-attitude link was moderated through concerns.

Both interaction terms were significant for the impressions of nuclear power variable, which suggests that ethical concerns independently moderated the relationships between both objective knowledge and subjective knowledge, and impressions towards nuclear power (see Table D2 in Appendix D). Considering support for future support for nuclear power in Saskatchewan, the interaction term was significant for the subjective knowledge interaction term (see Table D3 in Appendix D), but not the objective knowledge interaction term. With respect to risk/benefit perceptions, only the objective knowledge interaction term was significant (see Table D4 in Appendix D); the subjective term was not.

To what extent did ethical concerns of nuclear power generation moderate the relationship between knowledge and attitudes? Using the unstandardized beta coefficients from the regression models, the researcher constructed multiple regression equations that predicted how attitudes varied amongst levels of knowledge as moderated by low, mid, and high ethical concerns. All socio-demographics in the multiple regression equations were held constant by its mean value. When predicting the effects of the subjective knowledge interaction term, the objective knowledge and the objective knowledge interaction term were also held constant by their mean score (and vice versa when effects of the objective knowledge interaction term were predicted).

Figures 6 to 9 show attitude and risk perception scores as predicted by the interaction effects of ethical concerns and (subjective or objective) knowledge. They suggest that the relationship between knowledge and attitudes/risk perceptions varied across different levels of ethical concerns. Higher levels of concern made one less likely to have a positive attitude. The exception was the interaction between objective knowledge and impressions (Figure 7), where among those with lower levels of knowledge, greater concerns led to more favourable impressions than the less concerned (but only when knowledge was low). For all four interactions, as levels of knowledge increased, highly concerned residents showed less positive attitudes and greater risk perceptions. Alternatively, as knowledge increased for those with low ethical concerns, attitudes became more favourable and risk perceptions decreased. Those who reported moderate amount of concerns had more favourable impressions and showed greater support when subjective levels of knowledge increased, while they had less favourable impressions and perceived greater risk as objective levels of knowledge increased, all other things held constant.

Figure 6: Interaction Effect of Ethical Concerns and Subjective Knowledge on Impressions towards Nuclear Power Generation

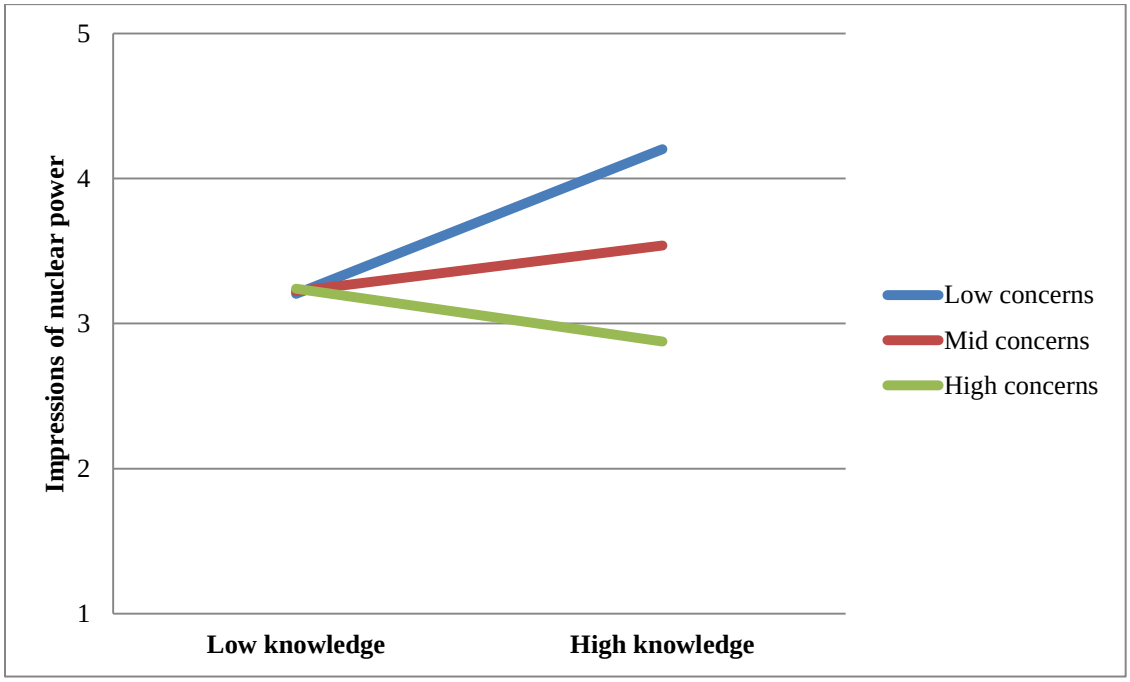


Figure 7: Interaction Effect of Ethical Concerns and Objective Knowledge on Impressions towards Nuclear Power Generation

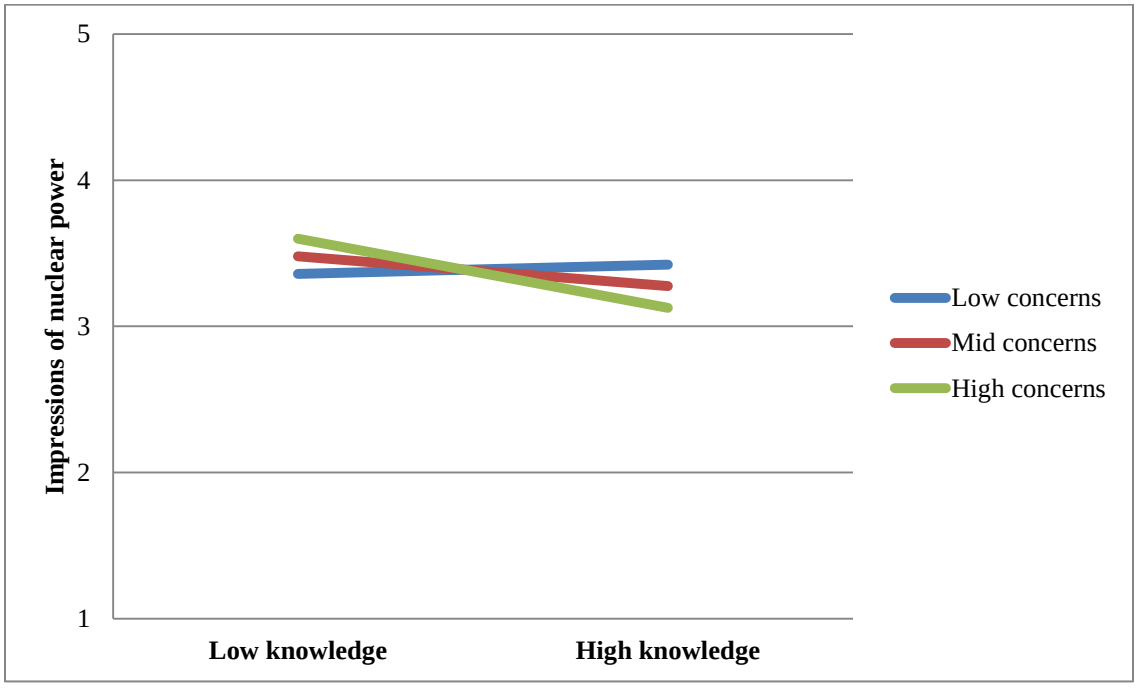


Figure 8: Interaction Effect of Ethical Concerns and Subjective Knowledge on Support for the Future of Nuclear Power Generation in Saskatchewan

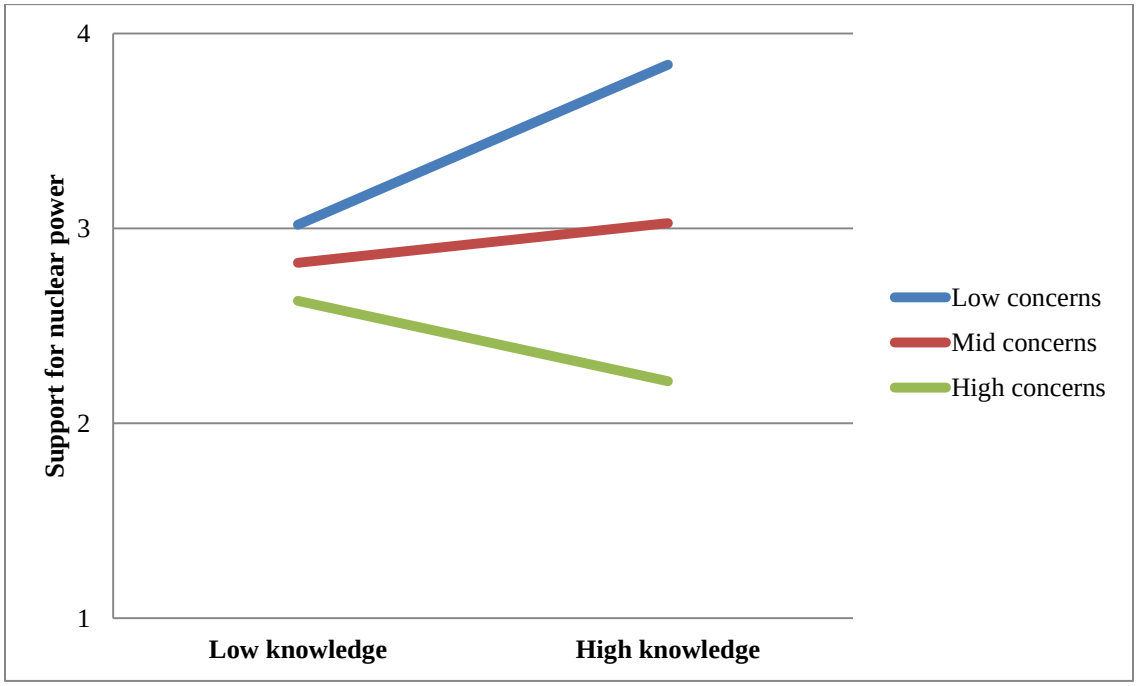
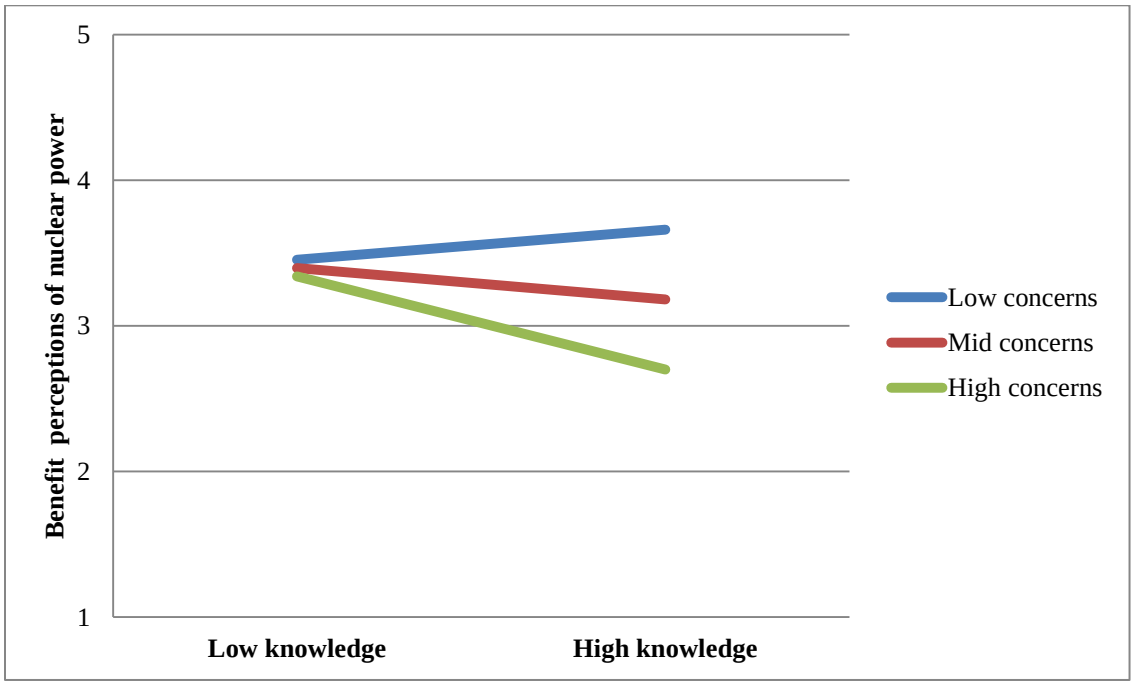


Figure 9: Interaction Effect of Ethical Concerns and Objective Knowledge on Risk/Benefit Perceptions of Nuclear Power Generation



6.6 SEM: Predicting Direct and Indirect Effects on Attitudes

This final section presents SEM models that were constructed in AMOS. SEM was used to show direct effects of predictors on impressions and future support for nuclear power, as well as indirect effects on those two measures through risk perceptions. AMOS required complete cases when calculating standard errors, confidence intervals, and probability (p) values of indirect and direct effects through its Bootstrapping feature. Since this study was interested in knowing which effects are statistically significant, missing cases were replaced based on the mean score for each variable, which give a total of 1,355 cases. AMOS did not allow for fields to be weighted. Thus, the results were not weighted to reflect Saskatchewan's population parameters of age, gender, or area of residence.

Figure D1 (see Appendix D) represents the hypothesized causal relationship where predictor variables of knowledge/awareness, trust, emotions, and worldviews were thought to directly influence attitudes and indirectly through risk/benefit perceptions; this model was eventually discarded for different models. Preliminary models, which assessed both impressions and support for nuclear power generation, did not have good fits because their degrees of freedom (df) were zero. As a result, the probability level of chi-square ($\chi 2$), one measure of fit that evaluates "the magnitude of discrepancy between the sample and fitted co-variances matrices" (Hu & Bentler, 1999, p. 2), could not be calculated. This "saturated" model reproduced the fitted covariance matrices to the sample matrices, and was not valuable because it could not calculate the estimate of error to assess model fit (Gardner, n.d., p. 3). The original SEM models showed that a number of direct and indirect pathways were significant. These results, and other analysis in SPSS, were used to inform the removal of pathways in order to improve the fit of the final models.

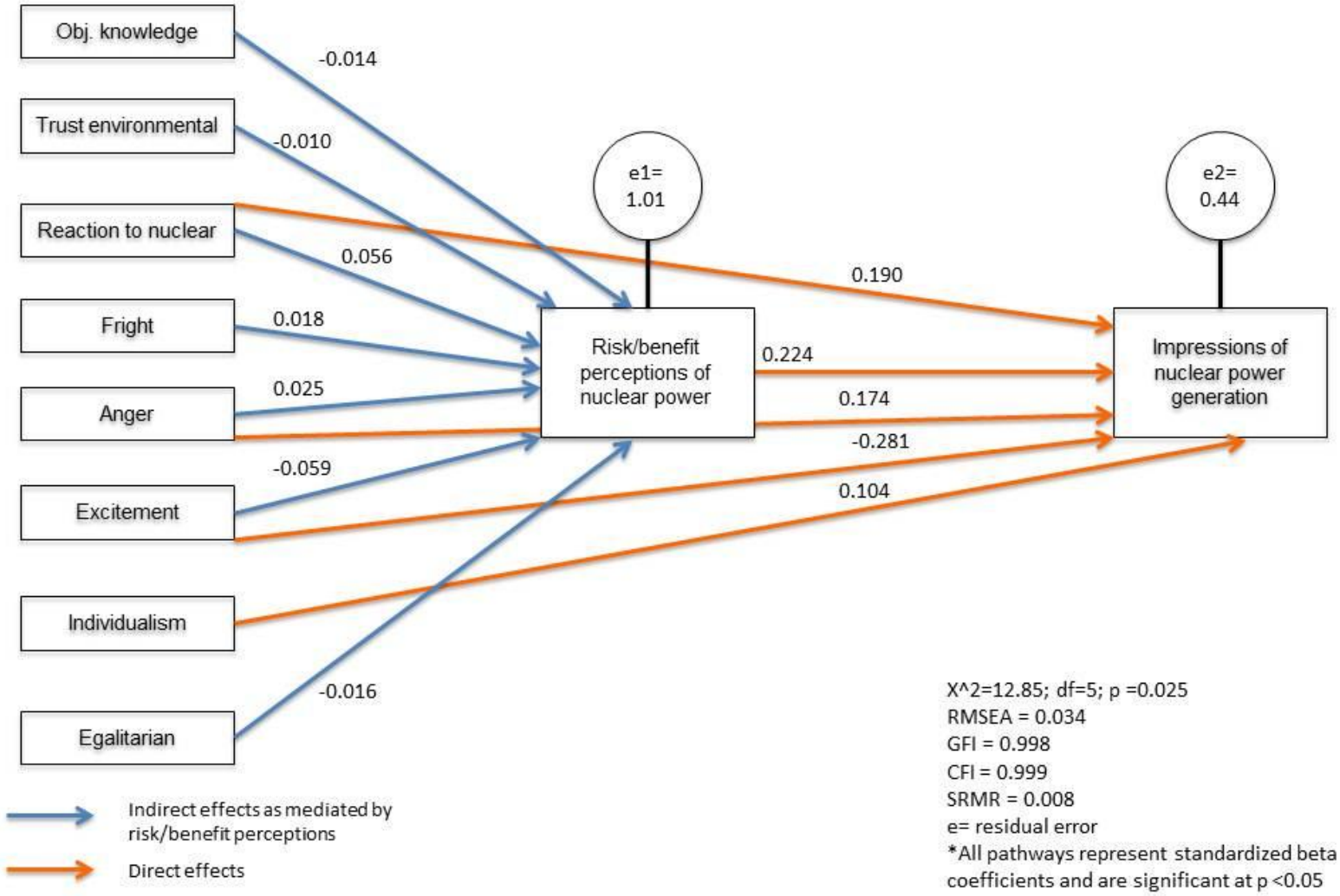
Since the $\chi 2$ statistic is sensitive to sample size and usually always rejects SEM models of large sample sizes (Bentler & Bonett, 1980, p. 604), other indicators of model fit are commonly reported in SEM literature, including the Steiger–Lind root mean square error of approximation (RMSEA), Jöreskog–Sörbom Goodness of Fit Index (GFI), Bentler Comparative Fit Index (CFI), and the Standardized Root Mean Square Residual (SRMR) (Kline, 2011, p. 204). Hooper, Coughlan, & Mullen (2008, pp. 53-55) have provided an overview of the interpretation of these statistics. $\chi 2$ is a measure of difference, thus a significant result ($p < 0.05$) signifies "badness of fit", while an insignificant result suggests the model fits well. A RMSEA statistics of less than 0.05 usually indicate a good model fit. GFI and CFI statistics greater than 0.90 are also considered to be representative of a good fitting model with numbers closer to 1.0 indicating a better fit. A SRMR value of less than 0.05 indicates a model that fits well, however this measure tends to decrease as the number of parameters in the model increases, and as the sample increases.

Impressions of Nuclear Power Generation

Figure 10[3] presents the final accepted model for direct and indirect effects of impressions towards nuclear power generation. Except for the large $\chi 2$ due to the large sample [(df, 5) =12.85, p =0.025], all other indicators showed a very good fit (RMSEA = 0.034, GFI = 0.998, CFI = 0.999, SRMR = 0.008). The model accounted for 58.9% of the variance in impressions of nuclear power.

[3] Pathways representing co-variances between exogenous variables are not included in either accepted models in Figure 10 or Figure 11 in order to keep the figures as simple as possible. Co-variance matrices are available in Tables D5 and D6, respectively, in Appendix D.

Figure 10: Final Model of Risk/Benefit Perceptions as a Mediator of Impressions towards Nuclear Power Generation



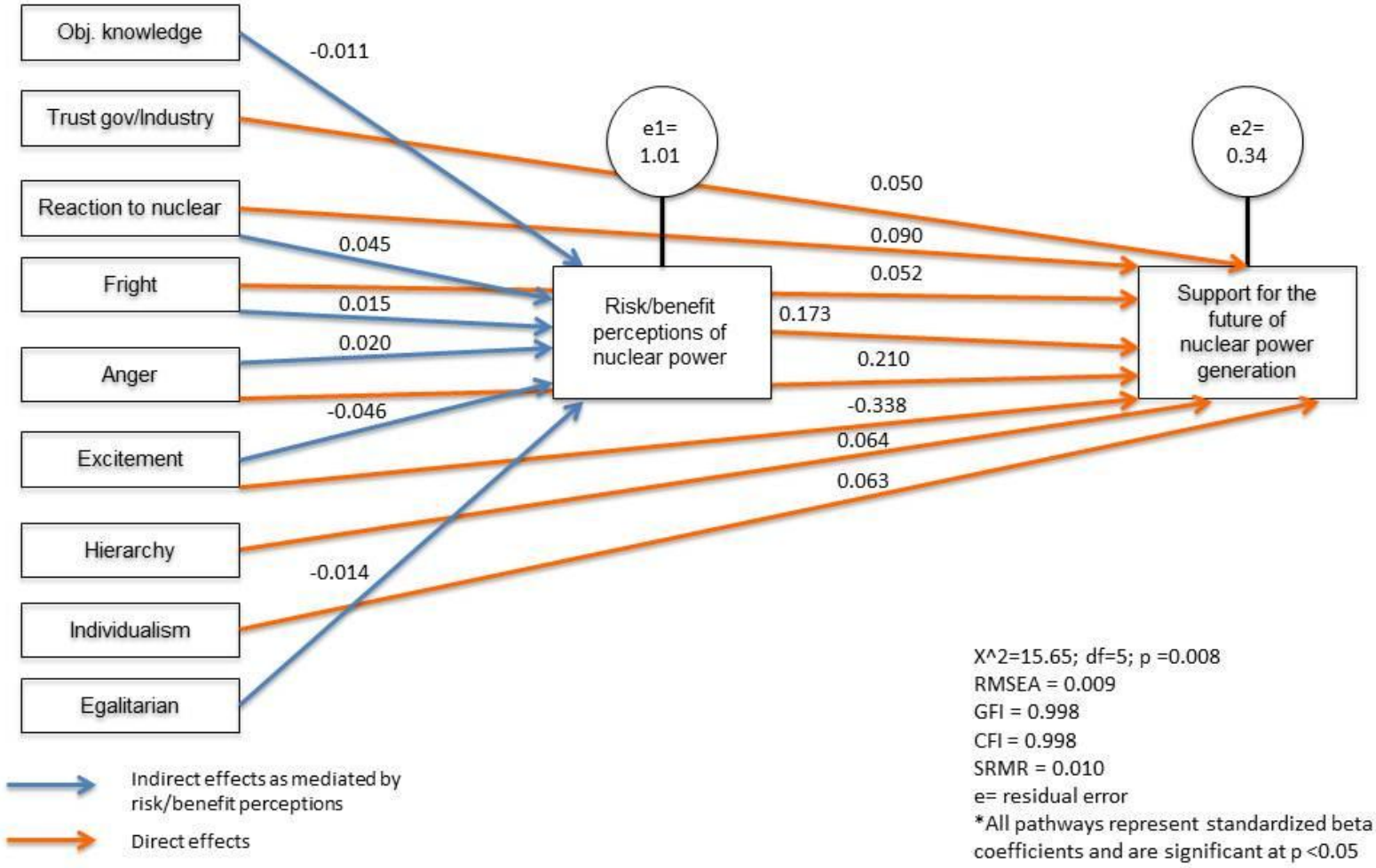
The SEM nuclear impressions model showed that risk/benefit perceptions of nuclear power were positively related to impressions of nuclear power (β = 0.224). In other words, lower risk perceptions led to more favourable impressions. The indirect effects of the independent variables on impressions, as mediated through risk perceptions, were very weak. The strongest indirect effects were reactions to the word "nuclear" (β = 0.056) and excitement (β = -0.059). In other words, positive reactions towards the word "nuclear" resulted in positive impressions by reducing risk perceptions (and vice versa for negative reactions). Similarly, being excited about nuclear power increased impressions through lowered risk perceptions. Reactions and excitement had significantly stronger direct effects on impressions (β = 0.190 and β =-0.281), respectively. Fright (β = 0.018) and anger (β = 0.025) also had small indirect effects; the two decreased impressions of nuclear power through increased risk perceptions. Anger had stronger direct effects (β = 0.174). As feelings of anger went down, impressions increased. The remaining indirect effects, while significant, were significantly weaker. Trust in environmental groups (β = -0.010) was the only trust measure that indirectly affected impressions, while the egalitarian worldview (β = -0.016) was the only worldview to have indirect effects. Individualist worldviews, rather, were directly related to impressions (β = 0.104) and were not mediated through perceptions of risk. Interestingly, objective knowledge resulted in lower attitudes, albeit the effect was small, through increased risk perceptions (β = -0.014).

Support for the Future of Nuclear Power Generation

Figure 11 shows the final accepted model for direct and indirect effects of the predictor variables on support for the future of nuclear power generation in Saskatchewan. The model accounted for 64.5% of the variance in support. Ignoring the $\chi 2$ statistic [(df, 5) = 15.648, p= 0.008], the remaining indicators suggested a good model fit (RMSEA = 0.009, GFI = 0.998, CFI = 0.998, SRMR = 0.010).

The risk/benefit perception measure was positively correlated with support for the future of nuclear power generation (β = 0.173), thus suggesting that support increased when perceived benefits increased. Similar to the nuclear power impressions model, indirect effects of the predictor variables as mediated through risk perceptions, while significant, were very weak. All four emotions variables had significant direct and indirect effects on support for nuclear power generation. Once again, reactions to "nuclear" (β = 0.045) and excitement (β = - 0.046) had the strongest indirect effects on support through risk perceptions. Similarly, objective knowledge was weakly and negatively mediated by risk perceptions (β = -0.011). Direct effects of reaction to "nuclear" (β = 0.090) and feelings of fright (β = 0.052), were substantially weaker than feelings of anger (β = 0.210) and excitement (β = -0.338). Such findings suggest that anger and excitement had stronger total effects (direct and indirect) on future support than other emotions. Trust in government/industry was the only trust measure included in the final model and it had weak, positive, direct effects on support (β = 0.050). The hierarchal (β = 0.064) and individualist (β = 0.063) worldviews had positive, direct effects on support, while holding an egalitarian worldview had only negative, indirect effects (β = -0.014). This suggests that positive support for nuclear power, in terms of worldviews, was not mediated through risk perceptions, while opposition to nuclear power was.

Figure 11: Final Model of Risk/Benefit Perceptions as a Mediator of Support for the Future of Nuclear Power Generation



6.7 Summary of Results Section

Saskatchewan residents were very supportive of nuclear medical applications and uranium mining. Support for nuclear power generation was also moderately high, while attitudes towards storing spent fuel were unfavourable. Almost 70% felt that the benefits of nuclear power were at least the same as the risks. Men and non-Aboriginals were much more likely to show positive attitudes for almost all of the nuclear activities; men were also less risk averse than women with respect to nuclear power. Trust, emotions, and worldviews were consistent and strong predictors of attitudes and risk perceptions, while the knowledge/awareness measures were not. The emotions model was the strongest predictor tested in this study and its inclusion in a catch-all-model reduced the effects of most other predictors. Reactions to "nuclear" and being excited about nuclear power were the strongest emotional predictors. While knowledge measures were not substantial predictors of the attitude scales or risk perceptions, theoretical evidence suggested that knowledge might be moderated through ethical concerns. Ethical concerns moderated the knowledge-attitude relationship in four of the six models tested, which suggests that both objective and subjective knowledge moderated attitudes differently amongst ethical concern levels. For both knowledge measures, those with higher concerns were less supportive as knowledge increased, while those with lower concern were more supportive as knowledge increases. Two SEM models showed that risk perceptions were weakly correlated to impressions of nuclear power and future support for nuclear power; they were also poor mediators of the predictor variables. Direct effects of significant predictors were much stronger than indirect effects. Emotions, specifically reactions to "nuclear" and excitement had the largest direct and indirect effects on attitudes towards nuclear power.

7.0 DISCUSSION

The discussion section will address each of the research questions in order by providing a high level discussion of implications. It will consider the results of the analysis in the context of the literature review and the research questions and hypotheses. Table 10, included at the end of this section, contains a summary of each research question and hypothesis, as well as and brief statement of whether each was supported completely, partially supported, or not supported by the data. This section will also discuss how well the NPRI measures performed and will note any limitations and changes during analysis. The discussion section will provide a basis and understanding for the proceeding recommendations section.

7.1 SASKATCHEWAN RESIDENTS' ATTITUDES TOWARDS THE NUCLEAR SECTOR

The majority of Saskatchewan residents, ages 18 and over, show favourable impressions of nuclear medicine, uranium mining, and nuclear power generation, while less than half hold a negative opinion of nuclear fuel waste management practices. Levels of support for the future of these four activities within the province are in the same direction, but are greater. Considering the impressions scale has a range of five and the support scale had a range of four, it is expected that such results would be greater due to the absence of an odd, mid-point category. Risk and benefit perceptions of nuclear power generation are also generally positive as almost 70% thought the benefits of nuclear power are the same or greater than the risks. Taken as a whole, Saskatchewan residents have positive attitudes towards activities at the beginning on the nuclear life cycle, but hold reservations with respect to storing and managing spent fuel.

The results of this study are similar to some previous public opinion findings, while different from others. The level of replication varies by nuclear application. Considering 80% show a favourable impression of medical applications and 89% support its future funding, the NPRI findings are consistent with those of Fast Consulting (2009) that showed 83% of residents supported a facility to develop medical isotopes. As 61% hold a favourable impression of uranium mining and 82% support its continuation, the NPRI are somewhat consistent with Fast Consulting's (2009) most recently available data from 2005 to 2009 that showed support ranging from 81% to 84%. As Figure 1 demonstrates, support for uranium mining in the province has fluctuated in cycles and the NPRI future support for uranium mining measure is comparable to those of the closest time period (2005 – 2009). The NPRI impressions of nuclear power measure was about 20 percentage points less favourable than Fast Consulting's (2009) findings, however, this difference may be the result of the NPRI variable having a five point scale.

Prior studies showed that support for nuclear power generation generally ranged from 42% to 55% and occasionally as high as 62% (Insightrix Research, 2009 in Warren, 2009) and 72% (Fast Consulting, 2009). Given this range, NPRI levels of support (55% of residents' have a positive impression of nuclear power and 70% support the idea of generating power from nuclear sources) are more consistent with higher levels of previous studies. The NPRI survey findings that 28% have a positive impression of nuclear waste management practices and 41% support storing nuclear fuel waste in Saskatchewan is significantly less than previous findings that showed 62% of respondents supported the establishment of a spent nuclear fuel facility (Fast Consulting, 2009). The difference between support levels for storing spent fuel in this study and this previous study are quite large.

Males and non-Aboriginals, among some other socio-demographics, are consistently more likely to have more favourable attitudes and less risk perceptions than their respective counterparts. The findings for gender differences are consistent with those found in previous public opinion poll in Saskatchewan (Sigma Analytics, 2008, 2009) and other academic literature related to science attitudes (Hayes & Tariq, 2000, Von Roten, 2004, Solomon et al. 1989, Slovic, 1999). Differences between Aboriginals and non-Aboriginals are similar to findings by the Regina Leader-Post (2006) whereby First Nations were less likely to support a nuclear power plant and a nuclear refinery than non-Aboriginals or Metis. Gender differences, and perhaps differences between Aboriginals and non-Aboriginals, may result from

differences in knowledge (Hayes & Tariq, 2000, Von Roten, 2004, Simon, 2010), risk perceptions (Gustafson, 1998), or perhaps other factors (Solomon et al., 1989). Understanding these differences is important and requires further study.

Public opinion is an important consideration for government when creating public policy. Obtaining public support is even more important considering nuclear related policies can constitute a major, long-term shift in policy related to energy production and consumption, public health, economics, and the environment. These policies affect all Saskatchewan residents in one way or another. Overall, the results show very strong support for the two nuclear related activities already occurring in Saskatchewan: nuclear medicine and uranium mining. Nuclear power generation, an activity that has been on the agenda of the provincial government and industry, is also well supported by the public, while storing spent fuel is not well supported.

7.2 Predictors of Attitudes and Risk/Benefit Perceptions

This report does not provide much support for the knowledge-attitude link (H1). Previous literature showed that objective scientific knowledge and awareness was positively correlated with positive attitudes towards nuclear activities (McBeth & Oakes, 1996, European Commission, 2007, 2010, Greenberg & Truelove, 2010, Kuklinski, Metlay, & Kay, 1982) and perceived benefits (Maharik & Fischhoff, 1993, Sjöberg & Drottz-Sjöberg, 1991). However, in none this report's models were objective knowledge/awareness significantly related to attitudes or risk perceptions and, as a result, it can be concluded that objective knowledge is not related to positive attitudes or risk/benefit perceptions.

One possible explanation for the results differing from expectations is that the four questions used to build the scale do not vary enough in terms of difficulty. Considering respondents scored fairly high on the objective scale with over 77% having got at least half of the questions correct, it is possible that the survey measures do not capture enough variance in scores among participants. A similar explanation could be that only four questions are not enough to capture variance in responses, which suggests that a greater variety of measures are needed. One final reason could be that the two factual awareness measures do not reflect the hypothesized relationship between **scientific** knowledge and attitudes.

On the other hand, objective knowledge might just not be correlated to support for nuclear activities. In terms of causality, it might be possible that people who oppose nuclear applications seek out information to educate themselves about nuclear topics, such as radiation. Thus, one can have a negative opinion of technology while still being informed, educated, and engaged in science. Other factors, such as ethical concerns or religiosity, might also influence attitudes, regardless of how knowledgeable one is. Although subjective knowledge is positively, but weakly, related with attitudes (and not related to risk/benefit perceptions) the data suggest that knowledge does not significantly influence attitudes towards the nuclear sector in Saskatchewan.

Prior studies have shown that greater trust in industry and government (Bord & O'Connor, 1992, Sjöberg, 1999, Pijawka & Mushkatel, 1992) and regulators of nuclear hazards (Biel & Dahlstrand, 1995, Flynn et al., 1992, Hallman & Wandersman, 1995) were linked to lower perceptions of risk and/or favourable attitudes towards nuclear applications. Similarly, trust in university scientists and researchers increased acceptance of gene technology (Siegrist, 2000). This report adds that greater trust in government/industry and university scientists is positively associated with attitudes towards the nuclear and reduces risk perceptions of nuclear power generation (H2). Previous work also found that greater trust in environmental groups was associated with increased risk perceptions and opposition. For example, trust in environmental groups was negatively linked to attitudes towards gene technology (Sparks et al., 1994) and did not result in support for a nuclear fuel repository (Bassett et al., 1996). This report shows that trust in environmental groups is a negative and significant predictor of attitudes towards nuclear activities

and benefit perceptions (H3). The findings correspond with the hypothesized relationship between trust and attitudes/risk perceptions.

The data support the idea that, when faced with the complex task of forming an attitude towards the nuclear sector, people rely on trust in the institutions that they have great faith in. This could be done to reduce complexity in the decision making process or might be related to trust in regulators to manage hazards. Unfortunately, the single risk/benefit construct in the survey does not allow for testing of the presence of trust as heuristic; this could only be done if there were separate questions assessing both risks and benefits (see Alhakami & Slovic, 1994, Finucane et al., 2000) Interestingly, factor analysis shows that most of the government/industry trust constructs are negatively correlated with trust in environmental groups. If one places greater amount of trust in government institutions, nuclear regulations, and industry representatives, and less trust in environmental groups, then they would be expected to support nuclear sector activities; the opposite would also be true. This further evidences the idea that people rely on actors that they trust and disregard cues from actors they do not trust when forming a decision. Furthermore, since all but two NPRI trust measures are general, rather than specific, it is hard to definitively know if the trust-attitude correlation is the result of trust in actors people believe are credible and/or align with their own personal values, or if people actually trust them to manage risks related to nuclear sector activities. The operationalization of the general and specific trust measures together into one scale is a limitation in this sense.

Negative imagery of a nuclear waste facility (Slovic et al., 1991) and nuclear power (Peters & Slovic, 1996), according to these studies, were linked to opposition to those activities. The research findings of this study are consistent and suggest that negative imagery of "nuclear" are related to impressions of nuclear activities, support for the future of the sector, and risk/benefit perceptions of nuclear power (H4). Other studies showed that negative emotions were associated with increased risk perceptions of biotechnology (Savadori et al., 2004) and nanotechnology (Cobb & Macoubrie, 2004), and greater opposition to nanotechnology (Lee et al, 2005). Considering the context of nuclear activities, the data reveal that feeling frightened and angry about nuclear power is negatively related to attitudes of nuclear activities; anger is also a predictor of risks outweighing the benefits (H4). Positive feelings of excitement have the opposite effect and result in more favourable impressions, more support for future activities, and greater benefit perceptions (H5). All of the emotion hypotheses are supported by the data. Emotions are the strongest predictors of attitudinal measures and risk perceptions evaluated in this report. They account for 63% to 73% of the variance in nuclear sector attitudes and about 45% of the variance in risk perceptions, which is more than previous findings in the literature review. Interestingly, emotions seem to play a role in gender differences. Males are far more likely to have positive attitudes and perceive less risk than females in almost all of the regression models. However, when emotions are controlled for, gender differences disappear. These results are interesting and suggest a need for further study. The data also show that positive emotions are better predictors than negative emotions, which challenges the findings of previous research (Sjöberg, 2007). Feeling excited about nuclear power is the greatest predictor of all dependent measures. In terms of negative measures, anger is a better predictor than fright in all of the models.

As noted before, one limitation of the NPRI risk/benefit perception measure is that it does not allow for testing of emotions or trust as heuristics. While there is previous research to suggest that emotions are employed as heuristics, this study can only conclude that emotions are predictors of attitudes, but cannot support the presence of an affect heuristic in guiding the decision making process. Despite this, the data provide substantial evidence that the decision making process in far more than just a rational judgment based in scientific fact. Taken together, emotions seem to influence the decision making process more than any other predictor and in a way that might be non-cognitive. It should also be noted that since the NPRI survey contains only one positive measure and two negative measures, it is hard to say to what degree these emotional measures are reflective of the broad range of emotions one might feel when

thinking about nuclear activities (ie: contempt, fear, sorrow, guilt, shame, worry, pessimism, interest, satisfaction, and optimism). Since emotions are so strongly related to attitudes, further study of this range of feelings is warranted.

Culture theory suggests that social, cultural, and political attitudes should influence the way Saskatchewan residents' judgments are formed. These worldviews help people understand the world and make judgments that align with what they believe is morally acceptable. The literature showed that egalitarians had more negative opinions or show more opposition towards nuclear activities than individualist or hierarchists (Jenkins-Smith, 1994; Wildavsky & Dake, 1990; Dake, 1991; Peters & Slovic, 1996; Marris, Langford, & O'Riodan, 1998; Sjöberg, 1998). This report's findings are consistent and show that individualist and hierarchal (H6) worldviews are positively related, and egalitarian worldviews are negatively associated (H7), with impressions and support for nuclear activities, as well as perceived benefits of nuclear power outweighing the risks.

Given the worldview measures did not load as expected during the factor analysis and the subsequent scales, which were informed and constructed by the literature, and have only moderate levels of internal consistency, it is promising that they perform as hypothesized. But how well do the NPRI worldviews represent what they are trying to measure? Hierarchists, who place much faith in authority to regulate health and environmental hazards of nuclear technology, and individualists, who favour the free market and economic benefits resulting from nuclear activities, are said to differ in their opposing views of social deviance, but both are expected to support nuclear activities. Unfortunately, the NPRI survey measures for these two worldviews only assess items towards economic aspects of the free market and experts' ability to manage risks, and not social deviance or regulation. Considering hierarchal and individualist worldviews are moderately correlated ($r = 0.444$) and both show similar levels of trust, respectively, in government nuclear regulators ($r = 0.330, 0.305$), industry representatives ($r = 0.383, 0.404$), government officials ($r = 0.289, 0.297$), and Canada's nuclear regulations ($r = 0.370, 0.335$), the construct validity of each operationalized worldview emerges as a questionable. Given individualists are thought to believe in self-regulation of individuals and markets (Peters & Slovic, 1996, p. 1438), it is surprising to see that, according to the data, they are equally as trusting in government as those holding an hierarchal worldview. Similar levels of trust in industry among the two are also interesting, as individualists would be expected to show more trust in free-market actors.

Although both worldview measures reflect the directions of attitude expected, it does not necessarily mean that the NPRI constructs actually measure differences in hierarchists and individualists according the grid-group theory. Another possible consideration could be that social and cultural values are shifting. Considering some of the survey questions are borrowed from studies published in the early 1990s, it may be possible that some do not accurately reproduce worldviews that are reflective of modern values, such as post-materialism. One final limitation of the NPRI measures is that they only assess the role of three of the worldviews that emerge from the culture theory of risk perceptions and not the fatalist worldview. However, most studies in the literature review also ignored fatalists or they were grouped together with individualists. Despite this, the data suggest that, according to the measures, worldviews allow people to make decisions that are consistent with their cultural experiences and ethics.

7.3 Ethical Concerns as a Moderator of Knowledge-Attitudes

Some studies hypothesized that the assumed positive association between knowledge and attitudes towards morally contentious policy were moderated by other variables (Kuklinski, Metlay, & Kay 1982; Brossard et al., 2009; Lee & Scheufele, 2006). Therefore, the strength and direction of the knowledge-attitude link, with respect to nuclear power, might vary among different levels ethical concern. While early analysis in this study finds little support that knowledge influences attitudes, further analysis shows that knowledge is moderated, in most instances, through ethical concerns. Greater knowledge has more

negative effects on attitudes when ethical concerns are higher, while it has positive effects on attitudes when concerns are lower.

These findings have further implications for the understanding of attitudes as a cognitive judgment and related efforts to increase public support through scientific literacy. Contrary to some of the literature, greater objective knowledge of nuclear topics decreases impressions and increases perceptions of risk for those who have mid and high ethical concerns. This suggests that the decision-making process is more than just a cost-benefit analysis or a judgment of risk and benefits. Given the moral contentiousness of nuclear sector activities, any attempts to lower risk perceptions or increase support among the public would, as the data suggest, only work for those with low ethical concerns. However, those reporting low ethical concerns (34.5%) are also more likely than those with mid-concerns (23.5%) and high concerns (24.4%) to answer all objective knowledge/awareness questions correctly; this suggests that they were already more knowledgeable. Considering those with low ethical concerns of nuclear power are also significantly more likely to have favorable impressions and to support the future of the sector than others to begin with, any attempts to generate public support through scientific literacy may be ineffective. In fact, increasing scientific knowledge could hypothetically lead to less favourable attitudes for two-third of the population that have at least mid-levels of ethical concerns. Although these findings cannot explain why greater knowledge is negatively moderated in the instance of high ethical concerns, it is possible that those who are more concerned (and therefore are more likely to show negative attitudes) sought out knowledge about nuclear items after they have already formed an opinion. These results not only challenge the direction and moderation of the conventional knowledge-attitude link, but also suggest that the assumed causal relationship between knowledge and attitudes needs to be re-evaluated.

7.4 Direct and Indirect Effects of Attitudes Towards Nuclear Power

Previous literature showed that trust (Flynn et al., 1992; Siegrist, 1999, 2000; Eiser, Miles, & Frewer, 2002; Whitfield et al., 2009), worldviews (Siegrist, 1999), and emotions (Sjöberg, 1992, 2007) influences attitudes towards science and technology through risk perceptions. Similarly, the hypothesized link between knowledge and attitudes has been argued to be mediated by risk perceptions (Wildavsky & Dake, 1990).

The original hypothesized SEM models were discarded for new ones because they did not fit the data well. The new models, which have good fits, account for significant amount of the variance in the impressions (59%) and future support of nuclear power (65%) measures. Both models show that the risk/benefit perception measure is weakly and positively correlated to both attitudinal measures, as predicted (H8). The SEM models also show that a number of predictor variables have direct and indirect effects on attitudes, as mediated through risk perceptions. In the case of support for the future of nuclear power generation, all four emotions measures have significant indirect and direct effects, although indirect effects are very weak. This study adds that both negative and positive emotions influence attitudes directly and through risk perceptions (H12 and H13). Excitement, the lone positive emotion, is the strongest predictor in both models. Knowledge, trust, and worldviews play less of a role, which suggest that their effects on attitudes through risk perceptions are captured by emotions or other variables not present in the data set. These findings, coupled with previous results, further suggest the importance of emotions as predictors of attitudes and risk perceptions.

Since the effects of risk perceptions on attitudes are generally weak, the indirect effects of the predictor variables as mediated through risk perceptions, while significant at conventional levels, are minimal. The direct effects of these predictors on attitudes are much larger. The models suggest risk/benefit perceptions of nuclear power play a much smaller role as a mediator of attitudes than previously thought. In other terms, hypothesized predictors have greater effects outside of how one perceives risk or benefits. These could be directly or indirectly mediated through some unknown variable not captured by the model. Thus,

the predictors seem to influence attitudes towards nuclear power in ways that do not necessitate a cost-benefit analysis of risk.

Given that many studies, especially those in the risk perception literature, appear to use risk perceptions as proxies for attitudes, these findings suggest that the two might are not related as once thought, at least in the case of nuclear power generation in Saskatchewan. Although risk perceptions influence attitudes to some degree, using them as indicators of policy preferences is problematic because of the weak correlation between the two. Instead, perceptions of risk might be thought of as one of many contributing factors that influence attitudes and policy preferences. While these models are interesting for understanding the role of risk perceptions on attitudes, they are not without their limitations. This report's SEM models assess how each of the predictor variables directly and indirectly influenced attitudes, however, it is within the scope of this project to see how some predictor variables may causally influence others. Therefore, it is possible that there may be some type of connection between trust, emotion, and heuristics that is not captured by these analyses.

Table 10: Summary of Research Questions, Hypotheses, and Main Findings

Research questions and hypotheses summary	**Main finding summary**
Research question 1: What are Saskatchewan residents' attitudes and risk perceptions towards nuclear sector applications?	Nuclear medicine, uranium mining, and nuclear power are viewed positively, while storing spent fuel is viewed negatively.
Research question 2: What is the role of knowledge/awareness, trust, emotions, and worldviews in explaining attitudes and risk/benefit perceptions?	Emotions were the greatest predictors. Trust and worldviews were also good predictors, but in a more limited capacity. Knowledge was not a good predictor.
H1: Greater knowledge/awareness is related favourable impressions, greater support, and decreased risk perceptions.	Not well supported
H2: Trust in gov/industry and scientists are related to favourable impressions, greater support, and decreased risk perceptions.	Supported
H3: Trust in environmental groups is related to unfavourable impressions, less support, and increased risk perceptions.	Supported
H4: Negative emotions are related to unfavourable impressions, less support, and increased risk perceptions.	Supported
H5: Positive emotions are related to favourable impressions, greater support, and decreased risk perceptions.	Supported
H6: Hierarchal and individualist views are related to favourable impressions, greater support, and decreased risk perceptions.	Supported
H7: Egalitarian views are related unfavourable impressions, less support, and increased risk perceptions.	Supported
Research question 3: Do ethical concerns about nuclear power generation moderate the link between knowledge/awareness and attitudes towards nuclear power generation?	Greater knowledge had more negative effects on attitudes as ethical concerns were higher, while it had positive effects on attitudes as concerns were lower.
Research question 4: Do perceptions of risks and benefits of nuclear power generation mediate the relationship between knowledge/awareness, trust, emotion, and worldviews and attitudes towards nuclear power generation?	Risk/benefit perceptions were poor mediators of predictor variables on attitudes; direct effects were stronger than indirect effects for all significant predictors. Emotions had the strongest direct and indirect effects.
H8: Greater benefit perceptions of nuclear power are related to related favourable impressions and greater support.	Supported
H9: Knowledge/awareness increases favourable impressions and support for nuclear power generation directly and indirectly.	Not supported
H10: Trust in gov/industry and scientists increases favourable impressions and support for nuclear power generation directly and indirectly.	Somewhat supported
H11: Trust in environmental groups decreases favourable impressions and support for nuclear power generation directly and indirectly.	Somewhat supported
H12: Negative emotions decrease favourable impressions and support for nuclear power generation directly and indirectly.	Supported
H13: Positive emotions increase favourable impressions and support for nuclear power generation directly and indirectly.	Supported
H14: Hierarchal and individualist views increase favourable impressions and support for nuclear power generation directly and indirectly.	Somewhat supported
H15: Egalitarian views increase favourable impressions and support for nuclear power generation directly and indirectly.	Somewhat supported

8.0 RECOMMENDATIONS

After considering the findings of the data, this report makes 15 recommendations. The first set of recommendations are concerned with public engagement related to the future of nuclear activities in Saskatchewan, the second set deal with areas of future research for the NPRI moving forward, while the third set consider research measures of attitudes towards the nuclear industry.

8.1 PUBLIC ENGAGEMENT

- Future public engagement should be framed in terms of emotions and trust, rather than knowledge or risk communication.
- Given that Aboriginal peoples constitute almost 80% of the population of northern Saskatchewan (the geographic area where a majority of nuclear sector related activities would likely take place) and are more likely to have negative attitudes, public engagement campaigns could be different than those for non-Aboriginals.
- Given females, who constitute 51% of the adult population in Saskatchewan, are significantly less likely to have a positive attitude and were more risk averse than males, public engagement campaigns could be different for females than for males.

8.2 AREAS FOR FUTURE RESEARCH

- Using the existing dataset, researchers should explore if there is a causal relationship or inter-relationship between emotions, trust, and worldviews in explaining attitudes towards nuclear sector activities.
- Using the existing dataset, researchers should analyze gender differences in attitudes towards nuclear activities and the role that emotions play in such differences.
- Using the existing dataset, researchers should assess differences in attitudes towards nuclear sector applications between Aboriginal and non-aboriginals.
- Using the existing dataset, researchers should further explore the role of ethical concerns as a moderator of attitudes towards nuclear medicine, uranium mining, uranium enrichment, and storing spend nuclear fuel with respect to knowledge, as well as trust, emotions, and worldviews.
- Using the existing dataset, researchers should consider the role of risk/benefit explanations as a mediator of attitudes towards nuclear medicine, uranium mining, uranium enrichment, and storing spend nuclear fuel.

8.3 SURVEY MEASURES FOR FUTURE RESEARCH

- Future research should use knowledge measures that assess objective scientific knowledge of nuclear items, rather than factual awareness. These should vary in terms of difficulty to increase the amount of variance in responses.
- When applicable, future research should employ specific trust measures that explicitly connect a nuclear activity, such as nuclear power generation, with the actors responsible for regulating it.
- Future research should explore the influence of other positive and negative emotional measurements, such as dread, contempt, fear, sorrow, guilt, shame, worry, pessimism, interest, satisfaction, and optimism, as predictors of attitudes and risk perceptions.
- Future research should incorporate additional questions that measure perceptions of social deviance and regulations in order to tease out differences between hierarchal and individualist worldviews.
- Future research should develop measures for the fatalist worldview.
- When measuring risk perceptions, researchers should employ a two-stage process to independently measure an activity's risks and benefits. This process can be used to produce evidence for the presence of the affect heuristic.

- Future research should develop dependent measures to assess
    - impressions of uranium enrichment practices; and
    - support for the future of uranium enrichment in Saskatchewan.

9.0 CONCLUSION

This report provided one of the most comprehensive empirical analyses of Saskatchewan residents' attitudes and perceptions of risk towards the nuclear sector to date. Not only does it find substantial public support for medical nuclear applications, uranium mining, as well as nuclear power generation, it also provided a critical assessment of how attitudes might be influenced. Emotions, and to a lesser extent, worldviews and trust, were the prevailing constructs in influencing attitudes and risk/benefit perceptions. Previously, elected officials, industry, researchers, and policy makers have not had a clear understanding of the role of these in determining public policy attitudes in Saskatchewan towards the nuclear sector. Given the findings of this report, additional research is needed to assess how emotions, trust, and worldviews interact together during the decision-making process.

Given that there has been recent interest from industry and the provincial government to extend into latter stages of the nuclear life cycle in Saskatchewan, particularly nuclear fuel enrichment and power generation, the results of this study are informative from a public policy perspective in a number of ways. With about 55% holding favourable impressions towards nuclear power generation and another 70% supporting the future use of this technology in the province, it may be feasible for both government and industry to collaboratively explore nuclear power generation as a solution for Saskatchewan to meet its anticipated future energy needs. Since uranium enrichment is a necessary step before power can be generated, further study may be needed to assess attitudes and predictors towards this application. Once power has been generated from enriched sources, the spent fuel will have to be disposed of and stored in a way that is safe and reduces environmental and health risks. Therefore, the exploration of nuclear power as an alternative energy source in Saskatchewan must be supplemented with a plan to manage the spent fuel. However, residents had unfavourable impressions of nuclear waste management practices and they opposed the idea that Saskatchewan should be involved in storing waste. The results and analysis in this report could be used for future research and to inform the development of public communication plans by industry and government to address residents' concerns.

A greater understanding of emotions, trust, and worldviews are needed for developing future public consultations, strategies, and policies the public will support. The data showed that attempts to increase the public's knowledge about nuclear activities would probably not result in lower risk perceptions or more positive attitudes towards the nuclear sector. Considering ethical concerns moderate the relationship between knowledge and attitudes towards nuclear power generation, it is likely that any attempts to increase support through knowledge might, if at all, only succeed for those with lower ethical concerns. Alternatively, positive emotions, as well as trust in government, industry, and university scientists were significant predictors of positive attitudes. Any type of communication plan to generate public support on behalf of industry or government might best be framed in terms of trust in regulators and industry or could appeal to positive emotions. In terms of trust communication, emphasis could be placed the adequacy of government and industry regulators, as well as the federal government's ability to regulate and enforce regulations.

Although this study's measure of risk perceptions did not allow for testing of the presence of the affect heuristic, the NPRI data suggested that emotions and trust, are used as heuristics. As the future of Saskatchewan's future energy demand continues to be pushed onto the provincial policy agenda, a greater understanding of *how* emotions, trust, and worldviews are interconnected and how they influence attitudes will ultimately lead to more effective public policy that is evidence-based.

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APPENDIX A

Table A1: Summary of Empirical Studies Evaluating Knowledge and Science in General

Source	Support for deficit model	Findings
Einsiedel, 1994	Support	Greater scientific knowledge led to greater trust in science and greater feelings of efficacy towards science in Canada.
Sturgis & Allum, 2004	Support	Scientific knowledge was positively correlated to general attitudes towards science in Great Britain.
Hayes & Tariq, 2000	Support	Scientific knowledge was positively correlated to scientific attitudes in Canada, Great Britain, New Zealand, and the United States.
Von Roten, 2004	Support	Scientific knowledge was positively correlated to attitudes towards science in Switzerland.
Bauer, Durant, & Evans, 1994	Mixed Support	Greater levels of scientific knowledge were moderately related with attitudes towards generalized science across 12 European countries. However, less knowledgeable countries were more supportive of EC level science funding than more knowledgeable countries.

Table A2: Summary of Empirical Studies Evaluating Both Science in General and Specific Policies

Source	Support for deficit model	Findings
Evans & Durant, 1995	Mixed Support	Knowledge was positively correlated with generalized science and useful and basic research funding, but negatively correlated with funding for morally contentious research (genetic engineering and embryotic research).
Bak, 2001	Mixed Support	Knowledge was positively related to attitudes towards generalized science. While knowledge was a significant predictor of perceptions of benefits outweighing risks of science in the abstract, space exploration, and genetic engineering, no significant difference in perceptions for nuclear power existed.
Allum et al., 2008	Mixed Support	General knowledge was positively related to attitudes towards generalized science, nuclear power, and genetic medicine. No relationship existed between general knowledge and attitudes towards genetic medicine, GM foods, and nuclear power.

Table A3: Summary of Empirical Studies Evaluating Knowledge and Attitudes Towards Biotechnology

Source	Support for deficit model	Findings
Brossard & Nisbet, 2007	Support	Specific knowledge of biotechnology was positively related to attitudes towards agricultural biotechnology, however, it was not the stronger predictor.
Brossard & Shanahan, 2003	Support	Knowledge was negatively correlated with perceptions of risk with respect agricultural biotechnology, although knowledge was not the strongest predictor tested.

Priest, 2001	Support	Higher levels of knowledge was related to greater support for agricultural and medical applications of biotechnology, albeit it was not the stronger variable tested.
Martin & Tait, 1992	Mixed Support	Greater knowledge was related to particularly high levels and low levels of support for agricultural biotechnology.
Connor & Siegist, 2010	Mixed Support	Basic biology knowledge, knowledge of gene technology, and knowledge of legal regulations were not related to acceptance of medical or non-medical biotechnology. While basic biology knowledge was negatively related to risk and positively related to benefits of both applications, knowledge of gene technology was only negatively correlated to risks of non-medical application; legal regulation knowledge was not a significant predictor of risks or benefits.
Simon, 2010	Mixed Support	Knowledge of biotechnology was positively related to attitudes towards biotechnology for men and negatively correlated for women.

Table A4: Summary of Empirical Studies Evaluating Knowledge and Attitudes Towards Nanotechnology

Source	Support for deficit model	Findings
Lee & Scheufele, 2006	Support	Knowledge about nanotechnology was positively correlated with support for general support the use of nanotechnology and funding for nanotechnology. Knowledge was not the strongest predictor variable tested.
Brossard et al., 2009	Mixed Support	Nanotechnology knowledge was positively related to support for nanotechnology funding in the abstract, although it was not the stronger predictor. Highly religious people were less likely to support funding even if they were more knowledgeable, while people with low levels of religiosity showed greater support as knowledge increased.

Table A5: Summary of Empirical Studies Evaluating Knowledge and Attitudes/ Risk Perceptions Towards Nuclear Technology

Source	Support for deficit model	Findings
Mazur, 1975	Support	Men with greater knowledge of nuclear technology were more likely to show support.
McBeth & Oakes, 1996	Support	Factual knowledge of radiation was positively correlated to support for transporting spent nuclear fuel.
European Commission, 2007	Support	Knowledge and awareness of nuclear issues was positively correlated to support for nuclear power.
European Commission, 2010	Support	Knowledge and awareness of nuclear issues was positively correlated to support for nuclear power.
Sjöberg & Drottz-	Support	Knowledge of radiation and risks of radiation was negatively associated with risk perceptions for several professional

Sjöberg, 1991		groups.
Bassett, Jenkins-Smith & Silva, 1996	Support	Knowledge of radiation and institutions were negatively related to risk perceptions of a nuclear repository site.
Greenberg & Truelove, 2010	Support	Factual awareness was positively related to support for nuclear power generation and trust in the nuclear industry.
Kuklinski, Metlay, & Kay, 1982	Support	Knowledge was positively related to support for nuclear power. Less knowledgeable people's opinion were influenced by perceptions of technology and cues from reference groups, while more knowledgeable people were influenced by their political beliefs.
Maharik & Fischhoff, 1993	Mixed	Greater knowledge of nuclear technology risks was positively related to support for the general public, but not for professional engineers, or environmental activists. As an aggregate, the relationship was not significant. An experimental group was more likely to show support after they were provided information on risks.
Solomon et al., 1989	No support	Awareness of local nuclear power plant issues was not related to support for nuclear power or support for building a nuclear power plant near one's community.
Bak, 2001	No support	No significant relationship existed between knowledge and risk perceptions for nuclear power.

Table A6: Summary of Empirical Studies Evaluating Emotions and Attitudes/Risk Perceptions

Source	Support for emotions model	Findings
Savadori et al., 2004	Support	Feelings of harm and dread were positively correlated to risk and negatively correlated to benefits perceptions of two biotechnological items for experts and general public participants. Emotions were the strongest predictors tested in the models.
Cobb & Macoubrie, 2004	Support	Feelings of worry were positively related to perceptions of risk and feelings of hope were positively related to perceptions of benefits with respect to nanotechnology. Emotion was the greater predictors of perceptions.
Lee et al, 2005	Support	Those with negative emotions towards nanotechnology were less likely to support it and more likely to perceive risks. Knowledge and trust were also positively related to perception of benefits.
Finucane et al, 2000	Support	Greater feelings of fear and worry were positively related to risk perceptions and negatively related to perceptions of benefits for a number of hazards, including nuclear power.
Slovic, Flynn, & Lyman, 1991	Support	Persons who reported negative imagery as their first emotion response to the thought of a nuclear waste facility were much more likely to not support the facility.
Sjöberg, 2007	Support	A negative emotions index, including anger, contempt, fear, sorrow, guilt, shame, worry, and pessimism, was positively

		related to risk perceptions of a nuclear facility and negatively related to attitudes towards nuclear power. The positive emotions index, including interest, satisfaction, and optimism, was negatively related to risk perceptions and positively related to attitudes.
Peters & Slovic, 1996	Support	Those reporting positive imagery when prompted to think about nuclear power were more likely to support it, while those with negative imagery were more likely to oppose it.
Sjöberg, 2003a	Mixed Support	After controlling for risk perceptions, fear was not a significant predictor of support or opposition to a spent nuclear facility.
Sjöberg, 1992	Mixed Support	Feelings of worry directly increased favourable attitudes towards nuclear power, while it reduced attitudes by increasing general risk perceptions. General risks and economic perceptions of nuclear power had more influence on attitudes than worry.
Sjöberg, 1998a	Mixed Support	Worry and pessimism were positively correlated to several applications of nuclear technology, such as nuclear power and spent nuclear fuel. Worry and pessimism were very weakly correlated with opposition to a spent nuclear fuel repository. Significance levels were not reported, however, the relationship would appear to be very weak and insignificant.
Sjöberg, 1998b	No support	Emotional affect was not significantly related to 36 concerns or risks, such as nuclear power.

Table A7: Summary of Empirical Studies Evaluating General Trust and Attitudes/Risk Perceptions

Source	Support for trust model	Findings
Bord & O'Connor, 1992	Support	Perceptions of health risks were positively correlated with concerns regarding the cleanup of a nuclear repository site. Trust in government and industry was negatively related to concerns; knowledge had no significant impact on risks.
Sjöberg, 1999	Support	Two of four trust measures were related to perceptions of risk; the direction varied by risk. In terms of perceptions of risk towards nuclear waste, trust in corporations was negatively related.
Sjöberg, 2001	Support	Social trust was negatively related to risk perceptions of 22 hazards, including nuclear power and a spent nuclear facility. Trust accounted to 10% of the variance in perceptions.
Bassett, Jenkins-Smith, & Silva 1996	Support	Trust in government agencies and government nuclear regulators results in greater support for a spent nuclear facility, while trust in environmental groups did not.
Sparks et al., 1994	Support	Trust in environmental groups was negatively related to attitudes towards gene technology and energy consumption, while trust in government agencies was positively related.
Pijawka & Mushkatel, 1992	Mixed Support	Trust in the United States Government and government agencies was negatively related to perceived risks of a spent nuclear fuel facility. Trust in state and municipal government

		was positively correlated to risk perceptions.
Siegrist et al., 2005	Mixed Support	General trust reduced risk perceptions for several hazards, however, it was not the strongest predictor tested. General confidence, age, and gender were better predictors of perceptions.

Table A8: Summary of Empirical Studies Evaluating Specific Trust and Attitudes/Risk Perceptions

Source	Support for trust model	Findings
Siegrist et al., 2000	Support	Higher levels of trust were related to greater benefit and lower risk perceptions of three applications, including nuclear power. Trust was also found to be an important predictor in terms of personal values.
Siegrist & Cvetkovich, 2000	Support	Greater trust was negatively related to risk perceptions and positively related to benefit perceptions in this study of 25 hazards, including nuclear power. Evidence supports the idea that less knowledgeable people rely on trust when forming opinions. Controlling for trust reduced the negative relationship between risks and benefits.
Sjöberg, 2001	Support	Specific trust measures were moderately and negatively correlated to general public and expert risk perceptions of 22 hazards. Correlations were much stronger for domestic power plants, a domestic nuclear repository, and transporting spent fuel. Specific trust accounted for between 14% and 22% of the variance of nuclear power and repository risk perceptions in two studies.
Sjöberg, 2006	Support	Trust in those managing spent fuel repositories, nuclear power inspectors, and a government entity responsible for protecting the public from radiation, as well as trust in science were positively correlated to voting in a referendum for a spent nuclear facility. Risk perceptions were also significantly related.
Hallman & Wandersman, 1995	Support	Specific trust measures were moderately and negatively correlated to risk perceptions of a nuclear waste facility; 16% of the variance was explained by trust.
Biel & Dahlstrand, 1995	Support	Trust in those involved in a spent nuclear repository was positively related to support for such a site and negatively related to having negative feeling of consequences.
Bord & O'Connor, 1990	Support	Specific and general trust measures were positively related to willingness to try irradiated foods and giving them to one's family.

Table A9: Summary of Empirical Studies Evaluating Trust on Attitudes as Mediated Through Risk Perceptions

Source	Support for trust-risk-attitudes model	Findings
Flynn et al., 1992	Support	High levels of trust in management of a nuclear waste facility indirectly increased supportive attitudes towards the site by reducing perceptions of risk.
Siegrist, 2000	Support	Greater trust indirectly influenced willingness to buy GM foods by lowering perceived risks and increasing pierced benefits.
Siegrist, 1999	Support	Greater trust indirectly influenced attitudes towards gene technology by lowering perceived risks and increasing pierced benefits.
Eiser, Miles, & Frewer, 2002	Support	Greater trust that information was trustworthy directly and indirectly influenced supportive attitudes by lowering risk perceptions.
Whitfield et al., 2009	Mixed Support	Trust in nuclear organizations directly increased attitudes towards nuclear power and indirectly through lowering perceptions of risk. Trust in environmental groups was not a significant determinant of either risk perceptions or attitudes.

Table A10: Summary of Empirical Studies Evaluating Worldviews and Attitudes/Risk Perceptions

Source	Support for worldview models	Findings
Buss & Craik, 1983	Support	Those subscribing to Worldview A perceived less dread and less feelings of fatalism than those hold Worldview B over 30 technological risks as an aggregate. Differences in risk perceptions between Worldviews were significant for some risk and not others. Considering nuclear power, Worldview B persons were more likely to perceive risks than Worldview A.
Jenkins-Smith, 1994	Support	Egalitarians were more likely to attach negative imagery to a nuclear repository site, while hierarchists and individualists tended to attach positive valiances.
Wildavsky & Dake, 1990	Support	Considering 25 applications of technology, egalitarians perceived more risks and fewer benefits, while individualists and hierarchists perceived more benefits and less risk. Hierarchists and individualists were more willing to take risks, while egalitarians tended to avoid risk. Egalitarians were most concerns about technological and environmental risks, hierarchists with social deviance, and individualists with war.
Dake, 1991	Support	Egalitarians showed more concern for technological and environmental risks, individualists showed more concern for social deviance and issues regarding the free market, and hierarchists showed greater concern for social deviance. With respect to nuclear power, hierachists showed less and egalitarians showed more concern for dangers.

Peters & Slovic, 1996	Support	The fatalist/hierarchist group and individualists were more like to support nuclear power than egalitarians. Egalitarians were much more likely than the others to perceive risks related to nuclear technology.
Marris, Langford, &O' Riodan, 1998	Mixed Support	Only one third of participants could be characterized to a worldview based on measurements by Dake (1991). Most relationships between worldviews and hazards were small and insignificant. Individualists and hierarchists perceived less risk for nuclear power, while egalitarians perceived more.
Sjöberg, 1998	Mixed Support	About 21 of 36 societal concerns were significantly correlated with worldviews. Egalitarians were more likely believe nuclear power was dangerous, while individualists and hierarchists were less likely.
Sjöberg, 1997	No Support	The relationship perceptions of risk of teachers in Brazil did not significantly differ from teachers in Sweden. Differences in risk perceptions between worldviews were minimal.
Palmer, 1996	No Support	For ten technologies, including nuclear power, there was no significant difference in risk perceptions between worldviews.

APPENDIX B

Figure B1: Approved University of Victoria Ethics Waiver

University of Victoria

Human Research Ethics Board
Office of Research Services
Administrative Services Building
PO Box 1700 STN CSC
Victoria British Columbia V8W 2Y2 Canada
Tel 250-472-4545, Fax 250-721-8960
Email ethics@uvic.ca Web www.research.uvic.ca

Certificate of Approval

PRINCIPAL INVESTIGATOR:	**Kelton Doraty**	**ETHICS PROTOCOL NUMBER** Minimal Risk - Chair/Vice-chair	**13-428**
UVic STATUS:	**Master's Student**	ORIGINAL APPROVAL DATE:	12-Nov-13
UVic DEPARTMENT:	**PADM**	APPROVED ON:	12-Nov-13
SUPERVISOR:	**Dr. Jim MacGregor**	APPROVAL EXPIRY DATE:	11-Nov-14

PROJECT TITLE: **An Empirical Analysis of Knowledge, Trust, Emotions, and Worldviews as Predictors of Attitudes and Risk Perceptions towards the Nuclear Sector in Saskatchewan**

RESEARCH TEAM MEMBERS: None

DECLARED PROJECT FUNDING: **None**

ADDITIONAL COMMENTS: Previous Title: 'Analysis of Attitudes and Perceptions Towards Nuclear Power Generation in Saskatchewan'

CONDITIONS OF APPROVAL

This Certificate of Approval is valid for the above term provided there is no change in the protocol.

Modifications
To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.

Renewals
Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.

Project Closures
When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.

Certification

This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.

Rachael Scarth

Dr. Rachael Scarth
Associate Vice-President Research Operations

Certificate Issued On: 24-Mar-14

13-428 Doraty, Kelton

APPENDIX C

This appendix provides a detailed overview of how NPRI measures were operationalized for analyses. It also provides a substantial review of measure used in the literature and an evaluation of how the NPRI measures correspond or deviate to these. It will begin with the three dependent measures and then will address the independent measures. Finally, socio-demographics are covered.

DEPENDENT VARIABLES: ATTITUDES TOWARDS THE NUCLEAR SECTOR

The NPRI survey contained several measures that were used to measure attitudes and perceptions towards the nuclear sector in Saskatchewan. Dependent measures included perceptions of nuclear sector applications, attitudes towards the future of the nuclear sector in Saskatchewan, and perceptions of risks and benefits of nuclear power. The following is an overview of how attitudes and risk perceptions were operationalized.

ATTITUDINAL MEASURES IN THE ACADEMIC LITERATURE

Attitudinal measures tended to vary in the literature. Generally, measures were phrased in terms of "acceptance" and "support" for a scientific item. One commonly employed method was to ask if a respondent supports or accepts an initiative. Available responses could be bi-categorical, such as "yes" or "no" (Sjöberg, 2003b, p. 743) or "favour" or "oppose" (Flynn et al., 1992, p. 421; Solomon et al., 1989, p. 406). Acceptance and support measures, more frequently, used wider, ordinal categories (Sjöberg, 2003a, p. 114; Siegrist, 2000, p. 198; Siegrist, 1999, p. 2099; Eiser et al., 2002, p. 2428; Maharik & Fischhoff, 1993, p. 347; Borssard & Nisbet, 2007, p. 46; Lee et al., 2005, p. 249; Lee & Scheufele, 2006, p. 834). Attitudes have also been phrased in term of agreement to statements and often ranged from "strongly disagree" to "strongly agree" (Flynn et al., 1992, p. 421).

Attitudes were also been measured in other ways. For example, Peters & Slovic (1996) and Whitefield et al, (2009) measured nuclear attitudes as a function of alternatives to other sources of power generation, an acceptable approach for meeting energy demands, and if one was willing to pay more taxes to avoid nuclear power generation (p. 1435; p. 430). Similarly, Kuklinski et al. (1992) employed several dependent measures of attitudes towards nuclear power, including safety of nuclear power plants, environmental impacts, disposal of radioactive waste, and alternative sources of energy (p. 638). Simon (2010) and Hayes and Tariq (2000), on the other hand, measured attitudes in terms of science making things better, worse, or having no effect for society (p. 646; p. 444). Hayes and Tariq (200), as well as Bak (2001), measured attitudes in terms of faith in science and faith in religion (p. 444; p. 784). Attitudes have also be measured in terms of support for funding (Brossard et al., 2009, p. 551; Lee & Scheufele, 2006, p. 834), and as "feelings towards" an activity (Brossard & Nisbet, 2007, p. 46).

RISK/BENEFIT MEASURES IN THE ACADEMIC LITERATURE

Perceptions of risks and/or benefits were generally operationalized in three ways in the literature. One common approach was to use two different scales; one that rated the risks of an item and one that rated its benefits (Alhakami & Slovic, 1994, p. 1088; Siegrist & Cvetkovich, 2000, p. 715). This approach was commonly employed to test if a negative relationship existed between perceived risks and benefits of a hazard. The second common method used is only assessment of a hazard's risks (see Sjöberg & Drottz-Sjöberg, 1991, pp. 609-610, Sjöberg, 1999, p. 91). The third type, which measured both risk and benefits in the same measure, was a scale that ranged from "benefits are greater than risks" to "risks are greater than the benefits" (Brossard & Nisbet, 2007, pp. 46-47; Bak, 2001, p. 784; Cobb & Macoubrie, 2004, p. 404).

NPRI: IMPRESSIONS OF NUCLEAR SECTOR APPLICATIONS

The NPRI survey contained four questions that asked respondents to "indicate if your *overall impression* is entirely negative, mainly negative, neither positive nor negative, mainly positive, or entirely positive

for […] nuclear medicine (B1), nuclear fuel waste management practices (B2), uranium mining (B3), and nuclear power generation (B4)". These measurements deviated from the dependent variables employed in other studies mentioned above as it measured positive and negative impressions, rather than acceptance or support. The survey also contained a sixth category that captured "a mix of positive and negative". This category, as well as "don't know" and "refused", were removed in order to provide a consistent five point scale (1-5) that ranged from "entirely negative" to "entirely positive".

Although the mean scores for impressions of medical applications were higher and those for nuclear fuel waste management practises were lower than the other two measures, factor analysis showed that all four recoded variables loaded high on one factor with a Kaiser-Meyer-Olkin (KMO) value of 0.768. The internal consistency between the four variables was modestly high with a Cronbach's alpha of 0.793. These four variables were then averaged into a single scale that was used to measure impressions of the nuclear sector. The impressions scale ranged from 1 to 5, where 1 represented an "entirety negative impressions" and 5 represented an "entirely positive impression". With 1,024 valid responses, the mean score was 3.42, the mode was 4.00, and the standard deviation was 0.79.

NPRI: Support for Future Involvement in the Nuclear Sector

In order to further understand attitudes, respondents were also asked "when thinking of Saskatchewan's future involvement in the nuclear sector, would you strongly oppose, somewhat oppose, somewhat support or strongly support […] generating power from nuclear sources (C1), continuing nuclear medicine research funding (C2), continuing uranium mining (C3), and storing nuclear fuel waste (C4). These four measures were more consistent with the dependent variables used in previous academic studies as they assessed support for applications of technology.

The four variables were recoded to remove "don't know" and "refused". Similar, to the impression variables, mean scores for attitudes towards nuclear medicine were higher and scores for storing nuclear waste were lower than for the other two variables. Despite this, all four loaded onto one factor with a KMO of 0.781 and they had a high amount of internal consistency (Cronbach's alpha of 0.825). The four recoded variables were the combined and averaged into a scale that ranged from 1-4, where 1 represented "strong opposition" and 4 represented "strong support". This scale was used to measure attitudes towards the future of the nuclear sector in Saskatchewan and had 1,121 responses, a mean of 2.94, a mode of 3.75, and a standard deviation of 0.76.

NPRI: Risk/Benefit Perceptions of Nuclear Power

The survey contained one question that explicitly assessed perceived risks and benefits of nuclear power generation (see Table C1) and it was consistent with the third type of risk measure found in the literature review. This scale was recoded to remove "don't know" which left 1, 237 responses. It ranged from 1-5 with 1 showing greater risk perception and 5 showing greater benefit perceptions. The mean response was 3.22, the mode was 4.00, and the standard deviation was 1.37.

Table C1: Risk and Benefits of Nuclear Power Measure

NPRI Survey Question
B5. Which of the following best reflects your opinion? 1. The risks of nuclear power generation far outweigh the benefits. 2. The risks of nuclear power generation slightly outweigh the benefits. 3. The benefits and risks of nuclear power generation are about the same. 4. The benefits of nuclear power generation slightly outweigh the risks. 5. The benefits of nuclear power generation far outweigh the risks.

INDEPENDENT VARIABLES

The NPRI survey also contained several measures that were used to test the various hypothesized predictors of attitudes that emerged during the literature review. These measures included scientific knowledge/ awareness, trust, worldviews, and emotions.

KNOWLEDGE/AWARENESS MEASURES IN THE ACADEMIC LITERATURE

The literature review showed that knowledge was measured in a number of ways, the most popular being: subjective scientific knowledge, objective scientific knowledge, and awareness. Subjective scientific knowledge measures were used to assess how knowledgeable people think they are about science or specific scientific constructs. For example, Bord & O' Connor (1992) asked participants to self-rate their knowledge about two chemicals related to spent nuclear fuel storage: benzene and trichloroethylene (p. 412). Wildavsky & Dake (1990) asked participants to self-report how much they think they knew about several applications of science and technology (p. 47), while Biel & Dahlstrand (1995) assessed self-reported knowledge of treatment and deposition of spent nuclear fuel (p. 29). Bassett (1996) used similar subjective measures to assess knowledge of nuclear power (p. 313).

Objective scientific knowledge, the most frequently employed type in the literature, was used to measure actual knowledge of science. Generally, these measures were "true/false" or "yes/no" and were also consistent with civic scientific literacy measurements proposed by Miller (1983, 1998). Miller (1983, 1998) created a three part construct of civic scientific literacy, which included: an understanding of basic scientific constructs and vocabulary, such as the comprehension of basic science terms, such as atom, molecule, cell, and gravity, to be able to make a judgment on opposing scientific views in a newspaper, a grasp of the scientific inquiry process, and knowledge of the impact of science at an individual level and on a societal level (Miller, 1998, p. 205, 1983, p. 38). Objective scientific measures, in this sense, are specifically related to scientific applications and constructs. Examples of objective scientific knowledge in the literature have included: "which travels faster, light or sound?" (Einsiedel, 1994, p. 38), "[is] exposure to low-level radiation is more hazardous than medical x-rays?", "[can] some types of radiation are easily stopped by an ordinary piece of paper?" (McBeth & Oakes, 1996, p. 426), "[are] electrons are smaller than atoms?", and "[is] all radioactivity is man-made" (Bak, 2001, p. 785).

Factual awareness generally has measured objective knowledge of applications of science within society, such as awareness of a mining activity in the province. While such measures are objective, there is no direct tie to scientific constructs. These measurements were less prevalent in the literature than objective scientific measures. In their study of support for nuclear power, Solomon et al. (1989) measured awareness across different constructs, such as "are you aware that the Shearon Harris Nuclear Power Plant is in Wake County?" and "are you aware that the Shearon Harris Nuclear Plant is scheduled to begin testing with nuclear fuel this summer?" (p. 409). Other studies, such as European Commission (2007, 2010) and Greenberg & Truelove (2010), also employed awareness measures, such as awareness of nuclear power plants in one's country and awareness of the storage location of spent nuclear fuel. Although, the studies referred to them as knowledge questions, these measures were more consistent with what Solomon et al. (1989) defined as awareness, rather than what Miller (1998, 1983) referred to as scientific knowledge.

NPRI: SUBJECTIVE KNOWLEDGE

The NPRI survey contained one question that asked respondents to rate their self-reported knowledge about nuclear topics on a five-point scale ranging from "very good" to "very poor" (A3). This measure was consistent with the self-reporting knowledge measures found in the literature. The subjective knowledge scale was recoded to remove "don't know" and "refused" and was reversed to range from "very poor" (coded as 1) to "very good" (coded as 5). There were 1,348 valid cases. The mean response was 2.81 and the mode was 3.00; the standard deviation was 1.03. This particular measure was used to assess if respondents' self-reported levels of knowledge were related to their attitudes or perceptions.

NPRI: Objective Knowledge/ Awareness

The survey also contained two questions that measured objective scientific knowledge of nuclear topics and two that measured factual awareness of the nuclear industry in Saskatchewan (see Table C2). Question A6 was consistent with objective measures employed by McBeth & Oakes (1996, p. 426), while the two factual awareness questions were similar in nature to those mentioned earlier. Variable A7, an open ended question, was quite unique when compared to those used in the literature.

Table C2: Knowledge and Awareness Measures

Type of Measure	NPRI Survey Questions	Available answers
Objective Knowledge	A6. As far as you know, is radiation only a man-made phenomenon that comes from sources such as power facilities and X-ray machines?	Yes, **No,** DK/Refused
	A7. As far as you know, which mineral resource is mined in Saskatchewan that is fundamentally important for nuclear power generation?	Open-ended: (**uranium***), DK/Refused
Factual Awareness	A4. As far as you know, does Saskatchewan currently use nuclear power to generate electricity?	Yes, **No,** DK/Refused
	A5. As far as you know, does Saskatchewan currently store nuclear fuel waste?	Yes**, No,** DK/Refused
Note: bold indicates the correct answer. (*) uranium was the correct answer to A7.		

New dummy variables were created for each of these four questions. For each, the correct answer was coded as "1", while the incorrect answer and "don't know" were coded as "0"; "refused" was removed. This was consistent with the coding scheme used by Bak (200, p. 785), except the principal investigator, unlike Bak, decided to remove "refused" instead of coding it as "0"[4]. Factor analysis revealed that all four objective knowledge measures fit together moderately well on one factor with a KMO of 0.647 and had a moderate level of internal consistency with a Cronbach's alpha of 0.601. The four questions were then summed into a scale that measured "objective knowledge/ awareness". The scale ranged from a minimum of zero correct answers, indicating "no knowledge/ awareness", to a maximum score of 4, indicating "high levels of knowledge/ awareness". The mean of the objective knowledge/awareness scale was 2.51, the mode was 3.00, and the standard deviation was 1.25 points. One additional variable was created in the same way, except that it had a range of 1-5. This second variable was used to create an interaction term with ethical concerns of nuclear power (research question 3). The first scale, which had a minimum of zero, would have, in some instances, resulted in an interaction score of zero.

Trust Measures in the Academic Literature

As noted in the literature review, trust measures have been categorized as general or specific. Specific measures were related to trust in relevant authorities for a hazard, while general trust measured trust in groups without referencing a particular hazard (Sjöberg, 2001, p. 192). The trust measures in the NPRI survey were consistent with those used in the literature, although some measures tended to vary by study in terms of their wording. Bord & O'Connor (1990, 1992) measured trust in government and trust in

[4] It should be noted that there was only one response of "refused" for the two objective knowledge questions and none for the two factual awareness questions; therefore removing "refused" did not significantly affect the sample size.

industry (p. 501, p. 413) and Sjöberg (1999, 2001) measured general trust in corporations and politicians as general trust measures (p. 91, p. 193); these were consistent with the NPRI measures. Siegrist (2000) operationalized specific trust measures for scientists and researchers at universities (p. 198). Looking at biotechnology, Priest et al. (2003) measured general trust in industry and environmental groups, as well as other groups, defined as "doing a good job for society" (p. 760). Whitefield et al., (2009) operationalized "nuclear trust" as trust in the nuclear industry and the Nuclear Regulatory Commission, while "environmental trust" measures included the EPA, national environmental groups, and university scientists (p. 430). Sparks et al. (1994) also measured trust in environmental groups, including Greenpeace and Friends of the Earth, and trust in government, which included general government agencies, the Department of Energy, the Ministry of Agriculture, Forestry and Fisheries, and the Department of Health (p. 24). Sparks et al.'s (1994) definition differed slightly from those of Whitefeld et al. (2009), who included government agencies and scientists in their conceptualization of environmental trust. Bassett et al. (1996) made a similar distinction as Sparks et al.'s (1994) and measured trust in government agencies (the Department of Energy and the EPA), as well as environmental groups, and government nuclear regulators (the Nuclear Regulatory Commission) (p. 315). In the context of biotechnology, Brossard & Nisbet (2007) used measures of trust in industry representatives, government officials, and university scientists (pp. 47-48).

Flynn et al. (1992) measured trust in management as a function of the Department of Energy to manage the spent nuclear fuel program (p. 420). Siegrist, Cvetkovich, & Roth (1999) measured trust in government regulations through the follow: "the responsible authorities accurately control whether legal regulations and restrictions are upheld in nuclear power plants" and "legal regulations regarding the disposal of radioactive waste are sufficient" (p. 359); similar questions were used in another study with respect to gene technology (Siegrist, 1999, p. 2099). Biel & Dahlstrand, (1995) operationalized trust as a measure of experts' knowledge, including government authorities, universities, experts working for the nuclear industry, and experts who have criticized nuclear power (p. 29).

NPRI Trust Measures

The NPRI trust questions were similar to the measures in the literature as they, at the least, measured trust in the same type of agencies, however, questions were often worded differently. Generally, measures and operationalization of trust deviated within the literature. In some instance, trust had different definitions, for example, Siegrist et al. (2005), measured general trust in terms of social confidence (p. 149).

The survey contained six measures of trust that were operationalized in this report. Four of these were categorized as general measures, while the other two were specifically related to trust in actors surrounding nuclear risks (see Table C3). The general and specific trust measures were consistent with those employed with those in other studies mentioned above.

Table C3: General and Specific Trust Measures

Type of Measure	NPRI Survey Questions
General Trust	On a scale of 1 to 5, where 1 means you do 'not trust them at all' and 5 means you 'trust them completely', how much do you think you trust: D1. University scientists D3. Industry representatives D4. Elected officials D5. Environmental groups
Specific Trust	On a scale of 1 to 5, where 1 means you do 'not trust them at all' and 5 means you 'trust them completely', how much do you think you trust: D2. Government nuclear regulators D6. the adequacy of Canada's nuclear regulations

New variables were created for all six-trust measures that involved removing cases of “don’t know” and "refused”. All six variables ranged from “no trust” (1) to “complete trust” (5). Factor analysis revealed that the six variables loaded on two factors with a KMO of 0.782. Trust in government nuclear regulators (D2), industry representatives (D3), government officials (D4), and trust in nuclear regulators (D6) loaded on the first component and trust in environmental groups (D5) loaded on the second. Trust in scientists (D1) cross-loaded on both factors and was analyzed separately from the first two factors.

The four variables that loaded on the first factor had a high level of internal consistency with a Cronbach’s alpha of 0.802. They were then averaged into a “trust in government/industry” scale that ranged from 1-5, where 1 represented “no trust” and 5 represented “complete trust”. With 1,163 valid responses, trust in government/industry had a mean of 2.82, a mode of 3.00, and standard deviation of 0.85 points. Mean trust in environmental groups was 2.99 and the mode was 3.00. There were 1,344 responses for trust in environmental groups and a standard deviation of 1.16. The third trust measure, trust in university scientists, had 1,336 responses, a mean of 3.93, a mode of 4.00, and a standard deviation of 0.91.

EMOTIONS

Two types of emotions or measures of feeling were prevalent in the literature. These included emotional reactions to words (a measure of affect) and specific feelings that measured negative and positive emotions.

INITIAL REACTION TO “NUCLEAR” IN THE ACADEMIC LITERATURE

Slovic et al. (1991) and Peters & Slovic (1996) employed a word association method where respondents were asked to provide several images or words that they thought of when they heard “underground waste storage facility” and “nuclear test site” (Slovic et al., 1991, p. 687), and “nuclear power” (Peters & Slovic, 1996, p. 1433). Once these images were elicited, respondents where then asked to rank these images on a five point scale from “very negative” to “very positive”. This scale was used as an independent measure of affect in both of these studies.

NPRI: INITIAL REACTION TO “NUCLEAR”

The NPRI survey asked respondents “[o]verall, would you say that your first reaction to the word nuclear is: entirely negative, mainly negative, neither positive nor negative, mainly positive, entirely positive, or a mix of positive and negative” (A1). The NPRI measure differed from the two mentioned above as it did not ask respondents to first provide a word or image before then ranking that image. Also, the measure employed in the data set had a sixth (unasked, volunteered) category that captured “a mix of positive and negative”; this was not present in the studies mentioned above. For the purpose of this study, the variable was recorded to exclude “don’t know” and “a mix of positive and negative” in order to have a five point scale (range of 1-5) that was consistent with these previous studies. In total there were 1,217 responses with a mean of 3.04, a mode of 3.00, and standard deviation of 1.03.

EMOTIONS TOWARDS NUCLEAR POWER GENERATION IN THE ACADEMIC LITERATURE

Biel & Dahlstrand (1995) operationalized several emotions, including feeling worry, upset, afraid, distrust, calm, confidence, interested, and indifference (pp. 28-29). The measures were operationalized as “faced with the prospect of a repository in the X-mountain, do you feel [emotion]” with answers ranging from “No, not at all” to “Yes, very”. Lee et al. (2005) measured negative emotions by asking respondents if they were worried about nanotechnology (p. 251), Brossard & Shanahan (2003) measured fear in terms of the potential impacts of scientific research (p. 311), and Salvadori et al.’s (2004) measured dread with respect to how frightening technological applications were for respondents (p. 1298). Sjöberg has employed variety of negative and positive emotions in his studies that are consistent with the NPUR measures, including: dread, anger, contempt, interest, sorrow, satisfaction, guilt, shame, optimism (2007,

p. 226), fear (2003, p. 114; 2007, p. 226) worry (1992, p. 3; 1998a, p. 88; 2007, p. 226), and pessimism (1998a, p. 88; 2007, p. 226).

Cobb & Macoubrie (2004) employed a two-step process to measure feelings of worry, hope, and anger (p. 404). Respondents were first asked if they feel worried/hopeful/angry about nanotechnology. If a yes was given, respondents were then asked to rate their feelings from "only worried a little" to "very worrie". Other measures of emotion were present in the literature. For example, Sjöberg (1998) measured negative emotion in terms of how satisfactory items were (pp. 141-142) and Alhakami & Slovic (1994) employed measure related to perceptions of how "good/bad" and "pleasant/unpleasant" they were (p. 1088).

NPRI: Emotion Variables

The NPRI survey contained three questions that solicited emotional responses towards nuclear power generation on a four point scale that ranged from "strongly agree" (1) to "strongly disagree" (4) (see Table C4). Two questions assessed negative emotions related to fright and anger and the third measured the positive emotion of excitement. The negative emotions employed in the NPRI survey were similar those used in a number of other studies mentioned above, however, they did not include as wide of a range of emotions as those explored in the literature and it sometimes had different response categories. The positive emotion of excitement was not present in any other study found during the course of this research project, however, it was generally consistent with the positive emotions mentioned above.

Table C4: Emotions Felt by the Idea of Nuclear Power Generation

NPRI Survey Questions
C13. I am frightened by the idea of nuclear power generation in Saskatchewan.
C14. I am angered by the idea of nuclear power generation in Saskatchewan.
C15. I am excited about the idea of nuclear power generation in Saskatchewan.

These three variables were recoded to remove "don't know" and "refused". The fright variable had 1,328 cases with a mean of 2.80, a mode of 3.00, and a standard deviation of 1.10. With 1,307 valid responses, the recoded anger variable had a mean of 3.10, a mode of 3.00, and a standard deviation of 1.03. The recoded positive emotion variable, which measured excitement towards nuclear power, had 1,320 responses, a mean of 2.57, a mode of 2.00, and a standard deviation of 1.04. These three measures were used to emotions towards the nuclear sector.

NPRI: Ethical Concerns About Nuclear Power Generation

The NPRI survey asked respondents, on a scale ranging from "no ethical concerns" (1) to "many ethical concern" (5), "to what extent does developing nuclear power generation raise ethical concerns?". The variable was recoded to remove "don't know" and "refused". New ordinal categories were also created to reflect three levels of ethical concern: low ethical concerns (1 and 2 were recoded as 1), medium ethical concerns (3 was recoded as 2), and high ethical concerns (4 and 5 were recoded as 3). The new variable had 1,306 valid cases, a mean of 2.07, a mode of 3.00, and a standard deviation of 0.83. This measure was used to assess if nuclear power as an ethical question moderates the hypothesized knowledge-attitude link. A similar type of measure was not found in any of the studies in the literature review.

NPRI: Worldviews

The NPRI survey contained nine survey questions used in or adapted from previous empirical studies that measured three worldviews: hierarchy, individualism, and egalitarianism (see Table C5). Each measure ranged from "strongly agree" (1) to "strongly disagree" (4). Each was recoded to remove "don't know" and "refused" and reversed so that it ranged from "strongly disagree" (1) to "strongly agree" (4) for the purpose of constructing worldview scales.

Table C5: NPRI Worldview Measures

Worldview	NPRI Survey Question	Source
Hierarchy	E3. Decisions about health risks should be left to the experts.	Slovic, 1999, p. 694; Peters & Slovic, 1996, p. 1434
Hierarchy	E4. Until public health officials alert me about a specific serious health problem, I don't really have to worry.	Peters & Slovic 1996, 1434
Hierarchy	E9. With expert management, we can prevent major environmental problems.	Hirsch & Baxter 2011, p. 854
Individualism	E5. A strong economy can only exist by giving companies the opportunity to prosper.	Marris et al, 1998, p. 638
Individualism	E6. Continued economic growth is necessary to improve our quality of life.	Peters & Slovic, 1996, p. 1434
Individualism	E8. The environment is very adaptable and will recover from any harm caused by people.	Marris et al., 1998, p. 644
Egalitarianism	E1. Misuse of scientific and expert knowledge is a very serious problem in society today	Oltedal et al. 2004, p. 20; Dake, 1991, p. 69
Egalitarianism	E2. Those in power often withhold information about things that are harmful to us.	Peters & Slovic, 1996, p. 1434
Egalitarianism	E7. The environment is very fragile and the slightest human interference can cause major problems.	Hirsch & Baxter, 2011, p. 854

Since these measures were adapted from previous studies, it was expected that a factor analysis would have resulted in three separate components – one for each worldview. Instead, the nine measures fell onto two components with a KMO of 0.745 (see Table C6). Two of the hierarchy measures (E3 and E9) loaded on the first component and the third measure (E4) cross-loaded on both factors. For individualism measures, E5 and E6 loaded on the first component and E8 cross-loaded on both factors. All three egalitarian measures (E1, E2, and E7) loaded on the second component.

A third component that emerged during the factor analysis had an Eigenvalue of 0.980, which was just below the minimum acceptable value of 1.00. Additional factor analysis was performed to include this third component. The minimum Eigen value threshold was set to 0.980 to see if the nine variables loaded better on the three components. Many of the values cross-loaded on the three factors and did not provide a more consistent reflection of the three expected worldviews.

The primary researcher elected to create scales based on the theoretical constructs of each worldview measure (see Table C5), despite the factors not loading as desired. An average scale was created for the hierarchy, individualism, and egalitarianism worldviews; each scale ranged from 1 to 4 with higher worldview scores at the top end of the scale. The three hierarchal variables had a moderately low amount of internal consistency as indicated by a Cronbach's alpha of 0.549. The hierarchal scale had 1,301 valid cases, a mean score of 2.76, a mode of 3.00, and a standard deviation of 0.68. With a Cronbach's alpha of 0.539, the individualism variables also had a moderately low amount of internal consistency. With 1,290 valid cases, the individualism scale had a mean of 2.65, a mode of 2.67, and a standard deviation of 0.68. The three egalitarian measures had a Cronbach's alpha of 0.503, which, like the other worldview measures, has a moderate low level of internal consistency. The mean for this scale was 3.11, the mode was 3.00, and the standard deviation was 0.622; it had 1,251 valid cases.

Table C6: Worldview Rotated Component Matrix from Factor Analysis

	Component 1	Component 2
Hierarchy		
E3. Decisions about health risks should be left to the experts.	0.631	-0.037
E4. Until public health officials alert me about a specific serious health problem, I don't really have to worry.	0.516	-0.371
E9. With expert management, we can prevent major environmental problems.	0.660	0.010
Individualism		
E5. A strong economy can only exist by giving companies the opportunity to prosper.	0.627	-0.202
E6. Continued economic growth is necessary to improve our quality of life.	0.683	-0.076
E8. The environment is very adaptable and will recover from any harm caused by people.	0.344	-0.484
Egalitarianism		
E1. Misuse of scientific and expert knowledge is a very serious problem in society today	0.108	0.670
E2. Those in power often withhold information about things that are harmful to us.	-0.137	0.660
E7. The environment is very fragile and the slightest human interference can cause major problems.	-0.134	0.691

SOCIO-DEMOGRAPHIC VARIABLES

The NPRI survey contained several socio-demographics measures that were used during bivariate analysis and as control variables during multiple regression analysis (see Table C7). Dummy variables, if applicable, were recoded to include "don't know" and/or "refused" in the reference category (0). For example, the Aboriginal status dummy variable was recoded to include all other values (No [non-Aboriginal], don't know, and refused) rather than just "No". This was performed in order to preserve cases. Additionally, the ordinal level variables for education, income, and age were coded to retain "don't know", "refused", and/ or any other missing values.

Table C7: Socio-demographic Variables and Coding

Measure	Variable(s) and coding
Gender	Gender dummy variable: • Male (0); Female (1)
Geographic region	CMA dummy variable: • Smaller cities, rural north, and rural south (0); Saskatoon CMA and Regina CMA (1) Smaller cities dummy variable: • Saskatoon CMA, Regina CMA, rural north, and rural south (0); Smaller cities (1) Rural south dummy variable: • Saskatoon CMA, Regina CMA, rural north, and smaller cities (0); Rural south (1)
Age	Age ordinal variable: • 18-34 (1); 35-54 (2); 55+(3); refused (9) Age interval variable:

	• Age in years (range 18 – 93)
Education	Education ordinal variable: • Completed high school or less (1), some university/ completed college (2), completed university or higher (3), don't know and refused (9). Education interval variable: • No schooling (1), some elementary school (2), completed elementary school (3), some secondary/ high school (4), completed high school/ secondary school (5), some technical/ community college (6), completed technical or community college (7), some university (8), bachelor's degree (9), master's degree (10), and professional degree or doctorate (11).
Employment status	Employment dummy variable: • Retired and not working, unemployed/looking for work, student and not working, caring for children or other family members full time, disabled, other, and refused (0) • Self-employed, working for pay, student and working for pay, caring for children or other family members and working for pay, and retired and working for pay (1)
Household member worked in uranium mining sector	Household uranium dummy variable: • No, not sure, don't know, and refused (0); Yes (1)
Nuclear industry near one's community	Nuclear industry in community dummy variable: • No, not sure, don't know, and refused (0); Yes (1)
Religion	Catholic dummy variable: • Anglican, United Church of Canada, Baptist, Lutheran, other Protestant denomination, Jewish, Muslim/Islamic/Sikh, Hindi, other religion, none / no religion, don't know, and refused (0); Roman Catholic or Ukrainian Catholic (1) Protestant dummy variable: • Roman Catholic or Ukrainian Catholic, Jewish, Muslim/Islamic/Sikh, Hindi, other religion, none / no religion, don't know, and refused (0); Anglican, United Church of Canada, Baptist, Lutheran, and other Protestant denomination (1) Other religion dummy variable • Roman Catholic or Ukrainian Catholic, Anglican, United Church of Canada, Baptist, Lutheran, and other Protestant denomination, none / no religion, don't know, and refused (0); Jewish, Muslim/Islamic/Sikh, Hindi, and other religion (1)
Aboriginal status	Aboriginal status dummy variable (First Nation, Metis, or Inuit): • No, don't know, and refused (0); Yes (1)
Country of birth	Country of birth dummy variable: • Canada and refused (0); Other country (1)
Annual household income	Income ordinal variable: • Under $50,000 (1); $50,000 - $99,999 (2); $100,000 or more (3); Don't know and refused (9)

	Income interval variable • Less than $25,000 (1); $25,000 to less than $50,000 (2); $50,000 to less than $75,000 (3); $75,000 to less than $100,000 (4); $100,000 to less than $125,000 (5); $125,000 to less than $150,000 (6); $150,000 to less than $175,000 (7); $175,000 or more (8)

APPENDIX D

Table D1: Pearson Correlation Matrix for Socio-demographics and Nuclear Attitude Measures

		Male dummy	Education	Employment dummy	Household mining dummy	Nuclear community dummy	Catholic dummy	Protestant dummy	Other religion dummy	Aboriginal dummy	Foreign born dummy	Income	CMA dummy	Smaller city dummy	Rural south dummy	Age
Nuclear medicine impressions	Pearson Correlation	.167**	.078**	.005	.053	.115**	-.001	.044	-.049	-.130**	.006	.025	.086**	-.058*	-.022	.063*
	N	1246	1246	1246	1246	1246	1246	1246	1246	1246	1246	1246	1246	1246	1246	1246
Nuclear fuel management impressions	Pearson Correlation	.151**	-.034	.085**	.055	.042	.020	.023	.044	-.094**	-.001	-.063*	.043	.008	-.033	-.123**
	N	1162	1162	1162	1162	1162	1162	1162	1162	1162	1162	1162	1162	1162	1162	1162
Uranium mining impressions	Pearson Correlation	.207**	-.009	.033	.090**	.026	.010	.014	-.017	-.067*	-.036	.016	.003	.017	-.003	-.068*
	N	1234	1234	1234	1234	1234	1234	1234	1234	1234	1234	1234	1234	1234	1234	1234
Nuclear power impressions	Pearson Correlation	.208**	.024	.064*	.106**	.041	.032	.014	.023	-.073**	.020	-.023	.014	-.009	-.002	-.074**
	N	1242	1242	1242	1242	1242	1242	1242	1242	1242	1242	1242	1242	1242	1242	1242
Support for nuclear medicine research	Pearson Correlation	.173**	.062*	.000	.047	.125**	-.005	.052	-.018	-.185**	.000	-.029	.121**	-.040	-.062*	.029
	N	1287	1287	1287	1287	1287	1287	1287	1287	1287	1287	1287	1287	1287	1287	1287
Support for storing nuclear fuel	Pearson Correlation	.195**	.014	.080**	.096**	.116**	-.004	.068*	-.020	-.096**	.042	-.035	.026	-.026	-.022	-.027
	N	1265	1265	1265	1265	1265	1265	1265	1265	1265	1265	1265	1265	1265	1265	1265
Support for uranium mining	Pearson Correlation	.221**	.002	.079**	.082**	.068*	-.016	.050	-.021	-.161**	-.055*	-.038	.041	-.048	.019	-.091**
	N	1275	1275	1275	1275	1275	1275	1275	1275	1275	1275	1275	1275	1275	1275	1275
Support for nuclear power	Pearson Correlation	.152**	.020	.049	.071*	.022	.031	.042	.004	-.083**	.011	-.033	.041	-.034	.005	-.064*
	N	1279	1279	1279	1279	1279	1279	1279	1279	1279	1279	1279	1279	1279	1279	1279
Nuclear power risk/benefit perceptions	Pearson Correlation	.171**	.002	.027	.024	.035	-.026	.039	-.017	-.052	-.042	-.038	.032	-.013	-.026	-.039
	N	1237	1237	1237	1237	1237	1237	1237	1237	1237	1237	1237	1237	1237	1237	1237

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table D2: Impressions of Nuclear Power/Knowledge as Moderated by Ethical Concerns

	Block 1	Block 2	Block 3
Male dummy	0.166*	0.087*	0.083*
Age	0.017	0.009	0.011
Education	0.075*	0.096*	0.101*
Employment dummy	0.015	0.030	0.034
Household mining dummy	0.058	0.040	0.031
Nuclear community dummy	0.009	0.008	0.016
Catholic dummy	0.087*	0.086*	0.080*
Protestant dummy	0.087*	0.100*	0.097*
Other religion dummy	0.065	0.055	0.057
Aboriginal dummy	-0.057	-0.021	-0.032
Foreign born dummy	-0.052	-0.030	-0.013
Income	0.151*	0.071*	0.061
CMA dummy	-0.114	-0.152	-0.175
Smaller city dummy	-0.074	-0.100	-0.106
Rural south dummy	-0.083	-0.117	-0.121
Objective knowledge	-0.061	-0.080*	0.091
Subjective knowledge	0.088*	0.080*	0.395*
Ethical concerns		-0.440*	0.145
Obj knowledge X Ethical interaction term			-0.242*
Sub knowledge X Ethical interaction term			-0.499*
R	0.307	0.518	0.543
R Square	0.094	0.268	0.295

Table includes standardized beta coefficients

*. Correlation is significant at the 0.05 level (2-tailed).

Table D3: Support for Nuclear Power/Knowledge as Moderated by Ethical Concerns

	Block 1	Block 2	Block 3
Male dummy	0.110*	0.022	0.016
Age	-0.028	-0.036	-0.034
Education	0.005	0.028	0.03
Employment dummy	-0.023	-0.003	0.000
Household mining dummy	0.030	0.007	0.000
Nuclear community dummy	0.022	0.019	0.026
Catholic dummy	0.060	0.063	0.056
Protestant dummy	0.097*	0.116*	0.110*
Other religion dummy	0.035	0.022	0.023
Aboriginal dummy	-0.058	-0.013	-0.024
Foreign born dummy	-0.043	-0.012	-0.002
Income	0.194*	0.104*	0.093*
CMA dummy	0.009	-0.043	-0.065
Smaller city dummy	-0.019	-0.043	-0.053
Rural south dummy	0.012	-0.032	-0.041
Objective knowledge	-0.045	-0.057	0.012
Subjective knowledge	0.059	0.054	0.368*
Ethical concerns		-0.492*	-0.035
Obj knowledge X Ethical interaction term			-0.094
Sub knowledge X Ethical interaction term			-0.495*
R	0.274	0.541	0.560
R Square	0.075	0.293	0.313

Table includes standardized beta coefficients

*. Correlation is significant at the 0.05 level (2-tailed).

Table D4: Risk/Benefit Perceptions of Nuclear Power/Knowledge as Moderated by Ethical Concerns

	Block 1	Block 2	Block 3
Male dummy	0.157*	0.089*	0.091*
Age	0.092*	0.088*	0.087*
Education	0.036	0.060	0.062
Employment dummy	-0.011	0.005	0.009
Household mining dummy	-0.027	-0.044	-0.048
Nuclear community dummy	0.004	0.000	0.004
Catholic dummy	-0.030	-0.030	-0.034
Protestant dummy	0.020	0.037	0.036
Other religion dummy	-0.009	-0.016	-0.014
Aboriginal dummy	-0.045	-0.010	-0.018
Foreign born dummy	-0.079*	-0.058	-0.051
Income	0.203*	0.134*	0.130*
CMA dummy	-0.141	-0.187	-0.196
Smaller city dummy	-0.115	-0.141	-0.144
Rural south dummy	-0.164	-0.202	-0.201
Objective knowledge	-0.047	-0.061	0.133
Subjective knowledge	0.036	0.027	0.161*
Ethical concerns		-0.382*	0.029
Obj knowledge X Ethical interaction term			-0.297*
Sub knowledge X Ethical interaction term			-0.213
R	0.287	0.461	0.472
R Square	0.082	0.213	0.223

Table includes standardized beta coefficients

*. Correlation is significant at the 0.05 level (2-tailed).

Table D5: Co-variance Matrix for Predictor Variables in the Nuclear Power Impressions Final SEM Mode

Co-variance			Estimate	Standard Error	Z score	Significant
Individualist	<-->	Egalitarian	-.118	.011	-10.869	*
Egalitarian	<-->	Excitement	.213	.018	12.073	*
Egalitarian	<-->	Anger	-.229	.018	-13.022	*
Egalitarian	<-->	Fright	-.241	.019	-12.957	*
Egalitarian	<-->	Reaction to nuclear	-.188	.016	-11.425	*
Egalitarian	<-->	Environmental groups	.224	.020	11.469	*
Egalitarian	<-->	Objective knowledge	-.121	.020	-5.974	*
Individualist	<-->	Excitement	-.306	.020	-15.411	*
Individualist	<-->	Anger	.228	.019	12.090	*
Individualist	<-->	Fright	.252	.020	12.543	*
Individualist	<-->	Reaction to nuclear	.229	.018	12.667	*
Individualist	<-->	Environmental groups	-.228	.021	-10.827	*
Individualist	<-->	Objective knowledge	-.018	.022	-.852	
Excitement	<-->	Anger	-.621	.033	-18.696	*
Excitement	<-->	Fright	-.654	.035	-18.590	*
Excitement	<-->	Reaction to nuclear	-.608	.032	-19.089	*
Excitement	<-->	Environmental groups	.378	.034	11.163	*
Excitement	<-->	Objective knowledge	-.119	.035	-3.402	*
Anger	<-->	Fright	.716	.036	20.016	*
Anger	<-->	Reaction to nuclear	.546	.031	17.742	*
Anger	<-->	Environmental groups	-.413	.034	-12.202	*
Anger	<-->	Objective knowledge	.148	.035	4.281	*
Fright	<-->	Reaction to nuclear	.598	.033	18.186	*
Reaction to nuclear	<-->	Environmental groups	-.387	.032	-12.043	*
Fright	<-->	Objective knowledge	.235	.037	6.340	*
Reaction to nuclear	<-->	Objective knowledge	.260	.034	7.745	*
Environmental groups	<-->	Objective knowledge	-.128	.039	-3.286	*
Fright	<-->	Environmental groups	-.440	.036	-12.269	*

*. Co-variance is significant at the 0.001 level (2-tailed)

Table D6: Co-variance Matrix for Predictor Variables in the Support for the Future of Nuclear Power in Saskatchewan Final SEM Model

Co-variance			Estimate	Standard Error	Z score	Significant
Individualist	<-->	Egalitarian	-.118	.011	-10.869	*
Egalitarian	<-->	Hierarchist	-.089	.011	-8.080	*
Egalitarian	<-->	Excitement	.213	.018	12.073	*
Egalitarian	<-->	Anger	-.229	.018	-13.022	*
Egalitarian	<-->	Fright	-.241	.019	-12.957	*
Egalitarian	<-->	Reaction to nuclear	-.188	.016	-11.425	*
Egalitarian	<-->	Gov/industry	-.165	.013	-12.295	*
Egalitarian	<-->	Objective knowledge	-.121	.020	-5.974	*
Individualist	<-->	Hierarchist	.190	.013	14.881	*
Individualist	<-->	Excitement	-.306	.020	-15.411	*
Individualist	<-->	Anger	.228	.019	12.090	*
Individualist	<-->	Fright	.252	.020	12.543	*
Individualist	<-->	Reaction to nuclear	.229	.018	12.667	*
Individualist	<-->	Gov/industry	.202	.015	13.630	*
Individualist	<-->	Objective knowledge	-.018	.022	-.852	
Hierarchist	<-->	Excitement	-.287	.020	-14.110	*
Hierarchist	<-->	Anger	.223	.020	11.398	*
Hierarchist	<-->	Fright	.230	.021	11.124	*
Hierarchist	<-->	Reaction to nuclear	.224	.019	11.971	*
Hierarchist	<-->	Gov/industry	.217	.015	14.007	*
Hierarchist	<-->	Objective knowledge	-.093	.023	-4.106	*
Excitement	<-->	Anger	-.621	.033	-18.696	*
Excitement	<-->	Fright	-.654	.035	-18.590	*
Excitement	<-->	Reaction to nuclear	-.608	.032	-19.089	*
Excitement	<-->	Gov/industry	-.386	.024	-15.793	*
Excitement	<-->	Objective knowledge	-.119	.035	-3.402	*
Anger	<-->	Fright	.716	.036	20.016	*
Anger	<-->	Reaction to nuclear	.546	.031	17.742	*
Anger	<-->	Gov/industry	.349	.024	14.667	*
Anger	<-->	Objective knowledge	.148	.035	4.281	*
Fright	<-->	Reaction to nuclear	.598	.033	18.186	*
Reaction to nuclear	<-->	Gov/industry	.304	.022	13.579	*
Fright	<-->	Objective knowledge	.235	.037	6.340	*
Fright	<-->	Gov/industry	.323	.025	13.065	*
Reaction to nuclear	<-->	Objective knowledge	.260	.034	7.745	*
Gov/industry	<-->	Objective knowledge	.087	.027	3.261	*

*. Co-variance is significant at the 0.001 level (2-tailed).

Figure D1: Hypothesized Model of Risk/Benefit Perceptions as a Mediator of Attitudes Towards Nuclear Power Generation