

**A Contingent Valuation Study of Winnipeg Municipal Water Quality  
Using Bounded Rationality**

**by**

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**A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University  
of Manitoba in partial fulfillment of the requirements of the degree  
of  
Master of Arts**

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## DEDICATION

I would like to dedicate this thesis to my wife Carolyn and two wonderful children,  
Margot and Peter.

## ABSTRACT

Contingent valuation (CV) is a survey technique used to value environmental goods not traded in markets, such as improvements to air or water quality. Despite its popularity, widespread acceptance of this methodology has been hampered by controversies stemming from numerous behavioral anomalies such as preference reversals, embedding and starting point bias.

This thesis argues that these anomalies are better understood using bounded rationality to model behavior, rather than traditional theories of rationality. To prove this, a conceptual framework is developed which explains the various aspects of bounded rationality. This framework is then applied to a literature review of contingent valuation and related studies, and a CV experiment.

The contingent valuation experiment uses a research design with techniques designed to both mitigate and observe these anomalies. A “shopping experience” scenario was constructed; a protocol analysis technique called *retrospective reporting* was used, and attitude questions in the survey were used to construct indexes for an econometric model. This latter application is consistent with the interdisciplinary approach of this thesis, which draws on both psychology and economics.

The environmental good valued was an improvement in Winnipeg municipal water quality that would result if a modern treatment plant was built. Over the past decade, numerous factors have combined to lower the quality of drinking water including: presence of the cryptosporidium parasite; algae blooms; chlorine byproducts and development around Shoal Lake, the source of Winnipeg’s municipal water supply.

The results indicated that the research design mitigated many possible anomalies and that bounded rationality provided a useful conceptual framework to understand anomalous results.

A cost-benefit analysis estimated the benefits generated by a water treatment plant at \$230-million over a 30-year time horizon. This is higher than costs borne by Winnipeg households estimated at \$144 million. As a consequence, this study recommends that the city proceed with construction of the treatment plant.

## CHAPTER ONE INTRODUCTION

Over the past twenty years, environmental economists have focused on developing methods to value the environment. During this period, over two thousand studies have been published in journals, books, government reports, working papers and as theses.<sup>1</sup> The reason for this plethora of work is that environmental valuation has a variety of applications: for environmental policy decisions; cost-benefit analysis; to construct sustainability indicators; damage assessment, and for exploratory work to green national accounts. As a result of this work, three *main* methods for valuing the environment have emerged: the hedonic price method; the travel cost method;<sup>2</sup> and contingent valuation.<sup>3</sup>

Of the three, contingent valuation has been the most popular. However, it has also been the most controversial. This controversy has stemmed from problems with behavioral anomalies<sup>4</sup> such as embedding,<sup>5</sup> preference reversals and starting point bias

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<sup>1</sup> This is an estimate of the total number of valuation studies. An unpublished bibliography of valuation studies compiled by the U. S. Environmental Protection Agency lists 1,232 studies. Similarly, the Environmental Valuation Reference Inventory, an Environment Canada database, contains 700 valuation studies.

<sup>2</sup> The hedonic price method imputes environmental values from changes or differences in housing prices adjacent to lakes or woodlands. The travel cost method imputes total values for recreational sites by constructing demand curves from travel cost data. There are numerous other valuation methods such as benefits transfer, actual expenditure, the random utility model and other cost-based techniques.

<sup>3</sup> Refer to Mitchel and Carson (1989) or Garrod and Willis (1999) for overviews of contingent valuation. Garrod and Willis also has overviews of other nonmarket valuation methodologies: hedonic price; travel cost and benefit transfer.

<sup>4</sup> For the purposes of this thesis, a behavioral anomaly is defined as an observed behavior that is not consistent with the model of economic rationality. This definition was used by J. Knetsch at a Canadian Environmental Economics Conference (CREE) in October, 1999, (See bibliography for citation).

<sup>5</sup> Embedding refers to the inability of respondents to differentiate between magnitudes of an environmental amenity.

observed during contingent valuation experiments. Economists have not been able to explain these anomalies using traditional economic models of rationality.

Concurrent with these developments, a group of psychologists associated with a field known as *behavioral decision research* have argued these anomalies are consistent with a model they developed called *constructive preferences*. This model is a subset of a more general theory called bounded rationality developed by Herbert Simon. It is the central argument of this thesis that behavioral anomalies observed during contingent valuation can be better understood using bounded rationality as the framework to model behavior. In an attempt to do this, this work will be divided into six chapters. Chapter two develops a conceptual framework for bounded rationality. This framework provides a blueprint for the way boundedly rational decision-makers are expected to behave, and includes descriptions of several aspects of this model including: cognitive abilities; constructive preferences; satisficing behavior and value. One section of this chapter develops a policy model which explains the way government decision-makers are expected to behave in the context of environmental policy.

The next step is to apply this framework to a literature review of contingent valuation and related studies, focusing on behavioral anomalies such as preference reversals, embedding and starting point bias. This is done in chapter three. Chapter four describes the environmental problem which is the focus of this study: declining quality of Winnipeg drinking water. Winnipeg tap water has been exposed to numerous stressors in the past decade including: algae blooms that periodically cause poor taste and odor, the cryptosporidium parasite and chlorine by-products. The City of Winnipeg plans to build a \$200-million treatment plant to purify city tap water.

Finally, the information and analysis from chapters two, three and four was used to develop a research design for a contingent valuation experiment which elicited a willingness-to-pay for Winnipeg drinking water quality.

This experiment was conducted to test the hypothesis that results of contingent valuation research are better understood using bounded rationality as a framework to model behavior, rather than traditional economic theories of rationality.

The main components of the research design are outlined in chapter five and include: i) survey administration; ii) a “shopping experience” scenario for the valuation question; iii) protocol analysis; iv) an attitude survey and v) an econometric model. Chapter six provides an overview of study results including results of the cost-benefit analysis of Winnipeg drinking water quality. Chapter seven provides concluding remarks.

## **CHAPTER TWO**

### **BOUNDED RATIONALITY: THE CONCEPTUAL FRAMEWORK**

#### **2.0 Introduction**

This chapter develops the conceptual framework for the thesis. Section 2.1 provides the context for a discussion of bounded rationality. Section 2.2 gives a brief biographical sketch of Herbert Simon's work. Section 2.3 develops the conceptual framework by comparing and contrasting the theory of bounded rationality with the economic theory of rationality using several aspects of both models, such as how they treat complexity, value or preferences. Section 2.4 discusses applications to government and the economy.

#### **2.1 Bounded Rationality: The Context**

Although numerous behavioral anomalies such as embedding (Kahnmen 1986, Kahnmen and Knetsch 1992) and preference reversals (Irwin et al 1993) have been observed during contingent valuation, there has been limited commentary about the need for an alternative framework to model decision-making, such as *bounded rationality*. Arrow (1996) is one of few economists who has raised doubts about rationality, based on the cumulative findings of contingent valuation experiments:

The evidence of failure of rationality creates a need for alternative models of behavior. Complete rejection of rationality has seemed too extreme to almost every scholar. Somehow we are convinced, by introspection if nothing else, that there is something purposive and consistent about our choices. These considerations have led to hypothesis of *bounded rationality*...(p.xivi)

Milion (1989) drew similar conclusions based on observed results of a contingent valuation study he performed:

These noncalculating motives and other implications of *bounded rationality* are aspects of respondents' decision process that deserve further consideration in the development of an integrated theory of CVM (contingent valuation methodology) respondent behavior (p. 306).

However, these observations by economists are rare in the *mainstream* contingent valuation literature. In a survey of 464 stated preference<sup>6</sup> studies contained in an Environment Canada database, the Environmental Valuation Reference Inventory (EVRI)<sup>7</sup> all but 32 used rationality as the model for respondent behavior.<sup>8</sup> Because economists have adhered to the model of rationality, they have not been able to explain in a consistent manner why these anomalies occur. The result has been a *fix-it* approach to survey design: as one anomaly crops up such as starting point bias (Desvousges et al 1983) techniques such as payment cards (Mitchell and Carson 1984) or dichotomous choice (Bishop and Heberlein 1979) were developed or come into widespread use. As well, these numerous anomalies have unnecessarily created an aura of controversy around the methodology. As a result, governments in Canada<sup>9</sup> have been hesitant to use numbers from contingent valuation for policy applications other than rough policy or project screening.

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<sup>6</sup> Stated preference studies are a class of valuation studies in which the respondent says or writes down his/her willingness-to-pay. This class includes contingent valuation, contingent ranking and conjoint analysis.

<sup>7</sup> This database has detailed summaries of environmental valuation studies. This database is currently managed by the author of this thesis.

<sup>8</sup> This observation was based on a scan of EVRI records in the searching module of the database.

<sup>9</sup> For example, see MacDonald et al (2000) for a pilot application of the federal Environmental Damage Assessment (EDA) process. This application relies on *actual expenditure* methodologies to estimate damages for a fish-kill caused by pesticide run-off.



As this mainstream work has progressed, a less visible group of cognitive psychologists have said that these survey results are not anomalies but are consistent with a different set of theories, or sub-theories. The one referred to most in this context is constructive preferences, (Payne, Bettman and Johnson 1992) however, a host of related theories such as articulated and basic values, (Fischhoff 1991) and the prominent attribute hypothesis (Tversky et al 1988) have been discussed in the context of these results. Unlike rationality, which assumes consumers have well-formed preferences, these models assume that preferences for environmental amenities are difficult to form because people have cognitive limitations. This literature draws from a parallel or satellite field of economics called behavioral decision research, (BDR) which is based on a general theory called *bounded rationality*. This theory was developed by Herbert Simon during the 1940's, 50's and 60's when he wrote a series of textbooks on public administration, and some journal articles, at Carnegie-Melon University. Bounded rationality is a general theory of decision-making that can be extended to several applications: firms, economic policy, administrative organizations, consumer research and the closely-related field of behavioral decision research (BDR). Bounded rationality will serve as the conceptual framework for this thesis. In order to develop this theory further, the next two sections will detail its development: i) the first will sketch the personal life of Herbert Simon, and the milieu in which he worked, and ii) the second section will develop, in detail, the conceptual framework for the theory of bounded rationality.

## 2.2 The Life of Herbert Simon

Although bounded rationality is a general theory of decision-making, Simon's first subjects were municipal employees. In 1935, 19-year-old Herbert Simon was an undergraduate student at the University of Chicago, and he did a term project on the operation of municipal government in Milwaukee, Wisconsin. While working on the project, he discovered that the way decisions were made in city government bore little relation to the account of rational decision-making he found in his economics textbooks. Simon (1995) recalls this project "ignited in me a passionate interest in human decision making (and its attendant processes of problem solving and thinking) that has not yet been quenched."

Ten years later, as a professor at the Industrial School of Administration at Carnegie-Melon University, he followed this "passion" by writing a series of books on administrative behavior from the 1940's until the final edition in 1976. Analysis in the early editions was often anecdotal and based on Simon's personal observations of the way people behaved in government organizations, with municipal government his favorite example.

In these editions, Simon separated out an "administrative man" from "economic man," with the former based on an emerging theoretical framework that Simon would label bounded rationality, and the latter based on the traditional neoclassical model of rationality. By 1958, Simon had not yet developed the concept of heuristics, however, he alludes to it as a tendency for people to simplify their decision environment:

Administrative man recognizes that the world he perceives is a drastically simplified model of the buzzing, blooming confusion that constitutes the real world. He is content with this

simplification...Hence, he is content to leave out of account those aspects of reality - and that means *most* aspects - that are substantially irrelevant at a given time. He makes his choices using a simple picture of the situation that takes into account just a few of the factors that he regards as the most relevant and crucial. (p.76).

It is an interesting historical fact that as Simon sharpened the theory of bounded rationality in the 1960's, it was done so in a small business school that was also home to several prominent economists -- Muth, Lucas and Sargent -- who would eventually develop a theory antithetical to it: rational expectations. By antithetical, it is meant the two theories are opposites: bounded rationality is a theory based on close observation of actual human behavior, through experiments and other empirical methods; it is an inductive approach to discovery. By contrast, rational expectations is an abstract or formal model of human behavior grounded in logic and made defensible through mathematical proofs: a deductive approach. It is because these approaches are diametric opposites that frictions eventually developed in this small industrial school, a clash of wits, so to speak. At first, relationships at the school were congenial with several collaborating on projects, such as one on dynamic programming that used bounded rationality as the central assumption. However, as biographer Sent (1997) observed, the atmosphere slowly deteriorated and Simon began to feel more alienated from the faculty which emphasized formal model building over empiricism. Later in life, Simon (1992) recalls:

Although I had never thought I lacked sympathy with mathematical approaches to the social sciences, I soon found myself frequently in a minority position when I took stands against what I regarded as excessive formalism and shallow mathematical pyrotechnics. The situation became worse as a strict neoclassical orthodoxy began to gain ascendancy among economists, (p. 32).

Around 1970, Simon moved his office at Carnegie-Mellon to the psychology department as tensions grew. Shortly after that, Lucas and Sargent gained national notoriety for their theory of rational expectations, and it has continued to be a pervasive influence in economics.

Although Sent does not draw this inference, the movement of Simon's chair from economics to psychology is perhaps a greater historical event than the biographer makes out. Simon's work from the early 1970's onward focused more on psychology, and less on applications of bounded rationality to the economy such as firms and consumer behavior. As a result, the field of economics was deprived, for at least part of his career, of one of the geniuses of that generation; someone who may have served as a needed prod to popularize an empirically-grounded (and less formal) approach to modeling economic behavior. Thus even though Simon received a Nobel Laureate in Economics in 1976, he did so as a professor of psychology and computer science - and the mainstream impact of his theories and work would rest in those fields. It is not until the late 1990's that bounded rationality is being reconsidered as a viable alternative, partially through the study results of contingent valuation (Arrow et al 1996).

### **2.3 Bounded Rationality: The Conceptual Framework**

As outlined in the last section, the theory of bounded rationality and the economic theory of rationality are contrasting theories of behavior, based on different research programs and conflicting academic perspectives. Rationality is the mainstream program, based on traditional or neoclassical economics, while bounded rationality is

an alternative theory based on the interdisciplinary work of Herbert Simon. However, they are similar in that both models of decision-making that can be applied to several aspects of the economy such as firms, consumer behavior, economic policy or as a framework to value environmental goods. It is the underlying assumptions or aspects of these models that make them different, and this will be the focus of this section.

This section will develop a conceptual framework for this theory using a comparison/contrast approach. Several aspects of both models will be examined for similarities and differences such as: their general approach; assumptions about cognitive abilities, and whether preferences are formed or constructed. By doing this, this section will build a *working definition* for bounded rationality that can be utilized for this thesis, and the contingent valuation experiment.

The central argument of this thesis is that behavioral anomalies frequently observed in contingent valuation studies are better understood using bounded rationality as the framework, so this section will be pivotal in setting the context for this argument. As such, the explanation in this section will rely on liberal use of examples drawn from the contingent valuation literature. Finally, the structure of this section will be organized according to Table 2.1 where five aspects of bounded rationality will be compared and contrasted to how these same aspects are treated by the mainstream theory of rationality.

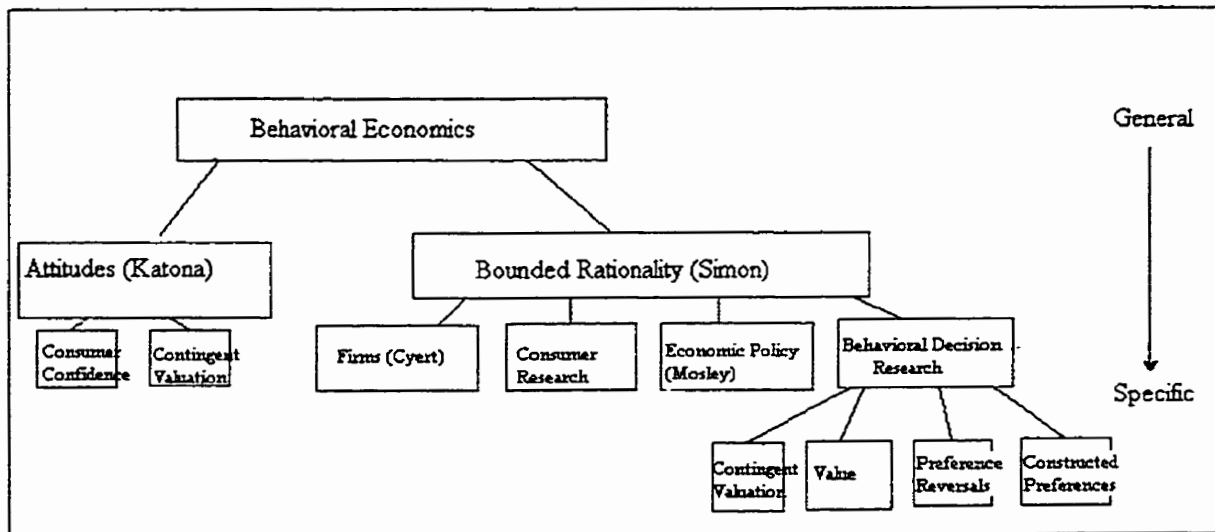
**Table 2.1 Comparison/Contrast between Conceptual Frameworks for Bounded Rationality and Rationality**

Aspect of Framework	Bounded Rationality	Rationality
Single or Interdisciplinary Approach	Utilizes two disciplines: psychology and economics referred to as "Behavioral Economics"	Economics only
Cognitive Abilities	Cognitive limitations of decision-makers, in complex world	Implicit assumption that agents have clarity of thought
Preferences	People have difficulty forming preferences: must utilize heuristics or other mental short-cuts to form or construct preferences	Preferences formed according to consumer choice theory
Satisficing versus Optimizing Behavior	People "satisfice" or are satisfied with intermediate goals	Optimal outcomes
Value	Theories of basic and articulate preferences: labile values	Values are theoretical construct: stable values

### 2.3.1 Single or Interdisciplinary Approach

A defining feature of bounded rationality is that the approach is interdisciplinary, drawing on both psychology and economics. Bounded rationality is part of a larger research program called *behavioral economics*, which includes work that attempts to integrate these two fields (See Figure 2.1).

Work in this program can be roughly divided into two main areas: work on attitudes that has been led by Katona et al (1953, 1957, 1963, 1975) and work that is based on the theory of bounded rationality, which was developed by Simon (1958, 1959, 1982, 1986, 1992, 1995). As can be seen from this schematic, work on attitudes has mostly centered on Katona's empirical analysis of consumer confidence, and its relationship

**Figure 2.1 Behavioral Economics Research Program**

to aggregate output. Katona developed an *index of consumer sentiments* during the 1950's and 1960's which has, in recent years, been adapted to construct numerous indexes of consumer confidence. The contingent valuation field has also done interdisciplinary work on attitudes (Ajzen 1992, McLelland 1997). These studies investigate whether attitudes are a good predictor of willingness-to-pay, and the meaning of willingness-to-pay from this perspective.

On the bounded rationality side of the behavioral economics program, work has been more extensive. There has been considerable work in consumer research (Bettman and Park 1991, Coupey 1994) that investigates the use heuristics and other strategies when people make decisions to purchase consumer goods. There has also been work by Cyert and March (1963) on firms and analysis by Mosley (1976) on economic policy using bounded rationality. Probably the largest extension of bounded rationality has been the behavioral decision research (BDR) program (See Section 2.3.3). Although this program encompasses several fields, it has done extensive work

on the border of economics and psychology in areas such as constructed preferences (Payne, Bettman and Johnson 1992); the study of preference reversals (Lichtenstein and Slovic 1971, 1973) and on the meaning of value (Fischhoff 1991). The similarity between the work in the BDR program and contingent valuation has led many of these psychologists (Kahneman et al 1993, Tversky et al 1988) to provide commentary on CV research, and do experiments using the BDR approach.

One of the advantages of using a behavioral approach, over an approach grounded solely in economics, is that it brings to the fore numerous methodologies and concepts used and developed by psychologists this past century, and applicable to contingent valuation. For example, experimental research techniques such as protocol analysis and psychological testing have been adapted for contingent valuation. The behavioral approach also focuses on analysis of the cognitive capabilities of respondents which is useful for understanding anomalous results of these experiments.

By comparison, rationality is grounded in neoclassical economics which has separated itself from psychology this past century. Katona (1963) speculates this separation occurred because psychology has historically focused on abnormal behavior, and that it was difficult to measure psychological factors. In recent years, advances in the above mentioned BDR field and psychological testing and attitudes (Anastasi 1988, Friedenberg 1995) have made behavioral factors more relevant to economics, and easier to quantify.



### 2.3.2 Cognitive Abilities/Complexity of World

One of the core assumptions of bounded rationality is that individuals have limited, or incomplete cognitive abilities, and that they live in a world full of complexity. Bounded rationality emphasizes *external constraints* (Sent 1997) - the massive amount of information individuals contend with, nowadays from advertising, television and the internet - and the inability of people to make sense of that information because of *internal constraints*: limits to their knowledge and computational capabilities. This compares to rationality, where individuals or consumers are assumed to have clarity of thought: they are able to choose between commodity bundles, or know if they are indifferent (completeness) - and the world around which those choices are made is generally not a consideration. The other major difference, in this respect, is that rationality focuses on the *outcomes* of decision-making as a theoretical construct, whereas bounded rationality focuses on the *actual cognitive process*: what sort of information-processing individuals are doing, and why.

Simon et al (1986) explained these *limits* to rationality in an essay on decision-making that critiqued orthodox rationality:

These limits are imposed by the complexity of the world in which we live; the incompleteness and inadequacy of human knowledge; the inconsistencies of individual preference and belief; the conflicts of value among people and groups of people and the inadequacy of computations we carry out; even with the aid of the most powerful computers. (Referring to rationality)<sup>10</sup>...the real world of human decisions is not a world of ideal gases, frictionless planes or vacuums. (p.3)

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<sup>10</sup> words in paranthesis are my own.

This assumption is relevant for contingent valuation of environmental values because almost all the amenities that are valued such as cleaner air and water; or improvements to natural habitats, are highly complex goods and services. Further, these goods are not traded in markets so people have little prior experience or knowledge from which to draw.

Using water as an example, people may have a general understanding of what water pollution is, and how pollution can kill fish, or close beaches, however, the complexity of this amenity means it is difficult to precisely tell respondents what they are to value. The result has been the evolution of a variety of techniques to deal with this complexity, by reducing the information load to a manageable level. One such technique that is frequently used is a visual aide called a *water quality ladder*, (Carson 1993) in which water quality improvements are displayed as a series of understandable uses: boatable, fishable and swimmable. Another technique has been to develop detailed scenarios in the questionnaire. For one, (Crutchfield, Cooper and Hellerstein 1997) respondents are asked to place a value on a household device put on taps that would eliminate nitrates in drinking water. Thus although the theoretical development of these studies has used rationality, there has been a tacit recognition that there are problems with cognitive limitations, and that the research design must address this deficiency.

### 2.3.3 Constructive Preferences

Many of the psychologists who critique contingent valuation belong to a loosely-knit research program known as behavioral decision research (BDR). Since the early 1980's, this program has conducted extensive experimental research into cognitive processes that occur when people make decisions such as during negotiations, experimental markets, problem solving and learning. It is an interdisciplinary field "employing concepts and models from economics, social and cognitive psychology, statistics and other fields," (Payne, Bettman and Johnson 1992). An important part of this program has focused on the study of how people form preferences, such as for consumer goods, or gambles. Lately, BDR has been extended to contingent valuation by Kahneman and Knetsch (1992) who have studied *embedding*; Ritov et al (1993) for a study of *reference points*, and Irwin et al (1993) for a study on preference reversals, and numerous other studies.

Unlike economics, BDR uses bounded rationality to model behavior. The link between the research program and Simon's theory is attributed to one of his understudies, March (1978) who argued that limited cognitive abilities prevent individuals from forming preferences consistently, as assumed by rationality.

Human beings have unstable, inconsistent, incompletely invoked, and imprecise goals at least in part because human abilities limit preference orderliness, (p.598).

The result of this extension is the idea of *constructive preferences* which assumes preferences for objects<sup>11</sup> of any complexity are not revealed, as rationality assumes, but are gradually constructed using a wide variety of mental short-cuts called heuristics, and strategies. BDR research indicates that decision-makers have a “repertoire of methods for identifying their preferences and developing their beliefs,” (Payne, Bettman and Johnson 1992). This compares to rationality which assumes people have preferences that are complete and transitive. As an outcome of a theoretical model, (consumer choice theory) people are assumed to be able to choose between two commodity bundles, or know if they are indifferent, (completeness). Furthermore, people are able to consistently order a series of commodity bundles (transitivity) according to their preferences.

Slovic (1995) notes that preference construction is normally associated with more complex or unfamiliar choices such as gambles, jobs, careers, homes, automobiles - *and environmental amenities*. Using a simple example, Slovic explains that the mechanism of consumer choice theory is analogous to preferences being read off a *master list*. By comparison, preference construction is done by an adaptive decision-maker over a period of time: there is considerable information-processing done prior to buying a complex good, (home or automobile) choosing a job, or placing a bet.

Slovic (1995) notes that constructive processing can take a variety of forms including:

...anchoring and adjustment, relying on the prominent dimension,  
eliminating common elements, discarding nonessential differences,

---

<sup>11</sup> An object is a term used by psychologists for anything that is the focus of a decision. For the purposes of this study, an object is usually an environmental amenity such as a change in air or water quality, a consumer good or a gamble.

adding new attributes<sup>12</sup> into the problem frame in order to bolster one alternative, or otherwise restructuring the decision problem to create dominance and thus reduce conflict and indecision, (p.369).

The BDR program has been an inductive exercise in which the central focus has been experiments performed in a controlled laboratory setting. An integral part of this program was a series of experiments conducted by Lichtenstein and Slovic (1968, 1971, 1973)<sup>13</sup> that demonstrated a behavioral anomaly named *preference reversals* for two bets of similar expected value. These experiments and related hypothesis are covered in chapter 3.

#### 2.3.4 Satisficing Versus Optimizing Behavior

An important component of the theory of bounded rationality is the notion of *satisficing* developed by Simon (1958, 1959, 1963, 1966). This notion is tied to psychological theories that suggest the motive to act stems from a drive, and that an action terminates when the drive is satisfied. The conditions for satisfying that drive are not fixed but may be "specified by an aspiration level that itself adjusts upward or downward on the basis of experience," (Simon 1963). Thus instead of being optimizers as prescribed by economy theory, Simon hypothesizes people are driven by variable aspirations and are satisfied with intermediate goals.

To compare the two theories, economics assumes the decision-maker has a hypothetical starting point from which all the alternatives are explored until an optimal

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<sup>12</sup> An attribute is one aspect of an object. For a consumer good this could be the color, quality, special features such as the engine-type in a car, as well as price.

<sup>13</sup> For the experiment done in 1968, Slovic's name appears first in the citation.

*outcome* is achieved. Satisficing, on the other hand, focuses on *process* and emphasizes the limited capacity of individuals to explore alternatives: people examine a select few which make sense, and then halt the search when an alternative is found which is satisfactory. As such, decision making is viewed as a process of being either satisfied or unsatisfied in which the boundary between the two is blurred. Being unsatisfied is what motivates an individual to act, and those actions continue until the satisfied state of mind is re-attained. In a contextual discussion of rationality, Simon (1958) suggests that people satisfice because "the number of alternatives he must explore is so great, the information he would need to evaluate them so vast that even an approximation to objective rationality is hard to conceive," (p.79)

Applying the notion of satisficing to heuristics, Simon (1992) notes that a heuristic can be viewed as a technique to manage the information when presented with a large number of alternatives, or complex alternatives, that are difficult to process. These heuristics govern the process of information gathering and choosing satisfactory alternatives. Simon links the two as such:

...the selectivity of the search, hence its feasibility, is obtained by applying rules of thumb or heuristics, to determine what paths should be traced and what ones should be ignored. The search halts when a *satisfactory* solution has been found, almost long before all alternatives have been examined, (p. 4).

Tying this back to the discussion in this chapter thus far; the main constraint faced by decision-makers when valuing environmental amenities such as air or water quality is not the number of alternatives but the complexity of those alternatives. Faced with goods that are unfamiliar, and lacking prior knowledge, respondents apply rules-of-thumb such as utilizing the prominent attribute or matching strategies to construct

preferences. In this context, the valuation process can be viewed as a satisficing exercise in which the respondent uses heuristics to select a satisfactory alternative such as a certain choice, or a dollar figure when asked for a willingness-to-pay. *Anomalous* results may occur if the satisfactory outcome is to simply choose any number (Schkade et al 1994) or to focus on a starting point (Desvousges et al 1987, Mitchell and Carson 1989). In order to obtain a reasonable estimate, the processing that occurs and heuristics used to satisfice should follow a *purchase model* that is an approximation of the way consumer or other goods are valued in the real world. The notion of a purchase model and issues related to experimental design will be discussed in chapters 3, 5 and 6 in the context of a discussion of protocol analysis that will be done as part of this study.

### 2.3.5 Value in Psychology and Economics

As a natural offshoot to the discussion on constructive preferences, BDR psychologists (Fischhoff 1991, Slovic 1995, Kahneman et al 1993, Tversky et al 1988 and Gregory et al 1993) have begun to formulate theories about the meaning of value. The most prominent of these was developed by Fischhoff (1991) which assumes there are a *continuum of philosophies* relevant for value formation and measurement. At one end of this continuum, is the philosophy of *articulated values* which holds that people have the ability to articulate and express values for the most diverse or complex goods, and that values are relatively stable across context and time. On the other end of the spectrum is the philosophy of *basic values*, which holds that people lack well-differentiated values for all but the most familiar goods or amenities, which they have experience with through “trial, error and rumination, to settle on stable values,”

(Fischhoff 1991, p. 835). At this end of the spectrum, people are thought to have *labile*<sup>14</sup> values, or values that are unstable across context and time. Between the ends is the philosophy of *partial perspectives*, which holds that people have stable values for goods of moderate complexity, for which there is an advanced starting point to begin constructive processing. This philosophy holds that people's values are partial or conditional: the values evoked in a contingent valuation experiment, for example, may be a limited subset of the respondent's value because of the complexity of environmental goods. Because values are partial, Fischhoff (1991) advises that experimental techniques may be required to evoke values and recommends using "naturally occurring situations."

BDR psychologists argue economists assume articulated values, meaning people are expected to have stable values for all goods, including a diversity of complex goods such as environmental amenities. This is consistent with the model of rationality which assumes, as a theoretical outcome, people have stable preferences that are complete and transitive.

By comparison, most BDR psychologists are proponents of the philosophy of basic values. Kahneman et al (1993) argues that experiments on constructive preferences provide evidence of lability of preferences and susceptibility to framing<sup>15</sup> effects. "The implication is that many outcomes (for environmental amenities)<sup>16</sup> are associated with

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<sup>14</sup> The word *labile* is used frequently by psychologists to describe unstable or changing in the context of valuation formation. Many psychologists assume people's values, especially for complex environmental goods, are not stable and change for a variety of reasons: intertemporal, if the type of question posed on a contingent valuation survey changes, and other reasons related to context.

<sup>15</sup> Framing is the context or general way a question put to a respondent, such as: wording, choice as opposed to a number, the order the question is in the survey; whether the elicitation procedure uses iterative bidding or is open-ended, or other aspects of context.

<sup>16</sup> My note in parenthesis.



preferences so labile that the assumption of a *true* value become untenable,” (p.311). Fischhoff (1991) suggests that refusals or protest responses during contingent valuation elicitation show how respondents “having only basic values cope with pressure...” (p. 841). Gregory et al (1993) relates to this continuum by suggesting that people may be able to articulate values for goods for which they have a high level of market experience such as groceries. However, as one moves to more complex goods such as appliances, automobiles, and homes; market experience lessons and the ease of representing preferences monetarily declines. Relating this model to environmental amenities, Gregory et al (1993) argues that:

For goods such as air or water quality, wilderness areas, endangered species, and many other elements of the natural environment, the market no longer applies, and the link between values and money becomes tenuous - so tenuous that it may not exist. Thus, we can have strongly held values that are not coded mentally in terms of dollars. Attempts to translate such values into monetary equivalents must take special cognizance of this problem, (p. 181).

The upshot of this discussion is that it is probably too early in this debate to make any firm arguments about the application of these “philosophies” to contingent valuation. Only a few contingent valuation experiments have been conducted (all in the 1990’s) from the BDR perspective, and there is a need for a greater diversity of investigation before we can begin to understand value from this vantage point. For the purposes of this study, it will be assumed that the philosophy of *partial perspectives* holds – in other words, people are assumed to be in the middle of this continuum between labile and stable values. It will also be assumed that the research design will be able to influence the way people construct values: emphasis on simplification and familiarity through the

use of a “Shopping Experience” scenario should facilitate value construction for the relatively complex water quality amenity which is the focus of this study.

### **2.3.6 Working Definition of Bounded Rationality**

The purpose of section 2.3 was to develop a *working definition* of bounded rationality. This subsection will provide a summary of that definition.

In a general sense, bounded rationality is a model of decision-making that can be applied to several aspects of the economy such as consumer behavior, firms, economic policy, or as a framework to value environmental goods. It is an interdisciplinary theory, drawing from both psychology and economics, and part of a larger research program called *behavioral economics*. Practitioners of bounded rationality research focus on observation of actual cognitive processes.

Two of the core assumptions of bounded rationality are that individuals have limited cognitive abilities, and that they live in a world full of complexity. Because of this, individuals have difficulty forming preferences consistently. Instead, they are assumed to construct preferences for objects of any complexity, including environmental amenities, using a variety of mental short-cuts called heuristics and strategies. The selection and use of heuristics can be viewed as a type of satisficing, in which decision-makers are driven by variable aspirations and satisfied with intermediate goals. Heuristics govern the process of information gathering and choosing satisfactory outcomes.

Finally, individuals are assumed to have stable values for goods of moderate complexity for which they have some real-world experience. However, people’s values

for complex goods such as environmental amenities are partial or incomplete, and experimental techniques may be required to evoke values. This viewpoint is known as the philosophy of partial perspectives.

## 2.4 Applications to the Economy and Government

Although bounded rationality has had an impact on consumer research (Bettman and Park 1980 and Coupey 1994)<sup>17</sup> and the field of behavioral decision research, applications of Simon's theory to the economy and government have been quite sparse. Of note are three streams of research: i) Cyert and March (1963) and their extension of bounded rationality to firms; ii) work by Cohen, March and Olsen (1988) on administrative organizations, and iii) the use of *satisficing* by Mosley (1976) to explain the way economic policy is formulated by governments..

This interpretation of the literature may be somewhat narrow, however, as Conlisk (1996) argues that many mainstream economic models “allow for bounded rationality” such as the idea of X-efficiency developed by Leibenstein, (1966); and the notion of imperfect information in organizational theory, (Schmalensee and Willig 1989) and others. These models develop a less informed rational agent, and to some extent, respond to the critique from bounded rationality. However, while these models may pick-up on aspects of bounded rationality, they are in no way comprehensive applications of the theory as outlined in this chapter: inductive; interdisciplinary; cognitive limitations; heuristics etc.

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<sup>17</sup> These applications will be discussed in section 3.4 which covers protocol analysis.

. This section will first provide a brief overview of these historic applications of bounded rationality to firms, administrative organizations and economic policy.

#### **2.4.1 Firm-level Applications**

The work on firms was conducted by Cyert and March (1967) for a project that made extensive use of computer simulations. The main conclusion of this empirical work is that firms generally do not maximize profits as a central goal -- but instead have a series of other/related goals for which they set targets and seek satisfactory results. These related goals (besides profit) are commonly: levels of sales; market share; the size of the firm or level of inventory. As part of the everyday management of a firm, each of these goals becomes the concern of certain managers, and these managers press their particular goal within the organization (Pass et al 1991). As such, these goals become the subject of bargaining amongst managers, and the overall goals of the organization that eventually emerge are compromises, often stated as satisfactory-level targets. For example, a conservative store manager may argue with an expansionist sales manager about what the satisfactory level of inventory should be (Mosley 1976). Although these models enrich the understanding of decision-making within firms, analysis beyond their gates is sparse. Questions about how these satisfactory targets affect equilibrium or other market outcomes have not been adequately addressed. For example, Simon (1959) speculated that a market comprised of satisficing firms would tend not to reach long-term equilibrium, and the size distribution of firms in actual markets could be better explained by bounded rationality.

### 2.4.2 Administrative Organizations

Cohen, March and Olsen (1988) developed a unique application of bounded rationality to administrative organizations, using universities as an example. For their case study, this research team used a computer simulation of the decision-making process made by various departments, groups and people within a university. The conclusion of this exercise was quite different than for firms or government which have a series of satisfactory goals for which they strive. Lacking any specific direction, Cohen et al argue that some administrative organizations behave in a manner resembling a *garbage can*, in which there is a *stream* of problems that are “dumped into a can” which, in turn, generate a corresponding stream of choices and solutions. Concurrent to this, there is a stream of energy from participants that is available for decision-making.

The outcome of this model is an organized anarchy in which problems are frequently not resolved. However, this type of model is only applicable to organizations of a certain type such as universities, which have unclear goals and fluid participation by many people for the same choice problem. Missing from this analysis, however, is the fact that academics who run universities are not concerned about administrative efficiency. A better model for universities might encompass satisfactory goals related to teaching or research, goals for which academics *are* concerned with attaining.

### 2.4.3 Formulating Economic Policy

A useful application of the theory of bounded rationality is the work of Mosley (1976) who extended the notion of satisficing to economic policy formulated by governments.

The decision-makers for this application are civil servants and their political masters, and these individuals simplify their decision environment by scanning numerous indicators, such as unemployment or the growth rate, and rate them as either *good enough* (satisfactory) or *not good enough*, (unsatisfactory). If not good enough, there is reason to act, using the levers of monetary or fiscal policy to restore the indicator to a satisfactory level. Mosley (1976) suggests that:

... "satisfactory" levels of particular targets of economic policy can be seen as compromises between groups in the policy-making circle pushing in opposite directions: the target level of unemployment as a compromise between the Bank of England, concerned to preserve a margin of unused resources, and the economic ministers, fearful of their standing in parliament and around the country...(p.321)

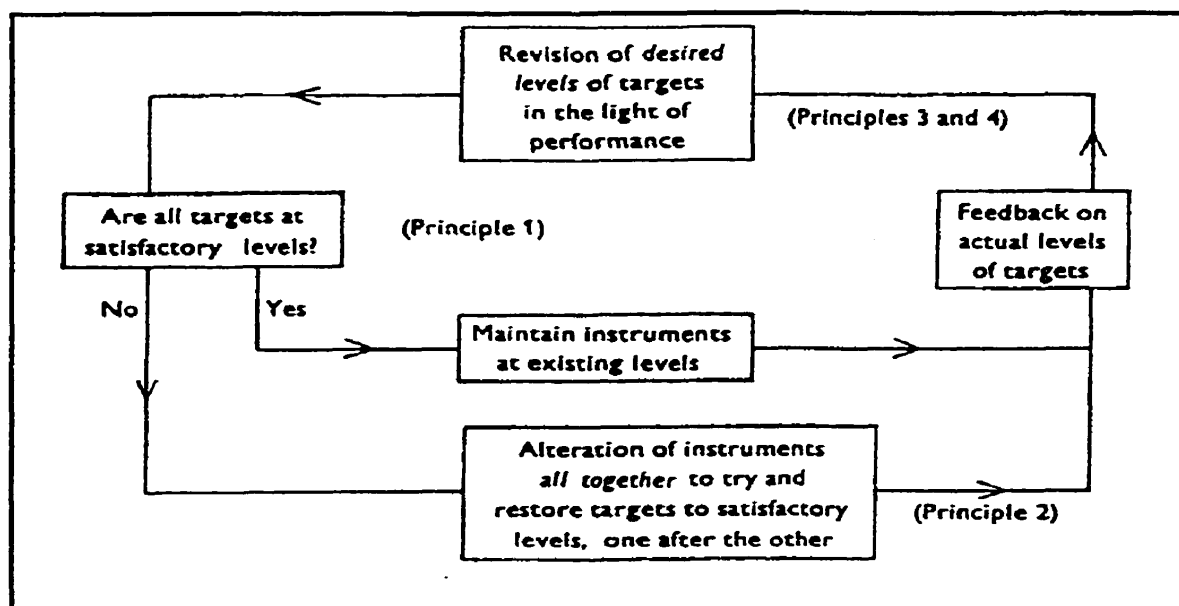
A schematic diagram (see figure 2.2) was developed by Mosley as a visual aide to explain the process of satisficing in government. As a first step, (principle 1) if all targets are at satisfactory levels (yes) then instruments are maintained at existing levels. However, if these targets are not satisfactory (no) then instruments are altered to restore indicators to satisfactory levels. Part of this loop is a feedback on the actual levels of targets to policy-makers, who assess the performance of instruments.

For the empirical part of this study, U.K. data on fiscal measures such as taxes, and monetary measures such as the bank (interest) rates were assessed for the period 1946-71. Results of the study confirmed Mosley's hypothesis, which he represented mathematically in equation 2.1

$$\text{Equation 2.1} \quad \Delta X_{i(t)} = \alpha + \beta(y_i - y_i^*)_{(t-k)}, \quad \text{when } y_i < y_i^*$$

where  $X_i$  is any instrument;  $y_i$  is any target;  $y_i^*$  is its desired value, and  $k$  is an empirically determined lag. For this equation, the inequality can be reversed if the target variable must fall.

**Figure 2.2 Circular Flow Chart of Government Decision-Making  
Assuming Bounded Rationality**



Source: Mosley (1976)

Using the "circular flow" framework for the problem of Winnipeg drinking water quality addressed in this thesis, (see chapter 4) the desired target is good quality or healthy drinking water. Up until the late-1980's, tap water quality in Winnipeg was perceived to be in the satisfactory range, that is, residents felt drinking water was safe and, and there were no warnings from health officials. In the early 1990's, however, there were numerous complaints from residents about poor taste caused by algae blooms, and related warnings from health officials about the cryptosporidium

parasite, and chlorine by-products that are linked to cancer. As a result, municipal officials and city councilors saw the desired target (good water quality) as unsatisfactory, and began to use instruments to try to restore this target. The city's first step was to commission a study by Wardrop Engineering (1994) to assess the problem, and then it took steps to create a reserve to finance a water treatment plant. However, funds were apparently drawn off this reserve to lower taxes (Ward 1999) and the start date for construction, as a result, was set back from 2002 to 2007.

One of the reasons for this delay may be related to the *feedback on actual levels of targets* (See Figure 2.2). Although there have been warnings about algae blooms and the cryptosporidium parasite, city officials and councilors may not perceive the quality of city tap water to be "unsatisfactory" enough to warrant swifter action. This could be explained within a boundedly rational framework: because decision-makers have cognitive limitations, it may be difficult for city officials and councilors to interpret a myriad of water quality problems, and whether these translate into unsatisfactory water quality or not. On a different level, these indicators have all been physical or biological which may restrict the information flow to decision-makers. A contingent valuation study enters this schematic as additional feedback, providing a dollar value for higher quality water. As well, an attitude survey done as part of this study also provides feedback to help decision makers determine whether water quality is satisfactory or not.



## **CHAPTER THREE**

### **LITERATURE REVIEW: BEHAVIORAL ANOMALIES**

#### **3.0 Introduction**

This literature review will be an overview of behavioural anomalies observed in contingent valuation studies. The anomalies covered are preference reversals, embedding, starting point bias, and anomalies observed during protocol experiments. As an introduction, the first section will provide a brief historical overview of contingent valuation.

#### **3.1 Contingent Valuation: An Overview**

Although Ciriacy-Wantrup (1947) made the first reference to a valuing public goods using a technique that would ask people directly, it was Davis (1963) who designed and implemented the first contingent valuation study to estimate the value of outdoor recreation in the Maine Woods.

Since then, there has been a steady growth in the number of studies and applications for contingent valuation with most of this research centred in the United States. In recent years, numerous Canadian researchers (Adamowicz et al 1994, Boxall 1995) have contributed to the development of the CV methodology.

Contingent valuation uses a direct approach to value public goods: surveys are usually mailed out to people and they are asked their willingness-to-pay for an environmental good, such as an improvement in water or air quality, or the preservation of a recreational area or habitat. The word contingent is used because markets do not exist for environmental goods so, as part of the survey design, an imaginary or contingent

market is constructed.

One of the advantages of contingent valuation is that it can be used to estimate existence values (Krutilla 1967) which are values people have for a good based on simple knowledge that it exists. These values for pristine lakes and wilderness in Canada are thought to be quite substantial. A second advantage is its flexibility to measure a wide variety of environmental amenities. Revealed preference<sup>1</sup> techniques such as the travel cost and hedonic price methodology are constrained by the collection of market data (housing prices, recreational costs) that can be used to impute environmental values. By comparison, contingent valuation is limited only by the imagination of the researcher who develops the survey question.

Of note is the use of contingent valuation studies for major government policy initiatives, especially in the United States. Studies by Carson (1983) and Desvousgnes et al (1983) were commissioned by the U.S. Environmental Protection Agency in the early 1980's to support nation-wide regulations to clean-up water resources. A decade later, the National Oceanic and Atmospheric Administration (NOAA) commissioned contingent valuation studies to assess the damage from a major oil spill by the Exxon Valdez in Alaska. A follow-up report by the NOAA developed comprehensive guidelines for use of contingent valuation.

Despite these inroads, contingent valuation continues to be controversial. In a brief

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<sup>1</sup> There are two general classes of methods to value environmental goods: stated preference which includes methods such as CV and conjoint analysis in which people are asked their willingness-to-pay directly. By comparison, revealed preference methods impute environmental values from market prices associated with environmental amenities, such as housing prices next to a lake or recreational site.

historical analysis of CV, economist Winpenny (1997) concedes that it is “widely acknowledged, even by the champions of CV, that survey results are often anomalous and internally consistent.” Winpenny cites the embedding problem, which will be covered in this chapter, as well as whether people lack preferences for environmental goods. The rest of this chapter will discuss these behavioral anomalies from an interdisciplinary perspective using bounded rationality as the conceptual framework.

### 3.1 Preference Reversals

The behavioural anomaly named preference reversals has been studied by psychologists since a seminal experiment by Slovic and Lichenstein (1968). More recently, several contingent valuation studies have examined these reversals (Brown 1984, Magat et al 1988, Irwin et al 1993) and replicated results by psychologists. Preference reversals are experiments in which subjects are observed to reverse their preferences for a *pair* of objects of similar value - gambles, environmental or consumer goods - when the response mode<sup>2</sup> changes. The response modes compared are usually choice and willingness-to-pay.

These reversal experiments are important because they are valuation exercises similar to contingent valuation, and therefore provide a rich source of interdisciplinary

literature that goes back three decades. Further, this literature has spawned numerous

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<sup>2</sup> Response mode is a term used by psychologists to describe the way a question is put to a subject (respondent) during an experiment. For valuation experiments, subjects can be asked to make a choice between two or more consumer goods, for example, and the response mode is choice. If a subject is asked to assign a willingness-to-pay then dollar or monetary values are the response mode.

theories about how respondents process information during valuation -- using a variety of heuristics or strategies that reduce their information load. Although the first experiments were framed as gambles, subsequent work in this field has been extended to a variety of objects including environmental and consumer goods.

Preference reversals were first observed during a series of experiments by Slovic and Lichtenstein (1968, 1971, 1973).<sup>3</sup> These early experiments were similar in form, although the degree of complexity varied. As a general rule, they were performed in two stages. In the first stage, subjects were asked to make a *choice* between two bets of similar expected value. One had a high probability of winning a small amount while the second had a lower probability of winning a higher amount. For example:

**Gamble A: 90 percent probability of winning \$8 \*(expected value \$7.20)**

**Gamble B: 20 percent probability of winning \$30 (expected value \$6.00)**

**\*expected values not shown in experiment**

When choice is the response mode, people usually prefer the bet with the higher probability. For this example, that would be gamble A.

In the second stage, the response mode is changed and people are asked to assign a dollar value or willingness-to-pay for gamble A and gamble B. During this stage, people usually assign a higher value to the low-probability, high pay-off bet (gamble B) with 40 to 50 percent of subjects *reversing* their preferences. Thus the name of the behavioural anomaly was coined based on this observation.

These experiments were repeated and confirmed by this research team several times,

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<sup>3</sup> Lichtenstein's name appears first in the citations for 1971 and 1973.

once in the Four Queens Casino in Las Vegas (Lichenstein and Slovic 1973). This latter study has been noted for its realism as it was conducted over a 10-week period on the balcony of the casino using a computer, roulette wheel, professional dealer as well as volunteers who were patrons of the casino.

Based on these experimental results, Lichenstein and Slovic (1971) drew the conclusion that:

...a gamble is a multidimensional stimulus whose various attributes have differential effects on individual decision-making behaviour. In particular, (we) presented evidence that choices and attractiveness ratings are determined by a gamble's probabilities, while bids (assigning monetary values) are most influenced by the amount to be won or lost, (p. 462).

To reiterate, they argued that respondents simplify their decision environment by picking up on various cues or stimulus -- and that these stimulus can vary depending on the response mode. If choice is the response mode, then respondents focus on probabilities, and choose gamble A over B because it has the highest percent probability. By comparison, if respondents are asked to assign a dollar value, they focus on winnings; and choose B over A because \$30 is higher than \$8.

Several experiments subsequently performed by both psychologists and economists have confirmed these results.

The first contingent valuation studies to examine reversals were by Brown (1984) and Magat et al (1988). Brown (1984) found that subjects chose consumer goods such as

stereos and bicycles over environmental amenities such as air quality when they assigned dollar amounts -- however, when they rated responses using a scale, most respondents gave higher ratings to the environmental goods. Magat et al (1988) used morbidity risk reduction from chemical products as the environmental amenity and found similar results to Brown. (The reduction in risk was a 50 percent decrease in gas poisoning from a new bleach product). When confronted with a *choice*, or non-monetary decision, subjects preferred the environmental good in paired comparisons with consumer goods. However, when told to assign dollar values to the goods, respondents preferred the consumer goods.

Although this study was not done by psychologists, Magat et al (1988) nevertheless drew conclusions that would be consistent with a bounded rationality framework. They said the results:

...could be explained by a decision process simplification strategy that uses primarily one piece of data (the percentage reduction in injuries) because of the difficulty of consumers to comprehend rates composed with such large denominators, (p.408).

A third study by a research team of psychologists led by Irwin et al (1993) tested reversals using a reduction in Denver air pollution, or "Brown Cloud." as the environmental amenity, and improvements in cameras and TV sets as the consumer goods. For the first part of the study, a random sample of residents from the Denver Metro area was divided into two statistically similar groups. Group one (n=122) was mailed a version that asked *dollar value* or willingness-to-pay questions whereas group two (n=126) were asked to make *choices* between goods.

Using detailed photos, *group one* respondents were asked their willingness-to-pay for

a camera and a TV set, and then improvements to those consumer goods. Next, respondents were shown two pictures of a winter day in Denver - one with a greater amount of air pollution than the other - and they were asked how much more they would be willing-to-pay per annum to improve air quality.

*Group two* respondents were given the same photos but were asked to make *choices* between improved air quality and improvements to both consumer goods.

The result was that a preference reversal was demonstrated, although it was weak during this stage. For the cameras, 92 percent preferred air quality over the consumer good in the choice mode whereas 71 per cent preferred air quality in the WTP mode. For the TV sets, 83 per cent preferred air quality over in the choice mode as compared to 60 percent in the WTP mode.

The reason cited by researchers for the weakness of this reversal was the two goods - the air quality amenity, and improvements to the consumer goods - did not have similar values. During the final stage of the study, adjustments were made to increase the value of the consumer good improvements so they were more in line with the amenity: a VCR was added to the TV and a printer was added to the computer as the improvements. As a result of this change, the preference reversal was stronger. For the *choice mode*, air quality was chosen both times: 81 percent of subjects preferred this amenity over the printer, and 74 percent chose air quality over the VCR trade. In the WTP response mode, the consumer goods were preferred: 71 percent of subjects reported a higher willingness-to-pay for the printer when compared to air quality, and 76 percent had higher willingness-to-pay values for VCR's when compared to improved air.

### 3.1.1 The Prominence and Compatibility Effects

Two theories have emerged to explain preference reversals: the prominence effect, which has been attributed to Tversky et al (1988) and the compatibility effect, which has been elaborated by Slovic (1995).

i) The *prominence effect* supposes that when people make a *choice* between two goods, the prominent attribute stands out rather than the price. As well, the decision-making process when choices are made is thought to be complex and driven by qualitative-type internal (lexicographic) arguments and reasons about this prominent attribute.

For the gamble experiments by Slovic and Lichtenstein, (1968, 1971, 1973) the prominent attribute is thought to be *probability*, therefore respondents usually choose the first bet as the more attractive because it has a higher probability of winning. For the contingent valuation experiments, (Irwin et al 1993, Magat et al 1988 and Brown 1984) the prominent attributes of the environmental amenities (air quality in Denver or chemical pollution) form the basis of more compelling reasons or internal arguments than the attributes of the consumer goods, the VCR and printer. Thus these attributes are used primarily to construct preferences. This explains why these amenities are chosen over consumer goods when choice is the response mode.

ii ) The *compatibility hypothesis* explains why respondents choose the second bet in the gamble experiments when asked to assign a dollar value. Slovic (1995) reasons that subjects construct preferences using a type of heuristic that is compatible with the response mode, which is a dollar value. Subjects focus on the dollar-value pay-off of



the second bet which is much higher, \$30 as compared to \$8 for the first bet. Similarly, for the contingent valuation studies, one explanation is that respondents more readily associate money with consumer goods – as opposed to environmental goods, which are not priced in markets. That is why they consistently choose consumer goods over air quality when asked for their willingness-to-pay.

### **3.2 The Embedding Effect**

The embedding effect, or magnitude insensitivity as it has also been called, is another behavioral anomaly that has been observed in contingent valuation studies since a study by Kahneman (1986) on fishing stocks in Ontario. Embedding is the inability of respondents to differentiate between various levels of provision of an environmental amenity or consumer good. For example, respondents have been observed to assign *similar* values to clean-up one lake when compared to several. As well, the word embedding refers to the design of these experiments. The lower level of provision (one lake) is said to be embedded in the larger level: several lakes or the lakes in an entire province. This type of embedding varies geographic area. Others vary levels of risk or the amount of consumer goods.

Unlike preference reversals, this anomaly was first observed in contingent valuation studies – as a result, it has no history in the psychological literature. It has been a source of intense debate in the contingent valuation literature because the anomaly has practical implications: government policy makers may wish to know the value of environmental changes for different geographic areas, population sizes or magnitudes of risk. Problems with embedding have put in question the usefulness of contingent

valuation for delivering defensible estimates.

The first experiment on embedding was done by Kahneman (1986). It was a contingent valuation study on the preservation of fish stocks in Ontario lakes. In this study, it was observed that respondents' willingness-to-pay to preserve fish stocks in *all* of Ontario was only slightly higher than a small fishing region called Muskoka.

A second, more detailed study Kahneman and Knetsch (1992) was done to test these findings more rigorously. For one experiment in this study, fourteen pairs of public goods were constructed with each pair consisting of two goods, one embedded in the other. As an example, one *part*<sup>4</sup> public good was to ask respondents their willingness to pay to "improve literacy of recent adult B.C. immigrants" while the *whole* public good was to improve the literacy of all adults in B.C. Another embedded good was the willingness-to-pay for breast cancer research, or research on all forms of cancer.

As part of the experiment, the team tested a hypothesis that contingent valuation can be understood as eliciting a sense of moral satisfaction or a *warm glow* from subjects, and that this is the underlying cause of embedding. The notion of *warm glow* supposes that during elicitation respondents mimic a voluntary contribution to an environmental cause based on their moral feelings towards it. Thus instead of assigning a dollar value to the good, respondents mimic contribution to a charity such as third world aide. This contribution is closely tied to a monthly budget for making donations so the willingness-to-pay (or charitable contribution) changes little once an initial amount is elicited.

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<sup>4</sup> The embedding effect is also referred to as the part-whole effect, (Mitchell and Carson 1989) hence the term *part* in this context refers to the partial or embedded good

For the study, a telephone survey was performed on a random sample of residents (n=241) in the Vancouver region, with respondents divided into four equal-sized and statistically similar groups. Using an *open-ended* elicitation method, groups one (n=60) and two (n=61) were asked to judge their moral satisfaction from contributing to fourteen causes, using a ten-point attitude scale. Groups three (n=61) and four (n=60) had the valuation question, and it asked the most respondents would be willing to pay for a series of embedded public goods, such as literacy, cancer, acid rain and 11 others.

Results were reported for two aspects of this experiment:

i) **Moral Satisfaction:** for the moral satisfaction testing, high correlations between group one moral satisfaction ratings and group three median willingness-to-pay bids (0.78 and a p-value <0.01) were reported. A similarly high correlation was found (0.62 and a p-value <0.02) between group two satisfaction ratings and group four bids. Based on these statistical results, Kahneman and Knetsch, (1992) concluded this study supports the proposed interpretation of willingness-to-pay for public goods as an expression of willingness-to-pay to acquire moral satisfaction by mimicking a charitable contribution.

ii) **Embedding:** The results of the embedding exercise, however, were less conclusive. One public good that tested magnitude insensitivity for reduced acid rain in Muskoka, Ontario, as compared to all of eastern Canada showed statistically different mean bids: \$40.91 for the part good versus \$214.55 for the whole good. Similarly, a question that elicited improved sport fish stock in B.C. fresh water (part good) as

compared to all of Canada also had statistically different mean bids: \$41.89 as compared to \$147.16.

The public goods that did have problems were those that appeared to evoke this sense of moral satisfaction. A question that compared famine relief in Ethiopia (part good) versus all of Africa had a higher mean willingness-to-pay for the part good: \$157.67 for Ethiopia compared to \$72.68. There were similar anomalous results for breast cancer as compared to all forms of cancer, and others in the fourteen scenarios presented to respondents.

These anomalies are an indication that the information-processing that occurred during these elicitations was related more to the symbolic nature of the good, (Mitchell and Carson 1989) than to the good itself. Respondents assigned a distorted (high) value for the partial public goods based on a mental picture they had retrieved from their long-term memory: a starving Ethiopian child, or a women with a cancerous breast tumour. By comparison, the more general, whole goods - all forms of cancer, or famine relief in all of Africa - evoked little symbolism, and so there was less distortion and hence lower values. These results are similar to the preference reversal experiments where it was demonstrated that respondents simplify their decision environment by picking up on various cues, or stimulus in the response mode. For reversals, it was numbers or probabilities that were the cues, whereas for these embedding experiments, respondents appear to pick-up on the symbolic nature of certain public goods, especially ones that are framed as charitable giving to a well-known cause.

Since these early experiments by Kahneman and Knetsch numerous studies have been conducted to either prove or disprove the existence of embedding, (Diamond et al 1993,

Frederick and Fishhoff 1997, and Loomis, Lockwood and DeLacy 1993). Along with this empirical work, there has been discussion about the meaning of these results from a theoretical perspective (Fisher 1996, Frederick and Fishhoff 1997, Kahneman and Knetsch 1992). The last part of this section will provide a brief overview of these studies followed by an assessment using bounded rationality as the conceptual framework.

Diamond et al (1993) tested geographic embedding for a study that surveyed respondents' willingness-to-pay to preserve different combinations of the following wilderness areas in the United States: the Selway Bitterroot; the Washakie and the Bob Marshall areas. Using a telephone survey that underwent pretesting, the researchers found respondents had statistically similar willingness-to-pay bids for preservation of one, two or all of the wilderness areas, and concluded the experiment provided evidence of perfect embedding. However, Loomis, Lockwood and DeLacy (1993) contended they had limited the embedding effect in a study of forest protection in south-eastern Australia by improved survey design. They used a number of techniques such as focus-group testing, and visual aides such as drawings, graphics and maps to communicate which lands were to be preserved, and found some sensitivity to various magnitudes presented to subjects.

Psychologists Frederick and Fischhoff (1997) tested geographic embedding on a sample of students at Carnegie Mellon University using the reestablishment of the timber wolf as the public good. Using a simple verbal description of the areas: "to Maine, to Wisconsin, or to *both* Maine and Wisconsin," the researchers found evidence of perfect embedding: the median willingness-to-pay was \$20 for all three scenarios.

A second part of this study tested whether familiarity of the good would affect embedding, based on the contention by BDR psychologists that respondents construct preferences for less familiar or complex goods. For this experiment, they used common supermarket goods such as canned tuna, applesauce and toilet paper. For example, respondents were asked the “most I would pay” for four rolls of Charmin bathroom tissue, (the equivalent of a part good) as compared to twelve rolls; and their willingness-to-pay for two Duracell batteries compared to four. The results indicated that familiarity acted as a corrective measure for embedding as respondents consistently provided higher dollar values for the larger quantities. For example, the median price for two batteries was \$2.89 compared to \$5.19 for four, while the median price for four rolls of toilet paper was \$1.19 compared to \$3.45 for twelve rolls. There were similar results for the other five goods in this series.

The theoretical discussion that has flowed from these embedding results has centred on whether they can be explained by satiation effects, or by an interpretation of utility within the context of environmental goods. Arguing from a psychological perspective, Kahneman and Knetsch (1992) observed that only in the most restrictive cases would satiation explain embedding: for example, if someone consumed a large ice cream cone and was offered a second right after - where there was no opportunity for storage, resale or altruistic giving – would the willingness-to-pay for the second cone be zero. However, they argued, this restrictive case cannot be extended to environmental valuations of beautiful sites, or endangered species, where individuals cannot be expected to become satiated by providing funding for one of these in a set. Frederick and Fischhoff (1997) concurred noting:

It is difficult to believe that a clearer view 10 days out of the year would completely satisfy one's annual demand for atmospheric visibility, or that protecting the lakes in one small region of Ontario from acid rain is as valuable as protecting all the lakes in Ontario, (p. 12).

From an economic perspective, Fisher (1996) argued that embedding can be explained by the fact that utility is derived from the existence of a particular species, or preservation of a wilderness area - literally. Anything other than full preservation yields no change in utility while once preservation has been assured, utility remains constant, Fisher argues. Thus any increase in the population of a species, (as is sometimes modelled in embedding experiments) or the size of a viable ecosystem beyond a minimum viable level adds nothing to utility; marginal utility drops to zero. Fisher represented this argument graphically with a right-angled willingness-to-pay function which jumped at a point where a species survives and then flattens out after that.

As for an assessment, it will be argued these study results can be best understood within a boundedly rational framework in which embedding occurs because of cognitive limitations of individuals that result in behavioural anomalies. Using this model, embedding occurs for a variety of reasons that are dependent on the response mode used for the contingent valuation experiment. For the charitable goods constructed by Kahneman and Knetsch (1992) - famine relief in Ethiopia and breast cancer - embedding occurred because respondents constructed preferences based on the symbolic nature of the good, assigning high "values" for the partial public good based on mental pictures of the cause described in the question. As such, the respondent *satisfied* by choosing a number related to good's symbolism, instead of optimising by

searching for a value. Similarly, surveys that provided inadequate description of the different magnitudes of the environmental good (Diamond et al 1993, Frederick and Fischhoff 1997) caused embedding because respondents were unable to comprehend the various levels of provision. Thus respondents *satisficed*, in this case, by choosing similar numbers for various levels of provisions, instead of optimising by choosing higher values for a greater amounts of an environmental amenity. Finally, familiarity of the good has been shown to be important for respondents who construct preferences using a variety of heuristics (Payne, Bettman and Johnson 1992, Frederick and Fischhoff 1997). The experiment in which several common household goods were examined for embedding effects demonstrated that respondents *can* differentiate between varying magnitudes of goods if they are familiar enough, such as batteries or toilet tissue. That is, it is possible for respondents to choose an optimal strategy if the question is presented in a familiar form. Thus the argument made by Fisher (1996) that willingness-to-pay is a right angle function to the magnitude of an environmental good doesn't appear to hold. A better explanation is that embedding occurs because of the information-processing limitations of individuals: respondents often use satisficing strategies instead of searching for their true values which *do* vary according to quantity. Thus a research design that takes these limitations into account within a boundedly rational framework should be able to elicit reasonable valuations for environmental amenities.

### 3.3 Starting Point Bias

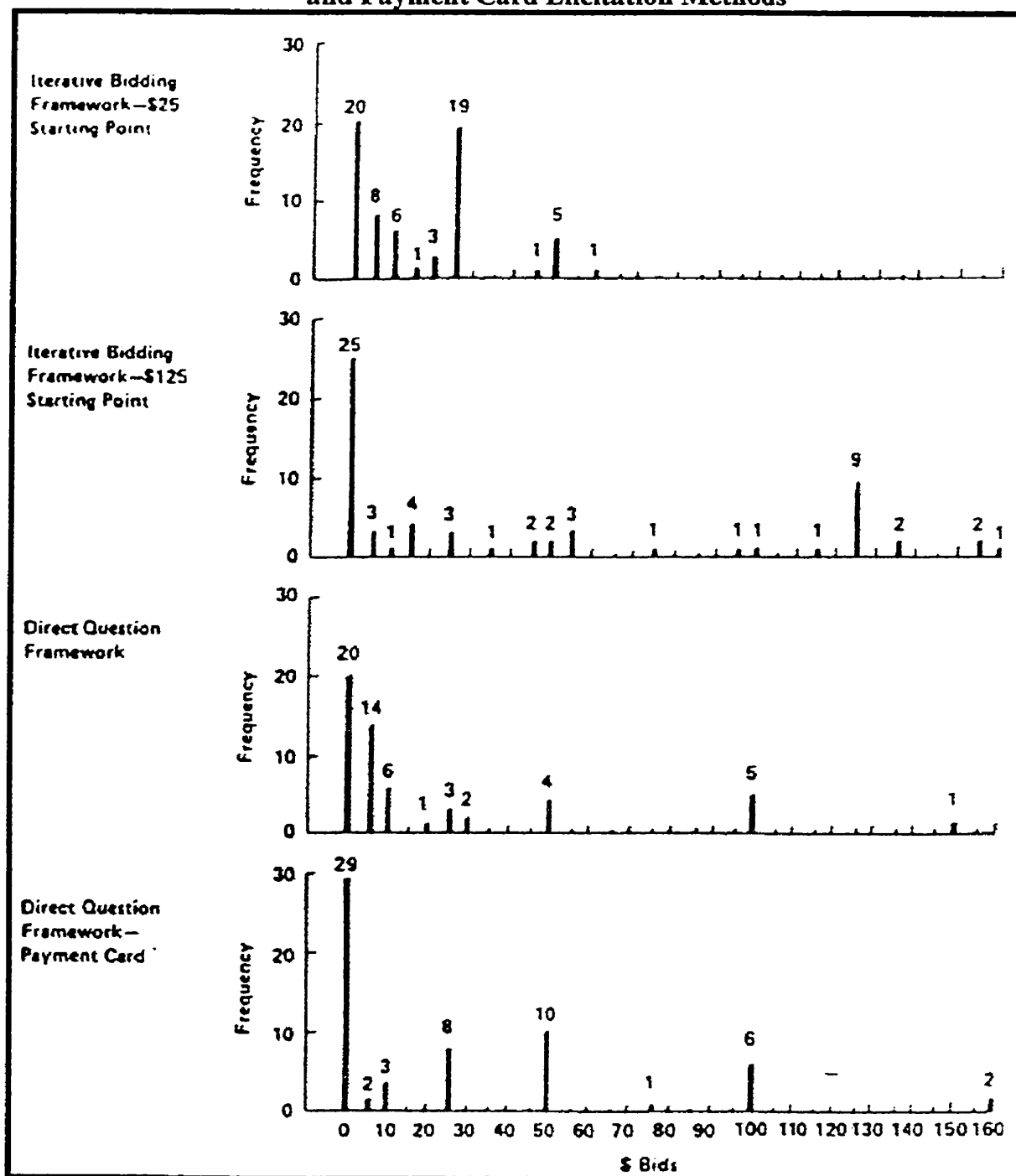
Starting point bias is perhaps one of the most pernicious of the behavioural anomalies



because it has such a pronounced affect on mean values obtained from samples, and has been difficult to correct by changing survey design. Economists Pearce and Turner (1990) define starting point bias as the “influence” of the first bid suggested to the respondent. They argue this may cause the respondent to agree too readily with bids in the vicinity of the initial bid in order to keep the bidding short. Similarly, Tietenburg (1994) argues this bias arises in survey instruments in which the respondent is asked to check off answers from a predefined range. How that range is defined by the designer may affect the answers. On the other hand, psychologists do not view starting point bias in isolation. They consider it to be part of a larger class of framing effects (Ritov et al 1993) and these will be discussed later in this section.

A seminal research project by Desvousges et al (1983) was one of the first to rigorously study this anomaly. This study was commissioned by the U.S. Environmental Protection Agency (E.P.A.) and the study site was the Monongahela River Basin located in three states: Virginia, Pennsylvania and Maryland. The research team used a visual aide called a water quality ladder for the study so water quality improvements to boatable, fishable or swimmable quality water could be more easily understood by respondents. Nevertheless, they found that changes in the first number in a series presented to respondents during an iterative bidding process had a pronounced influence on the distribution of willingness to pay bids. For example, when \$25 was the starting bid in an (n=58) sample for an improvement from boatable to fishable, there was a disproportionate number of bids at that number (See Figure 3.1). Similarly, when \$125 was the starting bid for a sample (n=48) there were nine bids for that number, even though there were none for \$125 when \$25 was the starting point. Using no

**Figure 3.1 Starting Point Bias for \$25, \$125, Direct Question and Payment Card Elicitation Methods**



Source: Desvovnges et al, 1983starting

starting point, or a direct question, (open-ended elicitation) resulted in a total of 34 bids of zero or \$5 dollars for a sample (n=51).

This problem has practical consequences because the means from the samples of these different starting points varied markedly: \$15.90 for the \$25 starting point; \$36.90 for the \$125 starting point bid, and \$17.60 for the open-ended question.

Desvousges et al (1983) did little analysis about the underlying causes of this effect except to identify it: "...starting point affects both the mean and the shape of the distribution of bids."

Another seminal project by Mitchell and Carson (1984) also commissioned by the U.S. E.P.A., estimated national water quality benefits by interviewing 813 adult heads of households at 61 primary sampling points in the contiguous United States. Recognising problems with starting point bias, this research team developed the payment card method, in which a series of cards were presented to respondents with price ranges on these cards based on income groups. Despite these changes, the starting point effect still persisted – with accumulations of bids related to the starting points on the various cards at \$25, \$50 and \$100 (See bottom of Figure 3.1).

Although neither Mitchell or Carson (1984) are psychologists, they explained starting point bias as related to the use of a heuristic they named *anchoring*. Anchoring is the tendency of the starting point to act as magnet or anchor: respondents find it difficult to choose bids far away from that starting point. Mitchell and Carson (1984) argue anchoring occurs because respondents' estimates of their value for an environmental amenity are based, in part, on the initial value:

These considerations suggest a "low" starting point may indicate to a

respondent that the good being valued has a lower utility than he or she initially believed while a "high" starting point might have the opposite effect, (p. 213).

Tying this back to earlier discussion on bounded rationality, starting point bias probably occurs because respondents satisfice or choose an intermediate goal which is a number close to the first one presented - instead of their true value for the object. Mitchell and Carson (1984) describe a specific type of heuristic (anchoring) which is consistent with the conceptual framework of this thesis. Because this anomaly has such a pronounced effect on mean bids, care was taken in the research design of this study to mitigate starting point bias.

### **3.3.1 Framing Effects**

Although economists consider starting point bias as an artefact of contingent valuation research, psychologists have long studied similar anomalies and consider them to be part of a larger class of effects called *framing*. Framing is the general way a survey question is worded or presented to a subject, including its context. Examples of framing are the amount and type of information provided; the attitudes and actions of the people supervising an experiment; the order the question appears in the survey, and so on. Psychologists assume that framing affects the way people process information: different cognitive strategies and heuristics are used when the frame changes.

There has been little work by psychologists on framing effects specifically associated with contingent valuation. However, a recent study by Ritov et al (1993) concluded that

evaluation of risks are affected by *reference points*, such as zero or the status quo. These reference points are analogous to starting point bias observed in contingent valuation.

For this study, the researchers performed five experiments using risks associated with a waste disposal site, reductions in cancer-causing chemicals in the air, and risks posed to forests by acid rain. Their finding was that subjects did not value risks in a linear relationship related to probability as expected utility theory predicts. Instead, they found distortions in probabilities that could be related to a variety of these reference points. For example, the respondents had a higher willingness-to-pay to reduce cancer risks if the risk was reduced from 0 in 10 million from 1 in 10 million ( $n=41$ ) when compared to a similar magnitude reduction, but higher overall risk, from 100,001 in 10 million to 100,000 in 10 million. In other experiments, the researchers introduced and varied other risks along with the target risk, and found these also had an affect on willingness-to-pay.

### 3.4 Protocol Analysis

A technique developed by psychologists to gain information about the decision-making process of respondents is called *verbal protocol* or *protocol analysis*. For this technique, subjects are asked to verbalise their thoughts or *think-aloud* while filling out a survey or performing a task, and this talk is either tape-recorded, or written out by a supervisor. *Retrospective reports* are similar except that the reporting occurs just after a

question or survey is finished.

The purpose of obtaining these reports is to generate hypothesis or ideas about human cognitive processes (Ericsson and Simon 1984). The basic assumption is that:

Most fundamentally, we see verbal behaviour as one type of recordable behaviour, which should be observed and analysed like any other behaviour. The cognitive processes that generate verbalisations are a subset of the cognitive processes that generate any kind of recordable response or behaviour, (p.9).

The earliest documented protocol exercises occurred in the 1920's when psychologists used notes taken during problem-solving to illustrate how the solutions were generated. With the widespread use of tape recorders in the 1950's, protocol analysis became more popular and rigorous, as accurate transcripts of verbalisations could be made and coded for analysis. However, it was not until a book (Ericsson and Simon 1984) popularised protocol analysis, that it has come into widespread use.

In psychology, protocol analysis has been used mainly to gain insight into problem-solving strategies of individuals, and has generated numerous theories, such as decision-trees. There has also been methodological inroads made, such as: encoding and quantifying of protocols; experimental control, and use of videotapes. In the last two decades, protocol analysis has been extended to disciplines other than psychology, such as consumer research, (Bettman and Park 1980, Coupey 1994) survey development, (Willis, Royston and Bercini 1991) and more recently to contingent valuation (Schkade and Payne 1994).

The remainder of this section will provide a brief overview of this research with emphasis on contingent valuation.

In consumer research, protocol analysis has been used to gain insight into how people

make choices about commonly-purchased household goods. In this field, bounded rationality is the accepted conceptual framework, so analysis focuses on what types of heuristics are used by subjects to interpret or process the various attributes of goods. A study by Bettman and Park (1980) used protocol analysis to study the effects of prior knowledge or familiarity of recognisable brands of microwave ovens. For the study, a random sample of 99 housewives were presented with a matrix of attributes such as price, number of cooking levels, timer; and whether the oven had a browner - and subjects were asked to perform two choice tasks, one of which was to choose the brand they preferred most. During these tasks, subjects were asked to *think aloud* and their verbalisations were tape recorded. Subject's prior knowledge was determined by a question which asked them to rate their familiarity as either low, moderate or high.

Analysis of protocols was done by first transcribing the tapes and then editing them into short phrases, which consisted of single statements on the same subject. These protocols were then coded or categorised as A1, A2, A3 and so on. For example, if the protocol was a comparison of the brands based on one aspect of that brand, it was labelled A9, while A6 was comparing "more than two brands; find worst brand." One-way analysis of variance was performed on these coded protocols, using subject responses to the familiarity question as the baseline.

The results indicated statistically significant differences in the amount of processing done by subjects with the moderate group consistently doing the most. The authors reasoned this was because the amount of processing is determined by motivation and the ability to process. The low group has limited ability to process whereas the group with high familiarity lacks motivation: it knows the brands well and makes a quick

decision based on *brand processing*.

The implications of these results for contingent valuation are that respondents who are unfamiliar (similar to low group) with environmental amenities can be expected to do little processing, and use *simple* rules and lexicographic, or qualitative reasoning (Bettman and Park 1980). Implicitly, the other implication is that it is normal or acceptable for consumers to make purchase decisions for goods with little prior knowledge; they just make them differently. With adequate background information about an environmental amenity, individuals should be able to make reasonable choice decisions for contingent valuation.

A more recent study on consumer research by Coupey (1994) used a variety of techniques for protocol analysis including video and audio tapes, as well as asking respondents to take notes. The note-taking was an important aspect of the research design because it reduced subjects' memory load, and provided a visible record of the subject's decision-making process.

For the experiment, subjects were provided with information about several attributes of five common household items, and asked to make a choice among the brands. The attributes included price, length of warranty and energy efficiency while the consumer goods included humidifiers; knitting machines and air cleaners. Based on extensive coding of the notes, the researchers concluded that subjects performed a variant of constructive processing they named *restructuring*. For restructuring, respondents reordered and organised information presented to them in a useable manner to facilitate decision-making.

Protocol analysis has also been used for design and pretesting of general surveys, by



detecting questionnaire flaws related to comprehension, recall and decision process. For a study by Willis, Royston and Bercini (1991) both *concurrent think aloud* techniques, in which subjects were asked to verbalise their thoughts, as well as retrospective *verbal probing* by experimenters were used. Audio and video recordings were made of subjects for analysis. Unlike other studies, the researchers made extensive use of qualitative analysis of the protocol reports. For example, probing of subjects indicated that many were unable to understand vague questions while others had attentional and comprehension problems produced by long lists. Verbal probing of subjects also uncovered cognitive problems for a question on radon risk:

...some individuals thought that the risks of radon in general have been greatly overemphasised. It was therefore clearly inappropriate to ask these individuals about the role of radon in causing six specific health problems; they answered 'no' to each, but tended also to exhibit signs of impatience when doing so, (Willis, Royston and Bercini 1991, p. 262).

Another finding was that for *retrospective* verbal probes done just after a question was answered, respondents had little trouble reporting on their cognitive processes as they appeared to be available in short-term memory.

Based on this brief literature review, it appears protocol analysis is a flexible technique that can be adapted for a variety of research problems. Protocols can be quantified and coded extensively, and this data used as inputs to statistical models (Bettman and Park 1980) - or verbal protocols can be analysed qualitatively to detect errors or other cognitive anomalies (Willis, Royston and Bercini 1991). Furthermore, audio and visual recordings, note-taking as well as retrospective reports have all been found to be useful techniques for analysing questionnaires or longer survey tasks. That

said, protocol analysis would be useful for analysing and pretesting contingent valuation surveys, and as a way to improve the understanding of numerous behavioural anomalies observed in these studies. However, only one contingent valuation study (Schadke and Payne 1994) has used this procedure to test a hypothesis, likely because of difficulties with interpreting the results using rationality (and not bounded rationality) as the conceptual framework.. The next part of this section will be a brief overview of this study.

Schadke and Payne (1994) conducted a verbal protocol analysis to investigate the decision-making process that occurs during elicitation in contingent valuation experiments. The research team wanted to probe whether respondents are making decisions according to a model that is consistent with economics: as a trade-off between income and the environmental amenity. They suspected they weren't because of the numerous behavioural anomalies that have been observed, to date, during contingent valuation studies.

For instance, in addition to (or in place of) the value of the resource, respondents might be thinking of a contribution to a charity, the "warm glow giving" or a feeling of moral satisfaction...other possibilities include a symbolic response to a larger set of environmental issues...(p. 91)

For the study, a scenario developed by Desvousges et al (1992) was used which dealt with threats to migratory waterfowl (such as ducks and geese) caused by waste oil holding ponds across the U.S. These ponds contain oil and other by-products from oil and gas drilling operations and often prove fatal to waterfowl that land in these ponds. Respondents' willingness-to-pay to reduce waterfowl deaths was elicited for three

levels: 2,000, 20,000 and 200,000 deaths. For the protocol analysis, respondents were asked to think aloud as they responded, and report everything that went through their minds. The protocol results were coded using five categories: references to the resource; to the respondents' economic situation; other considerations; payment vehicle, and miscellaneous.

The results of the protocol analysis, as expected, indicated a variety of considerations other than an amenity/wealth trade-off. For example, 23 percent had a desire to comment on larger issues such as preserving the environment, an indication of *symbolic bias*, while 17 percent viewed the willingness-to-pay amount as a contribution to a *charity*. (Symbolic bias is a general tendency for subjects to think about larger societal issues such as moral issues related to the bird deaths, or oil-covered birds struggling to survive). Another 20 percent of the sample indicated they made up a number or guessed at the answer. Based on these results, the research team observed that respondents, in general, engaged in a variety of (or random) cognitive activities in performing the contingent valuation task. These activities were so frequent as to invalidate the dollar number elicited, they argued. More generally, Schadke and Payne (1994) said these results raised serious questions about the ability of people to value unfamiliar environmental goods, noting that preferences for these goods are inconsistent and unstable.

As for analysis of this study, the methodologies were rigorous, utilising tape-recorded protocols that were transcribed and coded under a controlled experimental setting. However, analysis of the response mode or question format was not thorough. Schadke and Payne (1994) uncovered numerous problems with respondent cognition but offered

no suggestions for improvements to the elicitation procedure, background information or scenario. Instead, they chose to make sweeping generalisations about the validity of contingent valuation based on protocol analysis of this *one* contingent valuation question in one survey. Research done by Willis, Royston and Bercini (1991), for example, suggest cognitive problems or errors are common for survey questions, and protocol analysis should be used as a tool for pretesting and design of questions.

One of the problems in the Schadke and Payne (1994) research design might be related to the fact a number was elicited using an open-ended format. Evidence from preference reversal experiments (Brown 1984, Magat et al 1988, Irwin et al 1993) suggest people have difficulty with *compatibility* when trying to assign numbers to environmental amenities, and can more readily value goods when presented with a *choice*. The other might be related to the familiarity of this particular scenario. Respondents who are unfamiliar or have low prior knowledge of *any goods* - including environmental amenities - can be expected to do little processing, and use *simple* rules and lexicographic or qualitative reasoning (Bettman and Park 1980). This may explain why a large percentage of the sample - 20 percent - said they made up a number or guessed. If this is the case, additional background information, which would improve knowledge of the environmental good, would help.

Another problem with the Schadke and Payne (1994) study design may be related to the emotional nature of the amenity presented: saving oil-covered ducks. Referring to the embedding study done by Kahneman and Knetsch, (1992) it was argued earlier that respondents react to the symbolic nature of this type of good, and satisfice at distorted-high values. Symbolic bias was probably a large factor in the Schadke and Payne (1994)

study so there is a need to test verbal protocol with more general amenities such as water and air quality which don't evoke this type of emotional response.

To conclude, although the Schadke and Payne (1994) study used the latest techniques for protocol analysis, there is a need to further examine whether the problems encountered in this experiment are related to a fundamental problem with forming preferences for environmental amenities. Or whether improvements in research design can assist respondents to search for true values, instead of choosing intermediate or satisfactory goals, (numbers). A protocol exercise will be performed as part of this study and will examine these issues. The research design and results are described in chapters five and six.

## **CHAPTER FOUR**

### **WINNIPEG DRINKING WATER QUALITY: HISTORY AND BACKGROUND**

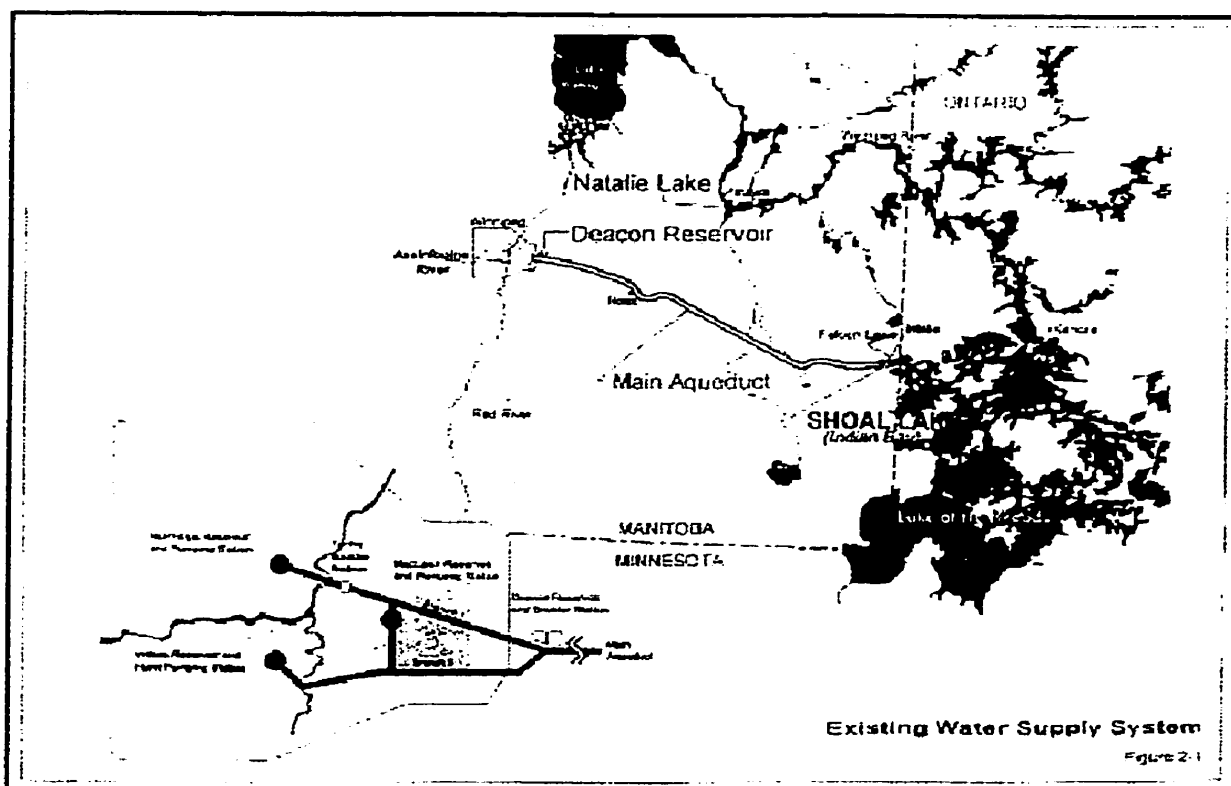
#### **4.0 Introduction to Water Quality Problem**

The City of Winnipeg is unique because it one of the few major cities in Canada that still does not have a modern plant to treat or filter its municipal water supply. This situation has resulted because of a decision made by city fathers earlier this century, in 1920. Instead of drawing water from the muddy Red River, the city decided to build a long aqueduct or pipe from Winnipeg to Shoal Lake - at a point just outside the Manitoba/Ontario border as a means of securing a pure source of water for residents to drink. (See Figure 4.1). The main aqueduct is 155 kilometers long, and currently runs as a single line from Shoal Lake to just east of the city where it branches into two lines. Within the city, there is a series of reservoirs - the Deacon, McPhillips and Wilkes - which temporarily store water as a "stockpile" measure because of seasonal uncertainties, and to allow greater control over potential contamination at the source (Pip 1993). At the site of these reservoirs are pumping stations to assist the flow of water to the city - although the topography between Winnipeg and Shoal Lake is such that the water flows by gravity all the way unassisted. Currently, the city is half way through a 10-year program to rehabilitate the aging aqueduct (City of Winnipeg 1999).

Historically, the quality of Winnipeg drinking water has been good because of the high quality of water at the source in Shoal Lake, part of the Lake of the Woods watershed. It is for this reason that the city has held back on building a treatment plant

to treat city water. The only treatment now is some on-site disinfection with chlorine to prevent disease and the addition of fluoride to prevent tooth decay.

**Figure 4.1 Winnipeg to Shoal Lake Aqueduct, and Reservoirs**



Source: Wardrop Engineering Report, 1994.

In the last 20 years, however, drinking water quality has declined for four main reasons, or issues: 1) algae in the water caused by stockpiling in reservoirs; 2) chlorine byproducts; 3) development pressure around Shoal Lake and 4) identification of cryptosporidium parasites. Each of these issues will be dealt in the remainder of this section.

The first problem is algae in the water supply. It is the most noticeable to residents, and has provided the political impetus to build a new treatment plant. The problem first

arose in the fall of 1993 when people across the city phoned to complain about foul-tasting tap water, and some suffered from upset stomachs (Wild 1993). At the time, a university toxicologist, Eva Pip, warned residents to boil water if they had the flu or other stomach problems.

The cause of the problem is that water stagnates in city reservoirs during hot summer months, and algae blooms form, causing the noticeable poor taste and color. This water quality problem has tended to reoccur every year to a greater or lesser extent in the late summer and fall when algae growth peaks. Although there has been design improvements to reservoirs, such as to water circulation, the problem has not been alleviated.

The result is that what has historically been tasteful water has in recent years lacked this quality. A report by Wardrop Engineering (1994) done for the city noted tap water has poor aesthetic qualities such as taste, odor and turbidity. These aesthetic qualities are marginal when compared to federal government guidelines, the report says.

Closely related to this problem is that as these taste and odor problems have occurred in recent years, the city has added more chlorine to improve water quality. However, when chlorine is added as a disinfectant, harmful byproducts are created called trihalomethanes, (TTHM's). The most common of these is chloroform. It has only recently been discovered that these byproducts pose a cancer risk to humans, particularly the risk of bladder cancer (Bueckert 1998). A federal report by the Laboratory for Disease Control based on review of dozens of studies in Canada and abroad indicates an elevated incidence of bladder cancer among those who have been exposed to chlorinated drinking water for long periods. This report concluded the most



effective way to reduce concentrations of these byproducts is to use filtration in a modern water treatment plant.

As a result of this discovery, Health and Welfare Canada has enacted more stringent guidelines for the level for TTHM's permitted. They lowered the guideline from 350 ug/liter to 100 ug/liter. The Wardrop study notes this change means Winnipeg water does not meet these standards, and this fact is cited as one of the main reasons why a large-scale treatment plant should be built. As part of the proposed treatment process, ammonia would be added to reduce the amount of TTHM's to within safe limits.

A third problem relates to development pressure around the source, Shoal Lake. Over the last few decades, recreational use, resource exploitation and other activities have increased in and around Shoal Lake and this has impacted water quality. This is part of a global trend in which water quality in lakes, rivers and other sources of drinking water is deteriorating. Pip (1993) describes the myriad of uses that have contaminated Shoal Lake:

Shoal Lake is subject to a number of uses that are incompatible with its functions as a domestic water source, for example, recreational use, (cottages, power boats, houseboats, roads and hydro rights-of-ways maintained by chemical spraying), hunting, commercial fishing, mining, logging, winter roads across the lake surface, contamination by sewage, and garbage disposal (p.3).

This historic problem has been compounded by the fact Shoal Lake and the surrounding Lake of Woods watershed in which it drains is not in the province of Manitoba. Most of the watershed is located in Ontario, and the immediate area surrounding the lake is controlled by the Shoal Lake Indian Band reserve. As a result, the city has little jurisdiction over the region and has little control over long-term

development plans -- such as limiting development around the lake to maintain water quality. Thus it can be expected that water quality will continue to decline as a result of this stressor.

A fourth water quality problem was first detected in 1996 when city and provincial health officials discovered the cryptosporidium parasite in low concentrations in the water supply. The parasite had entered at Shoal Lake through animal feces, such as from the beaver. During this incident, people with weak immune systems, such as AIDs and chemotherapy patients, were warned to boil their water, or face a host of intestinal-related ailments such as diarrhea, abdominal cramps and others -- including the possibility of death. Although no actual cases were reported during this first incident, a second incident in 1997 infected five children at the Shoal Lake Indian Band (Rollanson 1997). As well, 16 other adults and children exhibited symptoms of the disease on the reserve. During this outbreak, health officials went door-to-door at the reserve to ask residents to boil their drinking water for 10 minutes and to wash their hands to prevent spreading. Water tests done at the Deacon reservoir at the time indicated the parasite had not made its way up the aqueduct in sufficient concentrations to be a threat to Winnipeg residents. Nevertheless, provincial health officials warned the city that the only way to get the parasite out of the water supply is to filter it, and they recommended the city build a new treatment plant for this reason.

Across Canada, the same parasite was held responsible for 10,000 infections in Kelowna, B.C. in the summer of 1996 (Canadian Press 1996). Similar problems with the parasite have occurred in Penticton, B.C., and in Dauphin, Manitoba. Dauphin was awarded provincial funding in 1998 to build a new treatment plant.

Thus the Winnipeg water quality problem can be viewed as complex with multiple stressors. Although the most noticeable problem to residents is periodic poor taste and odor during algae blooms in reservoirs, a more critical problem is the presence of chlorine byproducts in the city water supply that pose a cancer risk. Compounding these problems are the risk of intestinal-related ailments related to the cryptosporidium parasite, and development pressures around Shoal Lake that have polluted the lake in recent decades.

The next section will deal with the city's response.

#### **4.1 City of Winnipeg Plans for Large-Scale Treatment Plant**

In the early 1990's, the city hired a firm (Wardrop Engineering 1994) to study these water quality problems, and the associated issue of a aqueduct capacity. The study identified four main reasons why a large-scale plant would be needed to treat Shoal Lake water:

- ◇ Changing water quality at the source, Shoal Lake.
- ◇ Increasing aesthetic concerns about water quality.
- ◇ Trends to higher water quality standards established by regulatory bodies; and
- ◇ Increased public health protection.

Related to this, the firm studied whether it would be feasible to use a source other than Shoal Lake as Winnipeg's water supply. The Assiniboine River was considered but was ruled out because of concerns about reduced water flows that would affect waste

assimilation in the river. Natalie Lake, which is 40 kilometers north of the city, was also considered but ruled out as well. Although its close proximity to the city would mean lower capital costs to build an aqueduct, water quality is poorer than Shoal Lake, and would require more treatment. The lake does not meet criteria of Canadian drinking water guidelines related to color, suspended solids and iron content.

Thus both alternatives were ruled out in favor of the original Shoal Lake source. As a result, city ratepayers have been paying the additional expense of \$170 million to twin the aqueducts from Shoal Lake to Winnipeg to meet projected growth in tap water consumption, and repair deteriorating portions of the existing duct. Currently, the city is half way through a 10-year program to rehabilitate the aqueduct (City of Winnipeg 1999).

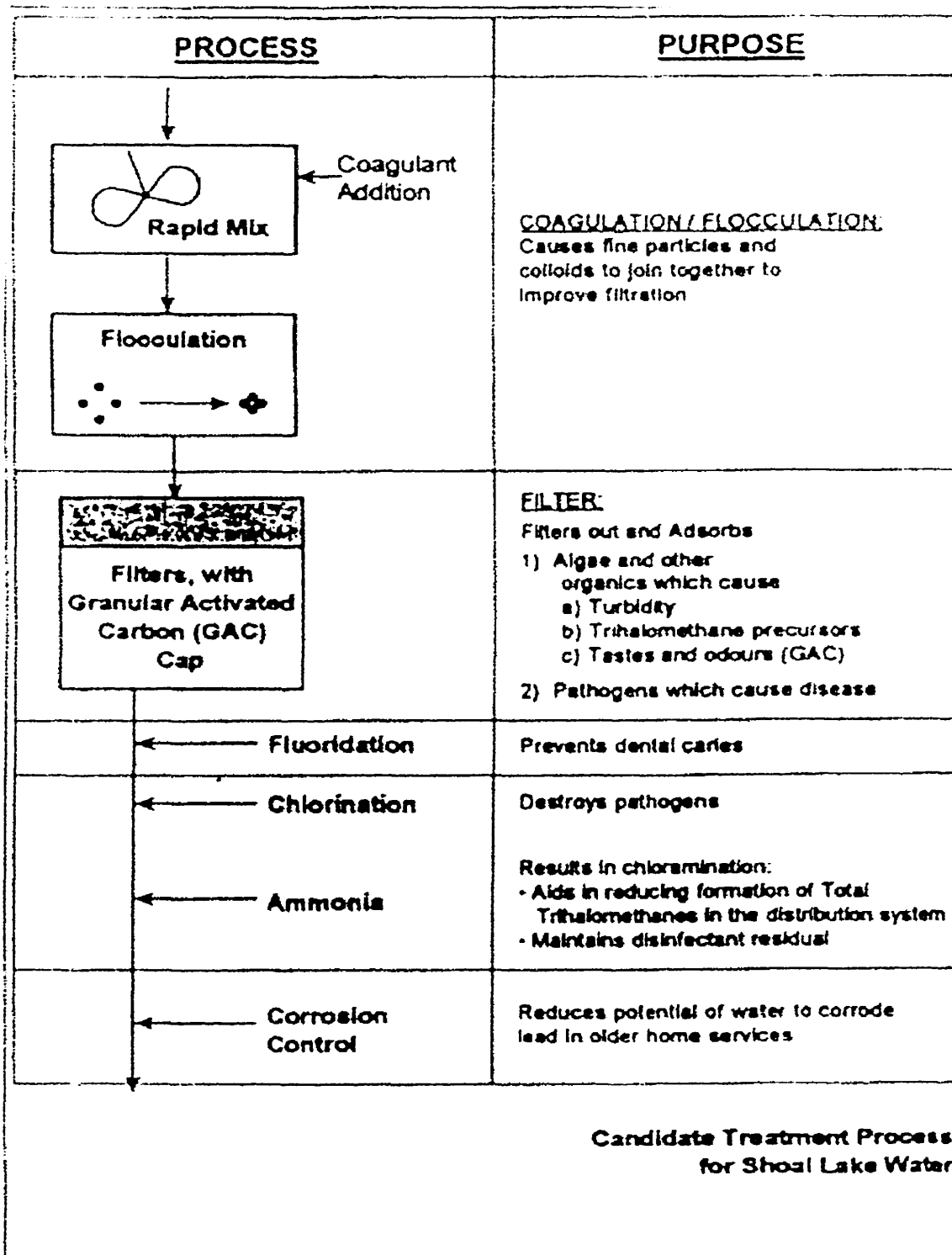
As for the treatment plant, the city estimates it will cost \$200 million to build the plant, (City of Winnipeg 1999) with annual operating costs of \$7 million. Although the Wardrop study recommended the plant be built between the years 1998 and 2002, the city has vacillated on start dates with the latest indication that construction has been set back to the year 2007 ( O'Hallarn 1997). The city's approach to financing the project has been conservative. Instead of building the plant in the near term and financing it through debenture, they began building a reserve in 1994 through increased water and sewer rates, and plans are to wait until the full amount has been raised until construction proceeds. However, several news reports indicate the city has, in the interim, drawn off that reserve to offset property taxes (Santin 1997). As a result, the latest financial estimates are that the city will have raised only half the required amount - \$100 million - by the year 2002 (O'Brian 1999).

This underfunding of water infrastructure is not unique to the City of Winnipeg. A federal survey of water rates and usage of 1,200 municipalities across Canada (Tate and Lacelle 1995) indicates this is a country-wide phenomena. The survey found that municipalities across Canada raised \$3.3-billion in annual revenues through water rates, much less than would be required to maintain deteriorating infrastructure -- an amount estimated in the \$4.5-billion range annually to the year 2003. The report recommended a doubling of water pricing practices to avoid transfers from other levels of government.

#### **4.1.1 Type of Water Treatment and Filtration**

As for the type of treatment plant, a candidate treatment process proposed by Wardrop Engineering (Wardrop Engineering 1994) indicates that specific procedures would deal with all the water quality problems outlined in this introduction (See Fig. 4.2 ). The first stage of the procedure would coagulate organic matter so it can be filtered more readily. Organic matter interferes with chlorination so there is a necessity for this step. The second stage would use a carbon filter to remove pathogens such as the cryptosporidium parasite. This filtration would also improve the taste and odor of the water, and reduce turbidity. A third stage would add a number of chemicals to treat specific problems: chlorine would be added to kill pathogens that cause disease such as typhoid - and ammonia would be added to limit the production of cancerous trihalomethanes discussed earlier. It is also proposed that fluoride continue to be added to the water supply as part of the new treatment process.

Figure 4.2 Candidate Treatment Process for Winnipeg Drinking Water



Source: Wardrop Engineering Report, (1994)

## CHAPTER FIVE

### RESEARCH DESIGN OF CONTINGENT VALUATION EXPERIMENT

#### 5.0 Introduction

A contingent valuation experiment was conducted to test the hypothesis that results of contingent valuation research are better understood using bounded rationality as a framework to model behavior, rather than traditional theories of rationality. The experiment was conducted during March and April of 1999 by a Winnipeg firm called *Tell Us About Us* that specializes in market research for small companies. The results of this experiment are presented in chapter six.

#### 5.1 Research Design of Winnipeg Drinking Water Study

This section describes the survey design for the contingent valuation experiment done in Winnipeg during the spring of 1999. The objective of the survey was to measure the value of a hypothetical increase in home drinking water quality. The City of Winnipeg plans to spend \$200-million to build a water treatment plant to filter and treat city water to remove impurities such as the cryptosporidium parasite, poor taste from algae blooms and chlorine byproducts. To manage the information load and create a more familiar situation, an imaginary scenario was constructed for the change in water quality by simulating a shopping experience (Payne, Bettman and Johnson 1992, Frederick and Fischhoff 1997, Bettman and Park 1980). For this scenario, respondents are asked to imagine they are shopping in a store near Polo Park, a major Winnipeg

shopping centre, for their home water supply which is contained in jugs that will then be hooked up to their houses.

The survey begins with a cover page with contextual information on the water quality issue, including a history of aqueduct construction, and causes of tap water quality decline over the past 20 years. The survey is provided in Appendix A. The purpose of the cover page is to improve prior knowledge of the amenity so as to improve the ability of subjects to process information (Bettman and Park 1980). At the bottom of this page, a paragraph explains the University of Manitoba's ethical standards as specified by the Ethics Review Committee. This paragraph says the survey is voluntary and the respondent's name will be kept confidential. The second, third and fourth pages have questions that probe respondents' attitudes toward tap water quality from a variety of perspectives: awareness of the issue; health concerns; as an environmental problem and whether they support construction of a water treatment plant. The fourth page also contains a series of five questions on consumer confidence, developed by Katona et al (1953, 1957, 1968, 1973). Survey questions will be dealt with in detail in section 5.2.

### **5.1.1 The Valuation Question**

The valuation question on page five of the survey (See Figure 5.1) is a combination choice/iterative elicitation format in which respondents are asked to imagine a shopping experience in which they have a *choice* between buying jugs with current water quality, or pay more for better quality-filtered water.

A *choice* was used and emphasized in the elicitation because of evidence from preference reversal experiments (Slovic and Lichtenstein 1968, 1971, 1973) that



**Figure 5.1 "Shopping Experience" Valuation Question for Home  
Drinking Water Quality Contingent Valuation Study**

*Please carefully consider the following scenario. Try to imagine you are experiencing the situation described. After reading it, please answer the questions that follow.*

Currently, tap water is piped into your house continuously. To pay for that water, the city mails you a water bill every three months. Imagine that situation no longer exists. Instead, changes were made so that every Winnipegger has a choice of the type (quality) of drinking water they can buy.

There is a giant shopping center near Polo Park owned by the City of Winnipeg and inside that store are different jugs - each jug contains a month's supply of tap water. Once you buy the jug you want at the check out stand, it is delivered to your home at no cost and hooked up so your faucets work the same way as they always have.

You can pre-order one years' supply if you wish, and this is what you are about to do. Although this is an imaginary situation, try to think about your actual household costs when answering this question. Do you have mortgage payments, food costs, and is your Autopac bill due? Does your car need repairs?

Your current monthly water bill is comparable to your cable bill - about \$30 a month or \$360-a-year. The new store gives you a choice to pay more for better quality water. There are two types of jugs in the store for consumers to choose from: one jug is labeled Winnipeg Water and the other is labeled Filtered Water. Both contain a month's supply of water.

1) The WINNIPEG WATER JUG contains water the same as is currently supplied by the city. It is drawn from Shoal Lake and treated with some chlorine to eliminate bacteria that causes disease and with fluoride to prevent tooth decay. It is a soft water and tastes fairly good most of the time. Every few years, however, there are low concentrations of the cryptosporidium parasite in the WINNIPEG WATER JUG but it only harms people with weak immune systems such as those with AIDS. As well, WINNIPEG WATER from time to time in the summer and fall tastes funny because of algae build up in reservoirs. More chlorine is added at the time but low concentrations of harmful byproducts are produced. Health authorities at the store tell you this water passes water quality standards but it could be better. In particular, something should be done to lower the amount of harmful byproducts created when chlorine is added. You are led to the aisle with FILTERED WATER.

2) The FILTERED WATER JUG is also drawn from Shoal Lake but it is extensively treated and filtered by a modern plant. It is cleaner and tastes better than Winnipeg but it contains more chemicals. A health authority explains the many steps that the water is put through by the plant. First, the water is filtered through a carbon filter similar to a Brita filter. This improves the taste and purity, and removes any traces of the cryptosporidium parasite. Steps are also taken so that any traces of algae are removed during the late summer and fall - so it tastes better during those periods. As well, harmful byproducts resulting from chlorination are removed. A health authority tells you FILTERED WATER passes water quality standards with flying colors.

*Now, please circle the jug you would prefer to buy depending on the price charged.  
Recall, each jug contains a month's supply of tap water.*

1) If the FILTERED WATER JUG has a price tag of \$30 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
2) If the FILTERED WATER JUG has a price tag of \$100 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
3) If the FILTERED WATER JUG has a price tag of \$31 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
4) If the FILTERED WATER JUG has a price tag of \$32 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
8) If you answered FILTERED WATER to questions 3 to 7, what is the highest price you would pay for the FILTERED WATER JUG before you would decide the price was too high and switch to WINNIPEG WATER for \$30.	\$36 \$37 \$38 \$39 \$40 \$41 \$42 \$43 \$44 \$45 \$46 \$47 \$48 \$49 \$50 \$51 \$52 \$53 \$54 \$55 \$56 \$57 \$58 \$59	

suggest choice is a more suitable response mode for environmental amenities. These reversal experiments suggest that choice decisions are driven by qualitative arguments related to the *prominent attribute*, and this attribute is probably the health effects of drinking water quality. By comparison, dollar values are not normally associated with environmental goods which are *not* traded in markets (Gregory et al 1993). Therefore, respondents might have difficulty constructing a heuristic which is *compatible* with the response mode if willingness-to-pay was used, and the focus was on numbers.

For the valuation question, an imaginary situation was described in which jugs are used to supply tap water to homes in Winnipeg. The iteration starts with question 1: respondents are asked to choose between the two jugs at the same price (\$30) by circling either FILTERED WATER or WINNIPEG WATER. It then proceeds from Questions 3 to 7, where the dollar value of the filtered water increases by a dollar per question, (\$31, \$32, \$33, \$34 etc). At question 8, the respondent is presented with a series of prices (\$36 to \$59) and asked to choose the highest price they would pay for the FILTERED WATER before deciding the price was too high and switch back to WINNIPEG WATER. This price range was determined during pretesting of the survey instrument.

The price where the respondent *switches* back to the Winnipeg water is where he/she is indifferent between the two jugs. The difference between the two dollar values at this *switch price* is the respondent's willingness-to-pay for the environmental amenity: tap water quality. If the respondent switches at \$42, for example, the respondent's willingness-to-pay is \$12-a-month for water quality.

This format was designed with *reference points* (Ritov et al 1993) and *anchoring effect* heuristics (Mitchell and Carson 1989) in mind (See Section 3.3). These anomalies occur when the first number, or starting point in a series, becomes a focal point. For this experiment, a series of choices (not numbers) were chosen for elicitation with the intention that this format should deflect from this type of information processing. Further, it is improbable that respondents will choose the *first* question in this series as it means that they will choose to pay the same amount for a water jug of inferior quality when compared to filtered water (\$30). The plan is for respondents to skip over the first question and scan to the choice decision which is closest to their actual value for the attribute. The working definition of bounded rationality developed for this thesis assumes that people have relatively stable values as described by the *philosophy of partial perspectives* (See Section 2.3.5). Thus, it is expected that while some respondents in this experiment will have difficulty articulating values for this relatively complex good – question design, with emphasis on simplification and familiarity, should facilitate value formation.

As a check on whether a respondent *is* expressing a value, (and understands the question) question 2 in the series is designed as a cognitive check. The respondent is asked to choose between filtered water priced at \$100 per month, or Winnipeg water at \$30 per month. The \$100 amount was chosen because during a small pretest of Winnipeg households, there were no responses higher than that amount. If the respondent chooses filtered water at \$100 per month, and then later circles another dollar amount, it is clear that they do not understand the survey because they have chosen *two* values. If this occurs, the survey is removed from the sample. The

assumption is that people are boundedly rational and have cognitive limitations, so it is expected that several surveys will be removed for this reason.

One final consideration was to include budget reminders. Some contingent valuation studies (Desvousges et al 1992, Kahneman and Knetsch 1992) pose the valuation question as a charitable contribution to an environmental *cause*, (See Section 3.2) with no reference to real-life expenses. These types of scenarios usually result in a large number of values at the high-end of the willingness-to-pay distribution, attributed to a “warm-glow” giving effect. To counter this, numerous-realistic budget reminders were included in the valuation question: mortgage and insurance payments; food costs and car repairs. The inclusion of these reminders, along with the construction of the scenario as a shopping experience, should avoid this charitable giving effect, and other heuristics associated with donating money, as opposed to valuing the environmental amenity under study.

### 5.1.2 Protocol Analysis

The last page of the survey is a protocol analysis that uses a *retrospective report* (Ericsson and Simon 1984) filled out by the respondent just after he/she has completed the valuation question (See Section 3.4). Due to resource limitations, a simple experiment was performed similar to Slovic and Lichtenstein (1968) in which respondents are asked to write down on a blank space on the last page of the survey a response to the following question:

*Try to recall what you were thinking about when you answered the last (valuation) question, and jot those thoughts down? Please be as honest as possible. It doesn't matter how messy this answer is.*

The results from these written reports are to be sorted and coded similar to Schadke and Payne (1994) into a series of categories, and the results will be analyzed for two purposes: i) to gain general insight into the decision-making process during value elicitation; ii) to investigate what model respondents are using for information processing. These three categories are:

- a) a purchase or economic model in which a higher level of the environmental amenity (water quality) is traded off for lower wealth;
- b) a contribution model in which people mimic a charitable contribution to a good cause (Kahneman et al 1993) or;
- c) a variety of concerns or random processing observed by Schadke and Payne (1994) in which respondents said they made up numbers.

These results will provide an additional validity test for this study. If a large percentage of the sampled reports fall into categories b) and c) this casts doubt on the meaning of the dollar values elicited.

As for design, retrospective reports are not as accurate as verbal protocols which are done concurrently with the task (Ericsson and Simon 1984). Additional error is introduced because only a portion of the short-term memory is being retrieved. On top of this, error is increased if a retrospective report follows a series of similar problems. The retrospective report for this study, however, was designed so it followed immediately after a long task (the valuation question) so errors caused by similarity to other questions was probably non-existent. Furthermore, evidence by other researchers

(Willis, Royston and Bercini 1991) suggest respondents who complete a retrospective report just after a question is answered have little trouble reporting on their cognitive processes, as they appeared to be available in short-term memory.

## 5.2 Pre-testing the Survey

The questions for the survey were developed during a series of small-sample *pre-tests* conducted as part of course work at the University of Manitoba in the late 1990's. The first pretest survey was completed during an econometrics course, and was mailed to a random sample ( $n=37$ ) of Winnipeg residents. A total of 11 questions were included in this survey, and two probed respondents' attitudes.

Figure 5.2 is the first question in this initial survey, and it shows the simplicity of question design: answers were listed from a) to e) vertically. Two other small-sample

**Figure 5.2 Attitude Question in First Survey**

<p>1) <b>What is your attitude toward current tap water quality?</b></p> <p>a) Very Good</p> <p>b) Good</p> <p>c) Average</p> <p>d) Bad</p> <p>e) Very Bad</p>
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surveys ( $n=23$ ) were administered to a class of psychology students as part of course on psychological testing. These latter surveys were constructed using psychometric

techniques: in particular, item (question) analysis and factor analysis. This rest of this section will explain the development of the attitude survey questions in this context.<sup>1</sup>

### 5.2.1 Analysis of the Question Pool

The first step in constructing an attitude survey using factor-analytic techniques<sup>2</sup> is to develop a pool of questions (or items as they are referred to by psychologists) on the topic of home drinking water quality. This initial pool was generated by selecting and rewriting dozens of questions from four surveys: three are from PhD. thesis (Lindsay 1992, Powell 1991, Kwak 1992) while another survey was obtained from Whitehead (1995) by request. These questions probed a variety of issues such as: awareness of the water quality issue; health concerns; environmental concerns; and the cost of improving water quality. Another dozen questions, for a total of 47, were written specifically for this survey, and dealt with local conditions such as the type of contaminants in Winnipeg drinking water and details of the timing and cost of a proposed water treatment plant. Following pre-testing, a series of questions were added to test Katona et al's (1953, 1957) theory that consumer attitudes towards the prevailing degree of confidence or uncertainty in the economy have an influence on respondents'

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<sup>1</sup> For a discussion of statistical techniques used for factor analysis, and related theories see Gorsuch (1983). For a description of attitude theories and techniques used for contingent valuation see E. McClelland (1997) or Azjen (1995). For a general discussion of attitude surveys used for psychological testing see the textbooks of Anastasi (1988) or Freidenberg (1995). A detailed discussion on these topics is beyond the scope of this thesis.

<sup>2</sup> Factor analysis uses correlation analysis to sort survey questions into similar groups or factors. Each of these groups are thought to probe similar beliefs or attitudes, such as consumer confidence or health concerns. Psychologists theorize that these factors represent different aspects or dimensions of a person's personality or intelligence.

willingness-to-pay. These questions were drawn from an attitude index called the “Index of Consumer Sentiments,” which has proven to be a good lead indicator of consumer spending on durable goods, and economic growth.

Examination of the question pool indicated there was a scattering of attitude scale<sup>3</sup> types used with some designed similar to Likert (1932) and others that followed no received format. As a result, many of these scales were reworked considerably for consistency. Likert scales similar to those used by the Minnesota School Attitude Survey were used (Anastasi 1988) as is shown in Figure 5.3.

**Figure 5.3 Likert-Scale Question Used in Survey**

	Extremely Safe	Somewhat Safe	Neutral	Somewhat Unsafe	Extremely Unsafe
How would you rate the quality of your Drinking water in terms of contaminants Such as algae or other pollutants you have Read about?					

Likert scales begin with a question or statement which expresses an attitude, and there is a graded response ranging from clearly favorable to unfavorable. For the question above, the gradient ranged from extremely safe to extremely unsafe, and these are scored from 1 to 5 with 5 allotted for the response that indicates the most concern for drinking water quality. Similar scales are used for other questions with the highest points assigned for responses that indicate the most concern for water quality.

<sup>3</sup> An attitude scale is a specific type of survey question that asks respondents to rank their attitudes on an issue using a visual aide called a scale. Scale types differ mainly by visual presentation.



A *total score* for the entire survey is derived by adding up scores for all the questions in the survey. The total score measures the “latent trait” (Anastasi 1986) which, for this survey, is probably cost-related concern for drinking water quality.<sup>4</sup> The total score is used as a statistical test to screen survey questions: bivariate correlation analysis is performed by computing the Pearson Product-Moment Correlation Coefficient between individual questions and the total score (See Figure 5.4).

**Figure 5.4 Pearson Product-Moment Correlation Coefficient**

$$r_{xy} = \frac{\sum xy}{(N)(SD_x)(SD_y)}$$

If an individual question is negatively correlated with the total score, then it has performed poorly and is a candidate for removal from the attitude survey. A statistically significant correlation of  $\alpha = .05$  exists if the Pearson coefficient is 0.30, so this was the cut-off point to include a question in the survey, although a rewrite is a possibility if the question is important, or is needed for context or other reasons.

It is beyond the scope of this thesis to explain the conceptual underpinnings of the total score, and two other criteria used to screen survey questions. However, a brief explanation of these criteria follows.

i) **Discrimination:** Question discrimination refers to the degree to which an item differentiates among takers of the survey. For this survey, any question should be able to discriminate between respondents who are concerned about water quality and others

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<sup>4</sup> The latent trait is a central or overarching attitude that is measured by the survey.

who are not. This statistical test is a visual inspection of the histogram of responses for a question, or examination of percentages. If, for example, all but two or three respondents give the same answer, then the item has a problem with discrimination.

ii) **Factor Analysis:** Factor analysis is a statistical technique used extensively in psychological testing to break-out various factors, or aspects of human behavior. For this thesis, a statistical package (SPSS) was used to generate a *rotated factor matrix*, which was then used as a screening device for survey questions during pre-testing, and as an aide to construct attitude indexes for the econometric model. (A screening device is a technique used to determine whether a question is included or excluded in the survey). If a question was highly correlated within at least one factor - and the meaning of the question was similar to others in that factor - then it was a candidate for retention. Attitude indexes were constructed by summing scales from groups of questions that loaded in the same factor. Loading refers to the number of questions in a factor.

### 5.3 Results of Pre-testing

A tabular presentation was developed as an analytical device to assess the question pool (See Table B.1 in Appendix B). Each question of the original pool of 45 was assessed according to three criteria just discussed: discrimination; correlation with total score, and correlation within factor. Consideration is also given to loading within a factor: if too many questions were in one factor then some are removed. This consideration is somewhat subjective and left to the judgement of the researcher.

The results were that a total of fifteen questions were removed because of poor psychometric properties<sup>5</sup> leaving thirty for the final survey. Eleven questions discriminated poorly so this was a substantial problem in the original pool: all but one respondent answered the same for questions on regulations, roads and health. Six questions had unexpected signs when correlated with total score, which is an indication that these questions did not tap into the latent trait of the attitude survey. Finally, several questions were removed because of high loadings in some factors.

A cause for concern in the pre-test survey was the valuation question, which performed poorly. This question asked respondents to check off an amount from \$1 to \$11 in response to the following:

*How much more is your family willing-to-pay per month to fund a new treatment plant to improve the quality of your drinking water?*

Although the question discriminated well, correlation within factor was 0.367 while correlation with total score was only 0.166, which is not statistically significant. This was an indication that the question design was faulty: the a-priori expectation was that the valuation question should be highly correlated with total score, since the attitude survey deals specifically with the issue of water quality. This result led to a further literature search to investigate underlying causes of this anomalous result, and ways to improve the elicitation procedure. The outcome was the development of a “shopping-experience” scenario described in figure 5.1.

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<sup>5</sup> Psychometric properties refer to how well a question discriminates, correlates within factor or with total score.

#### 5.4 Usefulness of Attitude Survey

Extensive use has been made of an attitude survey as part of this thesis, and there is a need to explain the usefulness of this survey within the conceptual framework, bounded rationality. In this regard, this section will cover three points. The survey's use : i) as a tool to investigate behavioral anomalies; ii) as part of an interdisciplinary approach, and iii) as consistent with the policy-approach of bounded rationality.

i) **Behavioral Anomalies:** Attitude surveys and questions have been used to investigate underlying causes of cognitive processes in contingent valuation, and related consumer research. Kahneman and Knetsch (1992) used an attitude question on moral satisfaction to test a hypothesis on the *warm glow* effect. Ratings on this question were correlated with willingness-to-pay bids as a means to support their hypothesis. Similarly, Bettman and Park (1980) used an attitude scale on respondent familiarity in an analysis of variance (ANOVA) model to investigate information-processing when prior knowledge of the consumer good varied. The attitude survey for this study was used in a similar manner: as a tool to investigate information-processing related to behavioral anomalies. During pre-testing, the attitude survey was used as a screening device for the valuation question. Willingness-to-pay had a low correlation with total score thus there was reason to suspect anomalous results. Attitude indexes were also used to construct variables for an econometric model. Results of this model were used as an indicator of anomalous results, as well as a validity check. As part of the overall research design, results from the attitude survey

complement the protocol analysis, which provides more direct insight into cognitive processes, and improves the rigor of this study.

**ii) Interdisciplinary Approach:** The use of an attitude survey is also consistent with the interdisciplinary approach of this thesis. As outlined in section 2.3.1, a defining feature of bounded rationality is that the approach draws from both psychology and economics. Thus the use of attitude index variables such as the “Index of Consumer Sentiments” developed by Kantona et al (1953, 1957) - instead of socioeconomic variables such as income, age and education used for mainstream CV studies - is consistent with the conceptual framework advanced for this thesis.

**iii) Policy-Approach:** The final use of the attitude survey relates to the descriptive analysis of questions, presented in section 6.4. As explained earlier in this study, the usefulness of this analysis can be tied back to the conceptual framework developed for bounded rationality. For a model constructed by Mosley, (1976) survey results provide additional feedback on the actual level of targets for policy makers attempting to interpret whether tap water quality is satisfactory (good enough) or not.

## **CHAPTER SIX**

### **RESULTS OF THE CONTINGENT VALUATION EXPERIMENT**

#### **6.0 Introduction**

The purpose of this chapter is to describe the results of the contingent valuation study done on Winnipeg drinking water quality. The research design of the experiment was presented in chapter five.

#### **6.1 Data Collection and Sample Design**

The final survey was conducted in the spring of 1999 and was mailed to a random sample of Winnipeg property owners, who were the population sampling frame for the study. A computer database of Canadian telephone numbers and addresses, contained on a CD-Rom disc called *Select Phone*, was used to *spatially* sample the population using a technique similar to that of Kwak (1992). The first step was to randomly select five out of a possible fifty street addresses using Shazam's random number generator. Using the fields in *Select Phone*, these numbers were used to choose Winnipeg property owners with the street addresses corresponding to the numbers selected. This process generated five "packets" of names and phone numbers, and these were passed on to a professional survey firm, which was instructed to randomly select 25 names from each packet.

The survey was conducted from March 24 to April 28, 1999, by a firm called *Tell Us About Us* that specializes in market research for small Winnipeg companies. Table 6.1 provides call statistics compiled by the firm during the survey administration period.

The overall survey design follows a technique similar to that of Mason (1993) in which people are first solicited by telephone, instead of by numerous unsolicited mailings as in Dillman (1978) which in recent years has become standard procedure to administer dichotomous choice contingent valuation studies.

**Table 6.1 Call Statistics for Drinking Water Survey, (1999)**

Date	Calls	No Answer, Busy or Answering Machine	Agreed to Participate*	Refusal
March 24	32	9	11	12
March 25	53	14	17	22
March 26	19	5	7	7
March 29	76	24	25	25
March 30	48	20	20	8
March 31	23	5	12	6
April 5	36	10	13	13
April 6	10	3	5	2
April 7	42	14	15	16
Totals	339	104	125**	111

\*Once a respondent agreed to participate, he/she was mailed a copy of the survey and told to fill it out at home, and then wait a few days for a researcher to call. From March 23 to April 28, 1999, the survey firm retrieved answers for 80 completed surveys.

\*\* It took an average of 3.81 calls per household or a total of 304 calls to retrieve answers for 80 surveys. Forty-five people who agreed to participate refused to complete the survey once it was mailed to them.

The advantage of Mason's method is that it saves on postage and printing costs. Only one mailing is required. For Dillman's survey method, there is a first mailing, reminder postcard, and a second mailing for those who do not respond. As well, a

sample size of around 1,000 is required for a Dillman-type survey, and this would be too costly for this small-budget exercise.

As a first step to administering this survey, *Tell Us About Us* interviewers were briefed on the general contents and purpose of the survey, and then provided with a script written by this researcher to solicit participants by telephone. During a short pre-test before the final survey, it was found that homeowners agreed more readily to participate if tap water "health effects" were prominent in the script as opposed to "water quality." As a result, modifications were made to the script along this line. As well, interviewers were told of the ethical standards to be followed as outlined by the Ethics Review Committee at the University of Manitoba, and to emphasize that participation was voluntary. In-depth training of the interviewers was not required as their job was to simply solicit participation by phone, and then collect answers once the respondent had filled out the survey in their home.

During stage 1 of survey administration, phone solicitations began on March 24 and proceeded through to April 7 (See Table 6.1). During this period, 339 homeowners were contacted and 125 agreed to participate by having a copy of the tap water quality survey mailed to them to fill out. Of the ones who didn't participate, 104 either didn't answer their phones, had busy signals or answering machines. A full 111 homeowners refused to accept surveys when contacted by the survey firm. Thus it took an average 2.7 calls to get a "yes" answer during this stage.

Once the surveys were mailed out, the second stage was for the survey firm to call back people and ask them to relay answers to their completed surveys over the phone. This proved to be a difficult exercise as it took a total of 304 calls or 3.81 calls per



household to retrieve answers from March 23 to April 28. A total of 80 surveys were completed by the survey firm during this period.

The survey firm expressed concern about this stage, and the fact people had to be called back so many times to retrieve answers. Of the 45 who refused to complete the surveys, there were no consistent reasons for these refusals, although several said it was too long, and time consuming. One respondent said he was “not interested” in the survey after looking at it while another said he “threw it out; it was too long.”

The lesson learned from this exercise is that the call back stage is a difficult one. Remedies may include financial incentives for people to fill out surveys; inviting people to a university lab or school classroom, or using the Dillman mass mailing technique. Inviting respondents to a university lab would allow the interviewers to exercise more control over survey administration, and aspects such as interviewer bias. This is cited as an important factor by practitioners who administer psychological tests (Anastasia 1989). However, all of these survey techniques involve substantial outlays of funds, and probably could not be done without a grant.

The final step was for this researcher to carefully review the 80 surveys provided by Tell Us About Us for incomplete questions, or other errors. As a result of this examination, a total of 10 surveys were rejected either because questions were left unanswered, or there was a clear indication the respondent didn't understand the survey. Thus the total number of completed surveys was 70. Of the rejections, a total of eight respondents failed to answer the willingness-to-pay question indicating there may have been problems with this question: either it was too long, or too complex for respondents to understand.

Finally, the response rate was calculated which is the total number of completed surveys divided by the sample size, times 100, (expressed as a percent). For this survey, the sample size could either be the total number of calls made based on the random draws from the five packets, ( $n=339$ ) or the total number of surveys mailed out, ( $n=125$ ). If the latter number is used, the response rate is 56 percent. If the sample size based on the random draw is used, the response rate is 20.6 percent. As for which one to report, the literature is unclear on this. Dillman's mass-mailing surveys usually get response rates of around 25 percent unless some preselection technique is used to screen respondents, so intuitively the latter response rate seems the most accurate, especially since no financial incentives were provided to respondents. Additionally, the sample size is best reported as the initial random draw of  $n=339$ , not the secondary draw of  $n=125$  that resulted during stage 1 phone rejects. Thus the response rate reported for this study is 20.6 percent.

As for analysis of this response rate, it is fairly low and consequently there is probably some upward bias in the willingness-to-pay values. People who refused to answer the survey are probably less supportive of initiatives to improve municipal water quality, and it is expected this group removed from the sample will have lower valuations. Thus we expect some response bias for this survey. However, the sample distribution and mean of incomes were comparable with the population mean obtained from the 1996 Census, conducted by Statistics Canada. Thus response bias was probably quite small.

## 6.2 Results of the Valuation Question for Drinking Water

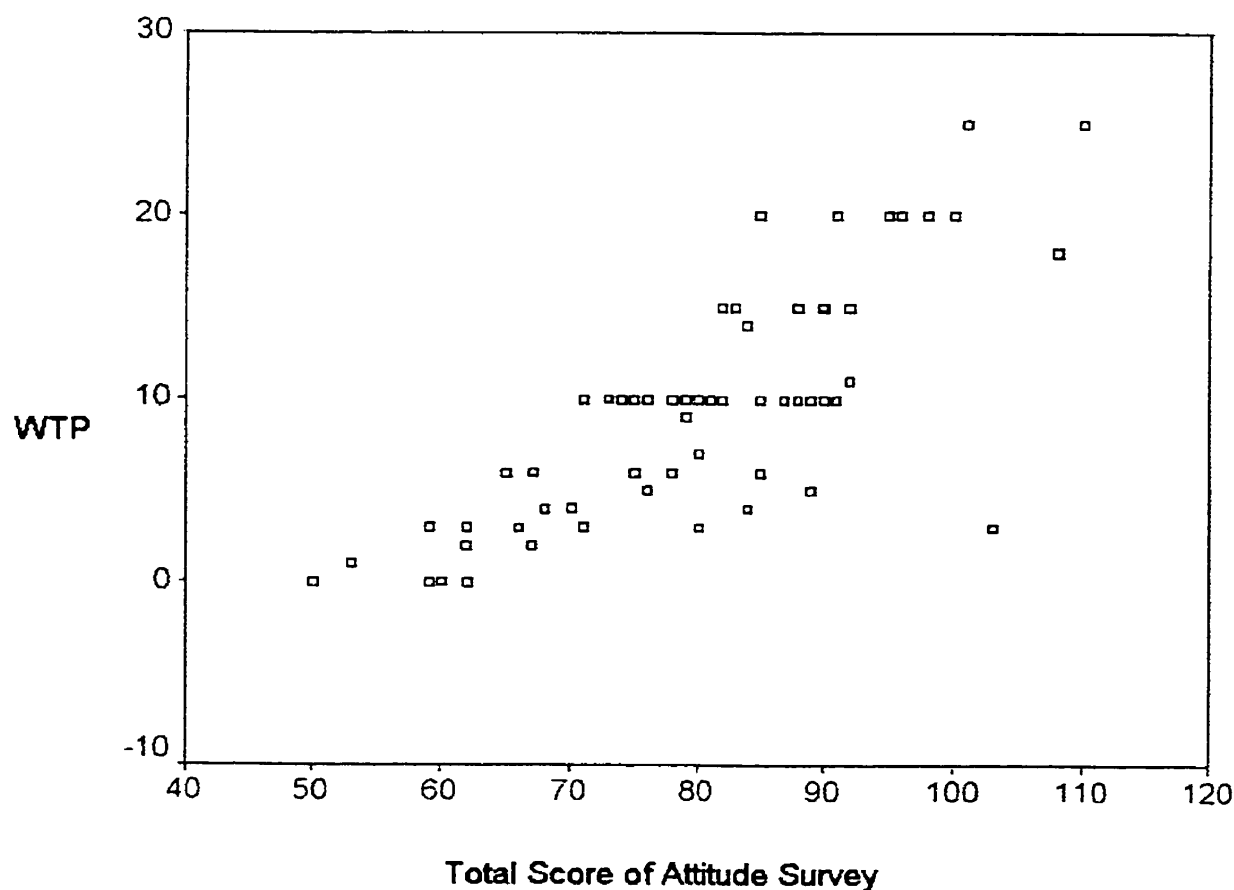
The valuation question was a combination choice/iterative format with several special features designed to mitigate the effects of behavioral anomalies, such as starting point bias and the “warm glow” giving effect. A shopping experience scenario was used, in which emphasis was placed on *choice* to facilitate information processing. As can be seen in Figure 6.1, the distribution of willingness-to-pay bids shows no accumulation of bids at the starting point, (4 bids) nor was there an unusually large number of bids at the high end of the distribution, (two bids). Thus we can assume two things:

- i) that respondents did not view the first question as a focal or reference point (Ritov et al 1993). Indeed, one respondent in the verbal protocol exercise remarked: “Who would want the Winnipeg water if it wasn’t as good as the filtered water but the same cost?”
- ii) that respondents did not attach emotional or moral feelings to the simulated shopping experience, and this avoided the “warm glow” giving effect.

The valuation question also performed reasonably well on the series of psychometric tests set-up as screening criteria for the attitude survey. The willingness-to-pay question had a correlation of 0.566 within factor and it had a Pearson-Product coefficient of 0.784 for a bivariate correlation with the total score (See Figure 6.2 for scatter plot) which is a statistically significant correlation. This is particularly

important because the overall attitude survey performed well, meaning the total score is probably a good indicator of the “latent trait,” which was identified as cost-related concern for water quality. Finally, although there were irregularities in the willingness-to-pay distribution, (discussed next paragraph) it appears to be roughly right-skewed as the contingent valuation literature indicates (Boyle and Bishop 1988). The problems that *did* arise with the valuation question were related to unpredicted behavioral anomalies. As can be seen in figure 6.2 there is a pronounced peak of the distribution at the \$10 bid level, and the right side of the distribution is spotty or has

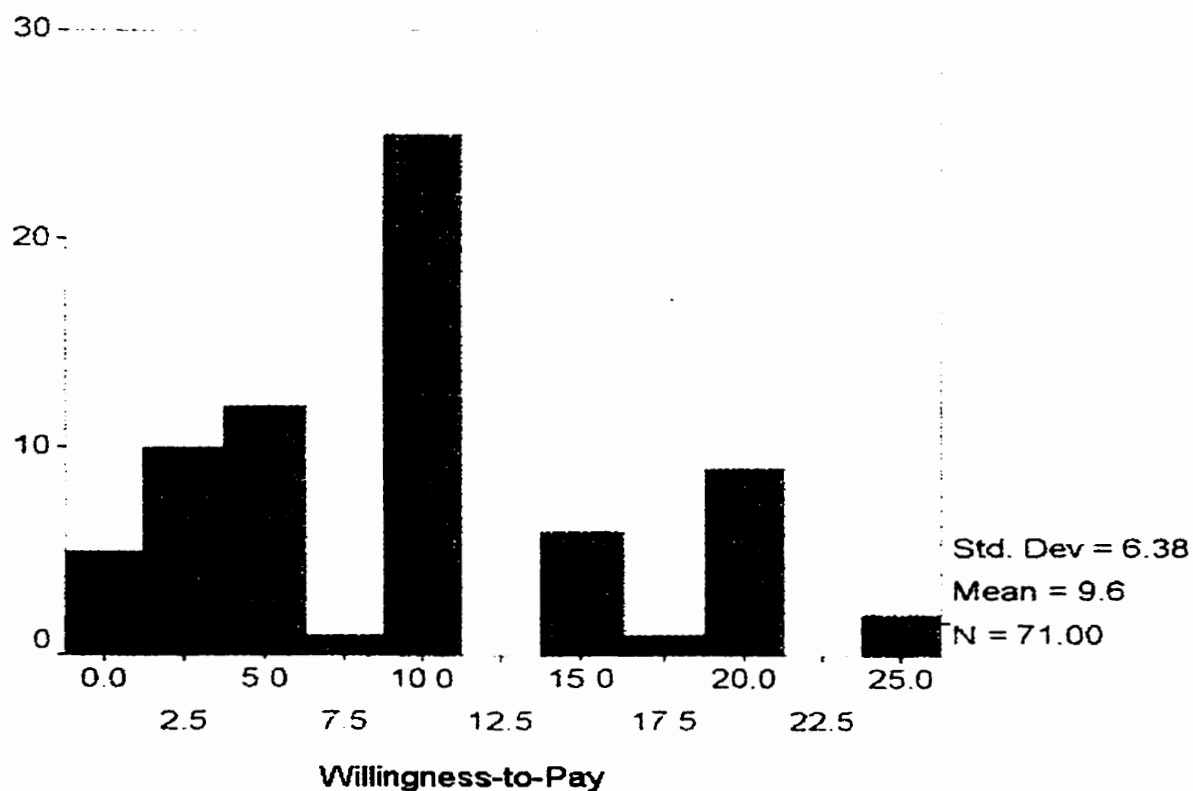
**Figure 6.1 Bivariate Correlation between Willingness-to-Pay and Total Score of the Attitude Survey**



$$r = 0.784$$

“holes.” This can be explained by the examination of the *response modes* of the valuation question (See Appendix A). To fit the entire question into one page, the bids from \$36 to \$59 appeared as a series of numbers, unlike the bids from \$30 to \$35 which appeared as a series of choices between FILTERED WATER and WINNIPEG WATER. In fact, what exists in the valuation question is two response modes, and this is what created the problem. Respondents probably had difficulty processing numbers in the lower half of the question and avoided these, creating “holes” in the distribution on this side. As explained in the research design, respondents have difficulty with *compatibility* between numbers and environmental attributes.

**Figure 6.2 Willingness-to-Pay for Winnipeg Drinking Water Quality:  
Distribution of Bids**



Meanwhile, the reason for the high peak of the distribution can be explained by reference points (Ritov 1993). Although respondents didn't focus on the starting point, they appeared to focus on a mid-point of the first line of numbers, which is \$10. As a result, 36 percent of the total bids were for this amount and it was the mode of the distribution. Thus although precautions were taken to mitigate starting point bias, an unexpected bias was created midway in the first line of numbers.

### 6.3 Results of Protocol Analysis

The question used for protocol analysis was on the final page of the survey, (See Appendix A) and asked respondents to recall what they were thinking about when they answered the valuation question, "and jot those thoughts down." As such, it was a *retrospective report* filled out just after answering one or a series of other questions on a survey. Of the 70 respondents who completed the attitude survey, only 49 completed this section which is a disappointing response rate. This is understandable, however, as the mail-out technique used for this survey provided little room for supervision. What was surprising, however, was that the general quality of these answers was quite good considering the crudeness of this exercise.

As a way of classifying results, the answers were placed into five categories, (See Table 6.2 below), based on references to: a wealth\amenity trade-off, substitution effects, cost alone, water quality alone or the political issue of water quality. On some surveys, respondents referred to two of these categories, and these surveys were entered twice. As a result, a total of 57 protocols were entered into the table. A protocol is a written response in any of the categories listed.

The purpose of this verbal protocol exercise was to provide a framework to analyze whether the information-processing model respondents utilized could be described as economic, (wealth/amenity trade-off) -- a contribution model in which respondents mimic charitable giving to a good cause (Kahneman et al 1993) or a “variety of considerations” that follow no pattern or are random (Schkade and Payne 1994). If the protocols follow either of the latter two models, there is grounds to invalidate the dollar figures elicited during contingent valuation.

**Table 6.2 Verbal Protocol Responses Related to Valuation Question**

<b>Protocol Categories</b>	<b>Number of Respondents</b>
References to trade-off between wealth and environmental amenity: water quality (economic model)	18
References to substitution effects such as use of Brita filter or boiled water	15
References to cost/income alone	6
References to water quality alone	10
References to political issue or role of government (or symbolic nature of amenity)	8
<b>Total</b>	<b>57</b>

The results of this informal experiment, however, suggest that the economic model cannot be ruled out:

- i) 33 of the 57 of the protocols referenced either a trade-off between their incomes and some attribute of water quality (algae, parasite), or for a substitute such as boiled water or use of Brita filter.
- ii) Another 16 protocols could be interpreted as fragments of this trade-off.

The following three protocols are examples of trade-offs in i) above, and indicates the strength of the substitution effect in this experiment:

- |                   |   |
|-------------------|---|
| <b>Protocol 1</b> | My household boils water and uses a Brita filter. I personally think there is a limit to the amount of money I would pay to have better water because I boil it anyway. |
| <b>Protocol 2</b> | If filtered or upgraded city water costs the same as what it costs now to buy bottled water, I would pay this extra money.  |
| <b>Protocol 3</b> | I thought of my finances and how much would it cost for the year. I truly enjoy drinking filtered water.  |

For 18 other protocols, the decision-making appeared to focus solely on *either* income/cost or some attribute of water quality, such as algae, parasites or chemicals.

Two examples (Protocols 4 and 5) of these follow:



- Protocol 4**      I was recalling the taste of water from the summer and recalling some information I heard on the cryptosporidium parasite on the radio.
- Protocol 5**      (A respondent who chose \$45 said): \$15 is the price and it means an extra \$180-a-year. Not willing to go any higher as the financial stress would be too much.

Although this group of protocols do not adhere strictly to the trade-off model, respondents are considering their responses in a way that would not be inconsistent with economic valuation. Possibly, this informal experiment is picking-up on a fragment of the decision-making process, and a more carefully supervised experiment with tape recorders might reveal these respondents did, at some point during elicitation, consider the other side of the trade-off nexus. Thus this group of responses are not cause for concern, and a case cannot be made for invalidating the dollar figures obtained based on these results.

The final group of protocols (n=8), however, were a cause for concern as the focus appeared to be on the symbolic nature of the environmental good (Mitchell and Carson 1989) and not valuation. For these protocols, respondents queried a number of broader issues, such as: whether city council would actually use the funds from increased water rates for the filtration plant, or moral issues related to paying for Shoal Lake pollution. This occurred despite a research design that used a “shopping experience” scenario as a way of detaching respondents from the political process, and as a means of deflecting from this type of anomaly. Examples of these protocols (7 and 8) include:

- Protocol 6** I would pay almost any price for good water. But I would be reluctant to give free rein to a politician with a political agenda.
- Protocol 7** The lack of control at Shoal Lake shouldn't be a cost to Winnipeg residents. Shoal Lake was a source of water for a long time....so why should we have to pay to clean it up now?

As for a general assessment of this verbal protocol exercise: although there was cause for concern with symbolic bias, only 8 out of 57 protocols exhibited this effect. The remainder of protocols appeared to be related to: i) trade-offs related to income and water quality or substitutes for water quality, and ii) a partial representation of this trade-off: the respondents' budget constraint, or analysis of the environmental amenity. Thus the results of this exercise are encouraging in that they mean the dollar figures obtained are probably not random, (Schkade and Payne 1994) and didn't appear to follow a model in which respondents mimic a contribution to a charity or good cause. Furthermore, these protocols provided additional insight into the strength of the substitution effect. Standard practice to measure this effect is to examine the coefficient and statistical significance of a substitute variable in an econometric model. By comparison, this exercise has shown that substitution effects can be examined using think aloud data. Finally, although this verbal protocol exercise was quite crude, it was nonetheless useful in analyzing results, and it was also done at little cost. A more thorough protocol study with paid supervisors and subjects would certainly be preferable, however, this type of primary research is quite expensive, and may require funding additional funding that may not be available.

An additional problem with verbal protocol research is that although there has been extensive work done in the fields of psychology and marketing, there have been few studies done in the context of contingent valuation. In fact, the conclusions drawn by Sckade and Payne (1994) and Kahnmen et al (1993) are based primarily on the results of one experiment on threats posed to migratory waterfowl by waste oil holding ponds. The emotional nature of this amenity probably makes it more prone to anomalies such as charitable giving, and random information processing. Thus there is a need for more verbal protocol research dealing with a wider variety of familiar (less complex) environmental goods such as water or air quality, as a means of understanding and validating the results of contingent valuation studies.

#### **6.4 Results of the Attitude Survey**

As outlined in the methodology section 5.1 the attitude survey was developed using a factor-analytic approach in which a pool of questions on drinking water quality was generated from various sources – and then narrowed using several criteria such as correlation within factor, correlation with total score, and question discrimination. This process generated 25 questions that were used in the final survey mailed out to residents. The next three sections will cover results of the attitude survey. Section 6.4.1 will be a descriptive analysis of the questions in the survey; section 6.4.2 will be a psychometric analysis of the survey while 6.4.3 will show how attitude indexes are constructed using factor analysis.

#### **6.4.1 Descriptive Results of Attitude Survey**

Questions from the final attitude survey could roughly be grouped into four categories (See Tables 6.3, 6.4, 6.5, 6.7). These categories include: health concerns, paying the costs of pollution, political support for drinking water quality and use of substitutes. Another group of questions on consumer confidence (See Table 6.6) was added to the final survey to test Katona's index of consumer sentiments for its usefulness as a predictor of willingness-to-pay for an environmental amenity.

This section is a descriptive analysis of the attitude questions with a view to providing policy guidance within a boundedly rational framework (See Section 2.4.3).

The first grouping of questions (See Table 6.3) probed attitudes related to health concerns about tap water quality: the first two dealt with specific contaminants - algae and the cryptosporidium parasite - whereas the last in this group was a general question in which respondents were asked how well they felt they were protected from contamination. A Likert scale was used for these attitude questions that ranged from extremely safe to extremely unsafe.

Concern about the parasite was the most intense, with 57 percent saying they felt somewhat unsafe because of the presence of the parasite in drinking water and 15.7 percent felt extremely unsafe. At the other end of the spectrum, concerns about algae in the water was the lowest with respondents split between feeling that drinking was either somewhat safe (32.8 percent) or they were neutral on the question (35.2 percent). For the general question about protection from contamination, half the respondents felt drinking water was somewhat unsafe with 28.6 percent neutral on the issue. Thus this section indicates that although Winnipeg residents do not think the water quality

problem is an extreme one, they are concerned, especially about the intermittent presence of a parasite in the water supply.

**Table 6.3 Health Concerns about Tap Water Quality  
(Percent Choosing Each)**

	<b>Extremely Safe</b>	<b>Somewhat Safe</b>	<b>Neutral</b>	<b>Somewhat Unsafe</b>	<b>Extremely Unsafe</b>
Contamination in terms of algae and other pollutants	4.3 %	32.8%	35.2%	25.7%	1.4%
Low concentrations of cryptosporidium parasite	0%	5.7%	21.4%	57 %	15.7%
Feeling of how well protected from contamination	0%	18.6%	28.6%	50%	2.9%

The second grouping of questions probed respondents attitudes about paying the costs of improvements to water quality by the city, and concerns about pollution generally (See Table 6.4). The survey found that 38.6 percent of respondents somewhat supported city plans to purify drinking water quality “no matter what the cost,” whereas 35.7 were neutral with regard to this question. The other two questions in this group had similar results. When asked if the respondent was someone who wants to pay the cost of pollution, 38.6 percent said this described them somewhat, while 37.1 percent said this described them “a little.” For the other question, 47.8 percent said they agree that environmental improvements should be made regardless of the cost.

**Table 6.4 Attitudes Towards Paying Costs of Pollution  
(Percent Choosing Each )**

	<b>A lot</b>	<b>Somewhat</b>	<b>A little</b>	<b>Not at all</b>	<b>No opinion</b>
Someone who wants to pay the cost of pollution	12.9 %	38.6 %	37.1%	7.1%	4.3%
	<b>Strongly Agree</b>	<b>Agree</b>	<b>Neutral</b>	<b>Disagree</b>	<b>Strongly Disagree</b>
Environmental improvements made regardless of cost	13 %	47.8%	30.4%	7.2%	1.45%
Support city plans to purify drinking water no matter what the cost	11.4 %	38.6%	35.7%	12.9%	1.4%

One of the problems with earlier drafts of these questions used during pilot tests were that they had difficulty differentiating between respondents, and it was only after rewrites that included the phrases “no matter what the cost” or “regardless of the cost” did respondents choose more than one answer: strongly agree. Even with these strongly-worded attitude statements, a large proportion of respondents still indicated they either agreed or strongly agreed to pay for improvements. This indicates a fairly strong willingness-to-pay for the cost of improved water quality, and environmental improvements, and validates the results of the valuation question, which indicated respondents on average would be willing-to-pay 32 percent more for improved water quality.

Another series of questions probed respondents political priorities related to the water quality issue. Respondents were asked to respond yes or not as to whether they felt drinking water quality concerned them more as an issue when compared to drugs, taxes or the poor state of city roads (See Table 6.5). Not surprisingly, taxes were viewed as a higher priority than water quality, and so were drugs. These issues are frequently in the media and these results were to be expected. However, the strength of support for water quality was higher than anticipated as 43 percent said they were more concerned about water quality than drugs, and 37 percent indicated similar concern for water quality over taxes. Respondents, however, consistently chose water quality over road repairs, even after an initial draft of the question was re-written to emphasize the “poor state of city roads” due to problems with discrimination. In the survey, 55.7 percent chose water quality compared to 44.3 percent who chose roads, even though the road issue (pot holes, crumbling streets) gets much wider exposure and debate.

**Table 6.5 Political Support for Drinking Water Quality  
(Percent Choosing Each)**

	<b>Drugs</b>	<b>Water Quality</b>
More concerned with drinking Water as an issue or drugs.	57%	43%
	<b>Taxes</b>	<b>Water Quality</b>
More concerned with taxes or drinking water quality	63 %	37% —
	<b>Roads</b>	<b>Water Quality</b>
More concerned with poor state of city roads or drinking water quality	44.3 %	55.7%

For the series of questions based on Katona's index of consumer confidence, the majority of respondents saw the financial-state of the economy about the same as it was a year ago, and they don't expect it to change much in the next year (See Table 6.6). However, when it came to the purchase of durable goods, 55.7 percent were confident that it was good time to buy durable goods such as major household appliances. There was a problem with this latter question, however, as the original version was dichotomous choice (good or bad time) and many respondents (22.9 percent) checked off a space between these two to express neutrality. As a result, neutrality is presented as part of the scale. Because of this survey design fault, however, it can be assumed the number of respondents choosing neutral were probably larger than the survey indicates.

**Table 6.6 Consumer Confidence Attitudes  
(Percent Choosing Each)**

	<b>Worse off</b>	<b>About Same</b>	<b>Better Off</b>
How getting along financially Compared to year ago.	28.6 %	57.1%	14.3%
A year from now, how well off financially	17.1%	61.4%	21.4%
	<b>Bad Time</b>	<b>Neutral</b>	<b>Good Time</b>
Good or bad time to buy major household items	21.43%	22.9%	55.7 %

The final two questions on the use of substitutes such as filtering devices for drinking water and boiled water, were consistent with results from the verbal protocol exercise,



and reinforced the strength of the substitution effect for water quality. These questions asked respondents whether they had used either of these substitutes in the past six months, and the results were that 53 percent said they had used a Brita or other make of water filter, and 43 percent said they had either boiled or bought water as a replacement for tap water (See Table 6.7). These results suggest that around half the Winnipeg population has used substitutes because of concerns about poor water quality. This demonstrates the overall importance of the issue to residents.

**Table 6.7 Use of Substitutes for Drinking Water Quality  
(Percent Choosing Each)**

	<b>Yes</b>	<b>No</b>
Use filtering device such as Brita to purify home drinking water quality	57%	43%
Boiled or bought water as replacement for tap water	43%	57%

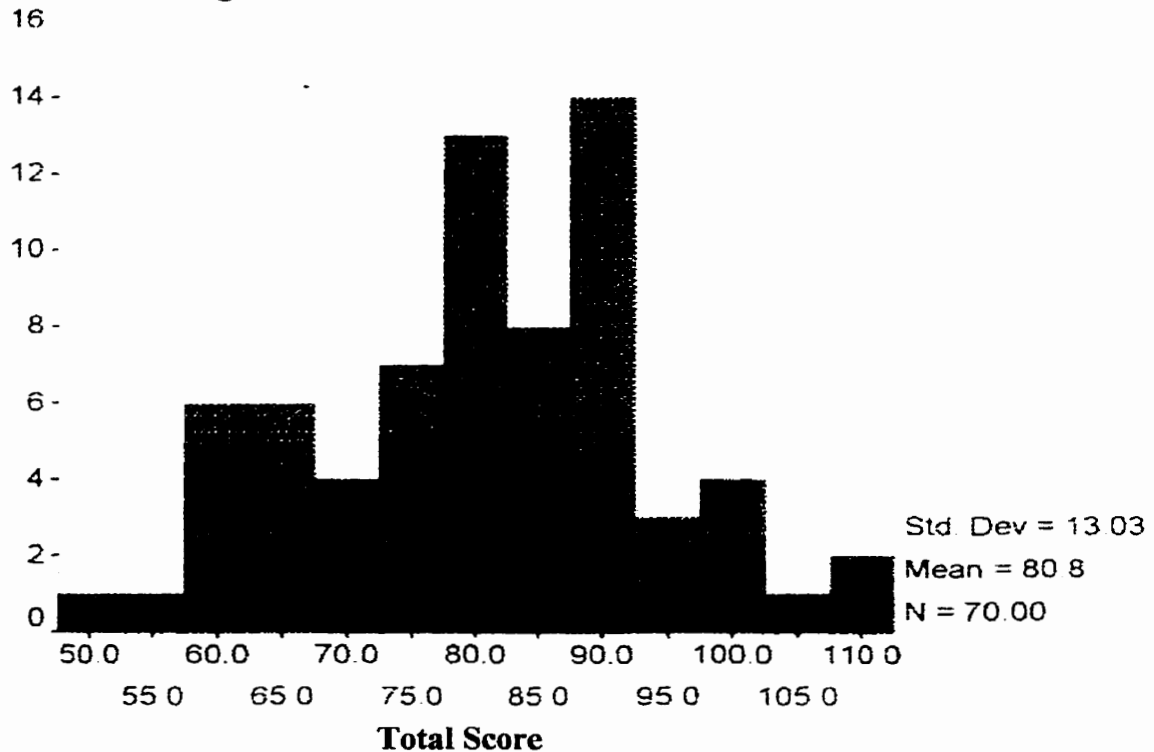
#### **6.4.2 Psychometric Analysis of Attitude Survey**

As part of survey development, numerous psychometric tests (e.g. correlation with total score and discrimination) were performed to assess versions of the attitude survey used for pre-tests, and these same tests were performed on the pilot survey mailed out for this thesis. This section will provide a summary of these results, as well as factor-analysis used to construct attitude indexes for the econometric model.

As can be seen from the last section, the attitude scales discriminated well amongst respondents. An inspection of percentages for each question showed a dispersion across the scales, and there were no questions with only one answer. There *were* some problems with a few questions: i) questions on paying the costs of improvements to the environmental were redrafted because of poor discrimination in earlier versions, and the resulting questions on asking for improvements “regardless of the cost,” in retrospect, were probably not realistic, and ii) one question on consumer confidence that asked whether respondents thought it was a good or bad time to buy consumer durables failed to discriminate amongst respondents who were neutral or in between the two available responses.

The distribution of total scores also performed well as it appears to be roughly normal (See Figure 6.3). This is an indication the test is tapping into a single aspect of behavior, or trait, which is probably a cost-related concern for water quality. Using a technique developed for psychological tests (Anastasi 1988, Friendenberg 1995) the attitude survey was *normed* for analysis of future, repeated surveys. This is a simple procedure in which the mean (80.8) and standard deviation (13.03) are calculated, and then generalizations about the trait are made based on an individual’s score.

A second test related to total score is bivariate correlation with individual questions. During pre-testing, this technique was used as a screening device to narrow an initial question pool to a manageable number for the mail-out survey. For the final survey, bivariate correlation will be used to assess the final survey, but also as a screening device for the attitude indexes used for the econometric model. The assumption is that if a question is correlated with total score, which is a proxy for the latent trait,

**Figure 6.3 Distribution of Total Score**

then it has performed well. Table 6.8 presents the results of this test: question correlations marked with two asterisks are statistically significant at the .05 level while questions marked with a single asterisk are significant at the .10 level.

As can be seen from this table, the test in its entirety performed fairly well: there was only one negative correlation out of the 29 questions presented -- and all except the first grouping of questions (1 to 6) were statistically significant with 15 of these significant at the .05 level. The problem spot in the survey was in this first grouping which mostly dealt with knowledge of the issue and whether the respondent trusts city councilors or their friends. These questions seem to be only peripherally related to the focus of the survey which is on cost-related concern about water quality -- so this result is not unexpected.

**Table 6.8 Bivariate Correlation Between Questions and Total Score**

<b>Question Number and Description</b>	<b>Correlation with Total Score</b>	<b>Question Number and Description</b>	<b>Correlation with Total Score</b>
Question 1 (General Information)	.127	Question 15 (Winnipeggers accept higher costs)	.275*
Question 2 (Information newspapers)	.177	Question 16 (Citizens responsible for air and water quality)	.434**
Question 3 (Information radio)	-.014	Question 17 (Support plant no matter what costs)	.641**
Question 4 (Trust City Council)	.023	Question 18 (Drugs or water quality)	.351**
Question 5 (Trust Friends)	.102	Question 19 (Taxes or drinking water quality)	.520**
Question 6 (Describe yourself as conservationist)	.156	Question 20 (Brita filter)	.238*
Question 7 (Pay the cost of pollution)	.588**	Question 21 (Boiled or bottle water)	.441**
Question 8 (Rate quality algae)	.381**	Question 22 (City roads or water quality)	.386**
Question 9 (Dangerous as compared to high cholesterol foods)	.191	Question 23 (Priority place on project)	.616**
Question 10 (Safeness related to cryptosporidium parasite)	.439**	Question 24 (City council rate increases)	.466**
Question 11 (Feeling about contamination)	.248*	Question 25 (Financially better or worse off than year ago)	.270*
Question 12 (Protect Env. Regardless of Cost)	.478**	Question 26 (Financially better or worse off a year from now)	.340**
Question 13 (Stricter gov. regulations)	.275*	Question 27 (Good or bad time to buy durable)	.206**
Question 14 (Fuss about environment)	.434**		

\*\* Statistically significant at .05 level    \*Statistically significant at .10 level

Note: The Pearson Product-Moment Correlation Coefficient was used for correlation calculations, which were done by the SPSS software package.

### 6.4.3 Construction of Attitude Indexes Using Factor-Analysis

The next stage of analysis will be the construction of attitude indexes, and this will follow techniques: i) developed by McClelland (1997) in the context of contingent valuation for a study on air quality, and ii) explained by Anastasi (1988) in the context of the development of psychological tests. The computer program SPSS was used for this analysis.

The same questions presented in Table 6.8 for the bivariate analysis were also entered into the SPSS program: the program works by first generating a component matrix of factors, and then rotating this matrix for several iterations to obtain a rotated matrix of factors. This exercise is an inductive test in which groups of questions called factors are generated which are closely correlated, and these can be summed for use as attitude indexes. As with other inductive tests, the results may or may not be theoretically meaningful, therefore it is up to the judgment of the researcher to determine the optimal number of factors, based on knowledge of the attitude survey and the issue being studied. A statistical test on the cumulative common variance captured by the chosen factors is also used for guidance.

For this survey, the SPSS output from three, four and five rotated factors were examined and analyzed, and the *four factors* generated appeared to be the most plausible, (See Table 6.9). Unfortunately, the cumulative common variance was quite low (40.01 percent) and this cannot be explained. McClelland (1997) recommends adding factors until 75-85 percent of the cumulative variance is explained. However, at the five and six factor levels the indexes made no sense theoretically. Interpreting these

**Table 6.9 Rotated Factor Matrix for Attitude Survey**

<b>Question</b>	<b>Factor 1</b>	<b>Factor 2</b>	<b>Factor 3</b>	<b>Factor 4</b>
Question 1 (General Info.)	-.129	.547	.087	-.046
Question 2 (Info. Newspapers)	.005	.466	-.149	-.132
Question 3 (Info. Radio)	-.261	.161	.174	-.03
Question 4 (Trust City Council)	-.046	-.456	.217	.190
Question 5 (Trust Friends)	-.124	-.094	-.012	.607
Question 6 (Describe yourself as conservationist)	.213	.031	-.151	.032
Question 7 (Pay cost pollution)	.516	-.060	.437	.193
Question 8 (Rate quality algae)	.204	.675**	-.075	.065
Question 9 (High cholest.food)	-.228	.428	.307	.423
Question 10 (Safe as cryp. Paras.)	.198	.563**	.171	.101
Question 11 (Focl about contam.)	-.020	.632**	-.118	.310
Question 12 (Protect env.regardless cost)	.595	.0098	.217	.014
Question 13 (Stricter gov.reg.)	.269	.353	.246	-.113
Question 14 (Fuss about environ.)	.337	.132	-.054	.594**
Question 15 (Winnipeg accept higher costs)	.440	.074	.482	-.139
Question 16 (Citizens respon. air and water quality)	.215	.190	.025	.550**
Question 17 (Support plant no matter cost)	.697**	.205	.194	.304
Question 18 (Drugs or water quality)	.480**	.297	.133	-.274
Question 19 (Taxes or drinking water quality)	.793**	.010	-.179	.043
Question 20 (Brita Filter)	.194	.012	-.083	.255
Question 21 (Boiled or bottle water)	.069	.533	.401	.060
Question 22 (City roads or water qualty)	.528**	.271	-.141	-.096
Question 23 (Priority place on project)	.786**	.194	.049	.041
Question 24 (City council rate increases)	.571**	-.205	.282	.143
Question 25 (Financially better off year ago)	.051	-.072	.737**	-.201
Question 26 (Financially better off year from now)	.0523	-.00859	.694**	-.079
Question 27 (Good or bad time to buy durable)	-.114	.074	.657**	.099

\*\*Correlations within factor for questions chosen for attitude indexes in respective factors (1-4)

results, the series of questions on knowledge of the water quality issue, and trust towards city councilors and friends, performed poorly as none of these lined up (loaded) with high correlations within any one factor. This confirms the poor results of the bivariate analysis, and as a result, this series of questions (1-5) will be dropped from analysis.

By comparison, factor one had a heavy loading with six questions with high correlations, ranging from .528 to of .793. It is clear that most of these questions are measures of political support for either the issue of water quality compared to drugs, roads etc., or the water filtration project through questions such as priority or supporting water rate increases. This factor can be interpreted as respondent attitudes (support or not support) towards the water quality issue from a political perspective, thus the first factor will be referred to as POLSUP (See Table 6.10).

The second factor clearly captures attitudes towards health-related concerns towards water quality. This set of questions deals with how safe respondents feel about the presence of the cryptosporidium parasite or algae in drinking water, or general feelings about contamination of the water supply. Question 9 in the survey about high cholesterol foods was included for contextual reasons, and as a validity test so it will not be included in this index, even though it loaded well in this factor, which will be called HEALTH. Again, the correlations within this factor were quite high and ranged from .563 to .675.

The third factor also performed well and captured respondent or consumer confidence with a series of questions used for the “Index of Consumer Sentiments,” designed by Katona, (1953, 1957). The within factor correlations ranged from .657 to .737, which is

quite high but not unexpected since these questions were tested extensively as an index of consumer confidence over a period of several decades, starting in the 1950's. In the next section, this index will be tested as a predictor of the willingness-to-pay for an environmental amenity, and will be referred to as CONFID.

**Table 6.10 Attitude Questions and Names of Four Factors**

<b>Name and Number of Factor</b>	<b>Questions in that Factor</b>
Factor 1 -- POLSUP	Drugs or water quality Taxes or water quality City roads or water quality Priority places on project Support city council rate increases Support plan no matter cost
Factor 2 -- HEALTH	Rate quality of water based on algae Safety of cryptosporidium parasite How feel about contamination
Factor 3 -- CONFID	Financially better off than year ago Financially better off year from now Good or bad time to buy durable
Factor 4 -- ENV	Fuss about environment Citizens response for air and water quality

Factor four had a light loading but had high correlations for two questions dealing with concern about the environment: one asked whether "everybody was making too much fuss" about the environment (.594) and another queried whether citizens should take responsibility for protecting air and water quality (.550). These questions seem to



be tapping into respondents' attitudes about environmental concern thus this factor this will be named ENV.

Thus, in the next section, four attitude indexes - POLSUP, HEALTH, CONF and ENV - will be tested as independent variables or predictors in the econometric model which uses willingness-to-pay for tap water quality as the dependent variable. Two other independent variables were constructed that have their foundation in economic theory (family income, INC, and use of a substitute, SUBSTIT) and a third is a socioeconomic variable (level of education, EDU) commonly used as a validity test in contingent valuation studies. The income variable was constructed from question 29 in which respondents were asked to estimate family income and check off one of 12 ranges provided, for example e) \$30,000 to \$39,000, or j) \$80,000 to \$89,999. These ranges were then scored from 1 to 12 and these numbers were used as inputs for the variable. The variable SUBSTIT was also censored and was constructed from questions 20 and 21, which queried respondents use of substitutes: i) a Brita or other filtering device; and ii) bottled or boiled water. This variable was constructed by scoring a 0 if neither were used, 1 if one was used and 2 if both were used. The last variable, EDU, was scored from 1 to 5 based on a question that asked respondents how many years of education they had.

## **6.5 Statistical Analysis of the Econometric Model**

The Box-Cox transformation procedure was used to investigate alternative function forms, and follows the methodology used by Sanders et al (1990) Soguel (1994) and Duffield et al (1992) for contingent valuation studies that used comparable willingness-

to-pay elicitation methods. This transformation is useful for correcting skewness of the distribution of error terms (Neter et al 1990) and this was suspected because the distribution of willingness-to-pay bids was right-skewed as has been observed by Boyle and Bishop (1988).

The Box-Cox procedure (Neter et al 1990) is based on a family of power transformations of the form in the first line of figure 6.4, where  $\lambda$  is a parameter determined from the data. This family has the list of simple transformations below where  $\lambda$  ranges from -1.0 to 2.

**Figure 6.4 Box-Cox Transformations**

$Y' = Y^\lambda$	
$\lambda = 2$	$Y' = Y^2$
$\lambda = .5$	$Y' = \sqrt{Y}$
$\lambda = 0$	$Y' = \log_e Y$
$\lambda = -.5$	$Y' = \frac{1}{\sqrt{Y}}$
$\lambda = -1.0$	$Y' = \frac{1}{Y}$

Source: Neter et al (1990)

The criterion for determining the appropriate parameter  $\lambda$  is to find the value that minimizes the error sum of squares or SSE. Both Sanders et al (1990) and Soguel (1994) determined that  $\ln Y$  or a semilog functional form was a better fit to their data

based on the Box-Cox procedure, and the results from this data were comparable. Using the Shazam (White 1993) computer program, the following output was obtained:

**Table 6.11 Results of Box-Cox Procedure**

Iteration	Lambda ( $\lambda$ )	SSE
1	1.000	1680
2	0.390	110.46
3	0.310	79.815
4	0.290	73.693
5	0.000	24.905*

\* Lowest SSE for  $\ln Y$  model

As can be seen, Shazam uses an iteration procedure that is different from Neter (1990). The iteration begins with  $\lambda=1$  and then progressively tests lower values until SSE is minimized. Table 6.11 shows that the lowest SSE of 24.905 was obtained when  $\lambda=0$  thus we can assume that a semilog functional form would be the best fit, and probably correct suspected skewness of the error terms.

The next step in the analysis is to determine which variables to include in the model and in what order, or importance. Due to the exploratory nature of this research, there is no received theoretical model for attitude indexes that can be used as a baseline for analysis. As a result, an atheoretic/inductive approach called stepwise regression was used (Neter et al 1990) in which an algorithm is utilized to determine which ones in the pool of independent variables are to be added or deleted. The F-statistic is used as a screening device for this procedure, in which independent or X variables are rotated with others in a simple linear regression with the dependent variable,  $\ln WTP$ . In the first step, the routine first fits a regression model for all the X-variables and then chooses the variable with the highest F-statistic below:

$$\text{Equation 6.1} \quad F_k = \frac{\text{MSR}(X_k)}{\text{MSE}(X_k)}$$

where MSR is the regression mean square and MSE is the error mean square. For this model, POLSUP was chosen first (See Table 6.12). For the next step, the algorithm now fits a series of models with two X-variables where POLSUP is one of the pair. For this series, the partial F-statistic is:

$$\text{Equation 6.2} \quad F_k = \frac{\text{MSR}(X_k/\text{POLSUP})}{\text{MSE}(\text{POLSUP}, X_k)}$$

The X variable with the highest partial F-statistic in this step was found to be CONF. This procedure is then repeated several times until a series of potential X-variables for the model are determined with a cut-off point set at a partial F-statistic of four. The results of this procedure on the four attitude index variables, and the income, education and substitution variable, are presented in Table 6.12. These results are to be expected and are consistent with the findings from previous sections on factor analysis. Generally, attitude indexes with the highest loadings in their factors, were also good predictors of willingness-to-pay and were stepped in

**Table 6.12 Results of Stepwise Regression (lnWTP Dependent Variable)**

Step Number	Variable Name	Status	F-Value
1	POLSUP	Stepped in	23.7586
2	CONF	Stepped in	12.2681
3	INC	Stepped in	4.9820
4	HEALTH	Stepped in	4.3222
5	EDU	If entered	1.6602
6	ENV	If entered	0.4194
7	SUBSTIT	If entered	0.2336

early with high F-statistics. The attitude index POLSUP, for example, was stepped in first and had the highest partial F-value of 23.7585, while in factor analysis, POLSUP had the highest loading with six questions, all with high within factor correlations. The same goes for the next two attitude indexes stepped in - CONF and HEALTH - these factors also had moderate loadings with three questions each. Thus it is not unexpected that factor four, ENV, performed poorly as it also had the lightest loading. The variables INC, EDU and 6.13 below.

**Table 6.13 Ordinary Least Squares Estimates of Willingness-to-Pay for Winnipeg Tap Water Quality, Semilog Model**

<b>Independent Variables</b>	<b>Estimated Coefficients</b>	<b>T-Statistics</b>	<b>P-Values</b>
POI SUP	0.1000**	3.480	0.001
CONF	0.1604**	3.097	0.003
INC	0.0680**	2.270	0.027
HEALTH	0.0925**	2.029	0.047
EDU	0.0694	1.074	0.287
ENV	0.0203	0.391	0.697
SUBSTIT	0.0135	0.217	0.829
ONSTANT	-1.3925*	-1.894	0.063

Notes: R-squared = 0.469 \*Statistically different from zero at 90 percent level

\*\*Statistically different from zero at 95 percent level or better

SUBSTIT will be discussed in the context of regression estimates presented in Table 6.13. Given the exploratory or novel approach, with a combination of attitude indexes and economic variables, the results of the ordinary least squares regression were quite good: all the variables had hypothesized signs, and four of the seven variables tested were statistically significant. The r-squared value (0.469) was also quite high when compared to other contingent valuation studies. As well, the fact that three of the four significant

variables were attitude indexes proved that beliefs and attitudes about environmental amenities are important predictors of willingness-to-pay.

As for analysis of the variables, POLSUP had the highest statistical significance at the 0.001 level, and this indicated that respondents' attitudes about the water quality issue from a political perspective - whether the issue is more important than taxes, drugs and roads - is an important predictor of willingness-to-pay. Thus people who support the water quality vocally when compared to other issues, or speak in favor of the treatment plant, are likely to value water quality highly. Similarly, CONF - the attitude index that measures consumer confidence - also performed well and was significant at the .003 level. This indicates that peoples' expectations or confidence about the economy is an important predictor for willingness-to-pay. Thus the adaptation of Katona's index of consumer sentiments for contingent valuation proved to be a useful extension of his theory. The factor HEALTH was also highly significant and this signals that people who are fearful of contamination from the cryptosporidium parasite, or algae in the city water supply, also place a high value on corrective measures to improve quality. The only attitude index that performed poorly was ENV and this measured respondents support for the environment generally. It was expected that people who feel responsible towards the environment, or who support the environmental movement (are people are making too much fuss about the environment?) would also have a high willingness-to-pay. The fact that this was not the case indicates this issue isn't likely to be readily supported by environmental groups when compared to, say, homeowners concerned about healthy water for their families.

The economic variable INC was highly significant and this is consistent with theory, and results of contingent valuation studies, however, the other economic variable - SUBSTIT - that measured substitution effects performed the poorest of all variables. This was unexpected since other results in this study indicated that substitution effects are quite strong: a full 57 percent of those surveyed said they had used a Brita filter to purify their water, and 43 percent said they had boiled or bought water in the last six months. The verbal protocol exercise also picked-up substitution effects, with a large number of respondents weighing the costs of substitutes they are currently using against an increase in their water bills if the city proceeds with a treatment plant. The explanation for this is that a portion of homeowners are likely satisfied with use of these substitutes, such as a Brita or other filters. They have entered into a routine with these defensive measures, (ordering monthly jugs of water, or replacing filters regularly on their Brita) and feel secure in their use. Thus the value they place on city-supplied water quality is quite low in some, but not all cases, and hence the low correlation with the dependent variable. This result is interesting and demonstrates the usefulness of the research design of this study. If only one method (a regression model) was used to measure substitution effects, it might have been wrongly concluded that these effects were weak or negligible. The fact that an attitude survey and verbal protocol experiment were conducted and revealed this wasn't the case, helps the researcher understand this phenomena more fully.

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### 6.5.1 Diagnostic Tests of Econometric Model

Diagnostic testing of the regression model followed techniques developed by Gujarati (1992, 1995) in a series of econometrics textbooks, while the computer program Shazam (White 1993) was used for calculations. These tests were performed to ensure that the ordinary least squares estimators for the model are BLUE: best, linear and unbiased. If, for example, autocorrelation is present, numerous errors can arise such as underestimating the residual variance, which will invalidate the tests of significance. The remainder of this section analyzes of each potential problem.

**Autocorrelation:** A Durbin Watson d-statistic was estimated at 2.1533 for the model with data ordered from lowest to highest income. Gujarati (1992) notes that the closer the d-value is to 2, the more evidence there is in favor of no autocorrelation, thus this problem was not suspected. This was confirmed by calculation of the lower limit  $d=1.768$ , and upper limit  $d=2.232$ . The fact that the d-statistic calculated for the regression falls within these two values means the null hypothesis of no positive or negative correlation can be accepted.

**Multicollinearity:** The first test of multicollinearity is whether there is a high r-squared value, but few statistically-significant variables in the estimated regression. The model has a moderate r-squared value of 0.469, and four statistically significant variables, so this test indicates no multicollinearity. A second test was performed using pair-wise correlations amongst the regressors. For this test, if a pair-wise correlation has a Pearson-Product coefficient of more than 0.80, then multicollinearity is suspected.



The result was that only one pairwise comparison - POLSUP and ENV - out of a possible 36 had an elevated coefficient: 0.596. Thus the presence of multicollinearity was ruled out.

**Heteroscedasticity:** Heteroscedasticity, or unequal error variance, was tested by visual inspection of a Shazam scatter plot of  $\hat{Y}$ -fit versus the collected residuals. This graph displayed a random dispersion of residuals with no coning, therefore heteroscedasticity was not suspected. As a further check, a Goldfield-Quandt test was performed on the ordered income variable regressed against  $\ln WTP$ . For this test, two regressions were run from sample points 1 to 35, and 36 to 70. Next, an  $\alpha$ -value was calculated using the residual sums of squares (RSS) from both regressions. Since  $\alpha=2.24 < 2.39$ , the critical F-value (.01,28,34) it was concluded that heteroscedasticity was unlikely.

**Normality:** The last procedure was the Jarque-Bera (JB) test for normality of error terms. This test first computes the skewness (S) and kurtosis (K) of the ordinary least squares residuals and uses these in the test statistic, which was calculated by Shazam as equal to 1.775. This test follows the chi-square distribution with two degrees of freedom (Guajarti 1995). Using chi-square tables, a p-value of 0.500 was obtained which is reasonably high so the normality assumption is not rejected. This result is consistent because non-normality was detected during pretesting, and so the Box-Cox procedure was used as an effective remedial measure.

## 6.6 Benefit-Cost Analysis of Water Treatment Plant Project

The purpose of this section is to do a benefit-cost analysis to determine if the construction of the water treatment plant should proceed.

The first step is to aggregate household benefits for improved tap water quality over the Winnipeg population. The mean willingness-to-pay was estimated at \$9.60 per-month from the survey, and this was multiplied by 12 months-in-year to obtain an annual willingness-to-pay of \$115.20 per household (1999 Canadian Dollars). Statistics Canada's 1996 Census estimated that Winnipeg has a total of 176,945 families, and this figure was used as a proxy for the number of city households. Multiplying this number by \$115.20, the annual willingness-to-pay for improved tap water quality for the Winnipeg population was estimated at \$20.38 million.

The next step is to calculate the present value (PV) of the stream of benefits from the water treatment plant, assuming a 30-year time horizon for the project. Using the methodology of Anderson and Settle (1977), the following equation can be used to calculate the present value when benefits are constant from year-to-year. For the water treatment plant, the annual benefits from improved water quality have been estimated at \$20.384 million, so the simplified equation is presented as:

$$\text{Equation 6.3} \quad PV = \$20.384 \text{ million} * \sum_{n=1}^{30} 1/(1+r)^n$$

where  $r$  = discount rate, and the right side of the equation, following annual benefits, is called the *present value factor* and can be estimated from a table, when the time horizon and discount rate are known. The assumption of a 30-year time horizon for the project is plausible and changes in this number have little effect on present value. An

increase to 40 years, for example, with an assumed 10 percent discount rate increases the *present value factor* from 9.427 to 9.779. However, changes in the discount rate have a substantial influence on the present value, and may even influence the final assessment of whether the project should proceed. Anderson and Settle (1977) recommend that if government guidelines for a discount rate are known, these should be used. The U.S. Office of Management and Budget recommends a discount rate of 7 percent for *water resource* public works projects, so this rate will be used as a guideline. Data for the present value factor are available from the tables in Anderson and Settle for discount rates of 5, 8 and 10 percent (not 7 percent) so these values will be used for sensitivity analysis of the project. The results of these calculations are below in Table 6.14:

**Table 6.14 Present Value of Benefits for Range of Discount Rates\***

<b>Discount Rate</b>	<b>Present Value</b>
5 percent	\$313.364 million
8 percent	\$229.484 million
10 percent	\$192.160 million

\*Assumes 30-year time horizon

This table shows the present value of the benefit flow of improved tap water quality at 5 and 8 percent exceeds project costs of \$200 million, so based on efficiency criteria the project should be undertaken. At a 10 percent discount rate, costs exceed benefits but this rate is not recommended by government so for this reason, this study will still favor construction. The other reason the filtration plant is favored is that the share paid

by Winnipeg households is only 72 percent of total costs, with the other 28 percent shared by commercial users of the municipal water supply (Wardrop Engineering 1994) whose benefits are unknown. Thus the costs borne by householders is only \$144-million. Using this figure on the cost side, even a 10 percent discount rate passes the cost-benefit test.

**Conclusion:** The city has over the past decade has taken a fiscally-conservative approach to tap water quality despite numerous warnings from health authorities about the cryptosporidium parasite, chlorine by-products and concerns raised by residents about poor taste caused by algae blooms. By waiting to slowly build a reserve before proceeding with the project, and delaying construction until 2006, the city risks health problems such as widespread sickness, that could be averted. This study looks at this issue from a different perspective: households' willing-to-pay for better quality water. The main finding is that the stream of benefits generated by this project are substantial, estimated at approximately \$230-million over a 30-year time horizon, (8 percent discount rate), compared to the costs to households of \$144 million for the treatment plant. Although this was a small sample survey, the values obtained are a reasonable estimate based on the consistency of results from numerous validity tests done in this chapter: correlation with total score, factor analysis, verbal protocol results and the econometric model that used attitude indexes, and other socioeconomic variables. Thus the recommendation is to proceed with the project in the next fiscal year, and finance it by debenture or other instrument that will be paid by city households.

## CHAPTER SEVEN CONCLUSIONS

### 7.0 Introduction

This chapter provides conclusions and recommendations for future work based on results of the contingent valuation experiment. The analysis of section 7.1 is in five parts based on aspects of the research design. These are: i) survey administration; ii) a “shopping experience” scenario for the valuation question; iii) protocol analysis, and iv) the attitude survey and econometric model. The last part of 7.1 will discuss insights from the literature search. Section 7.2 provides some final thoughts.

### 7.1 Analysis, Conclusions and Recommendations

i) **Survey:** The survey was conducted in March and April, 1999, by a Winnipeg firm that specializes in market research for small companies. The survey administration follows a technique developed by Mason (1995). This method was used because it saves on postage and printing costs. Unlike the Dillman Method (1978) which requires a series of large-sample, unsolicited mail-outs, this method utilizes a telephone pre-screening and one, smaller mail-out. However, this technique proved to be problematic as it took an average of 3.81 calls per household to retrieve answers, and 45 out of 125 people still refused to participate once they initially agreed over the phone to fill out the survey. The survey firm expressed concern and frustration about this fact.

An improvement to this method might be to screen or select people who agree to participate *in-person* at a classroom or other neutral institution for a small fee. Once people arrive at a site, they would be obligated to fill-out a survey, (and cannot tell the

survey firm to call back later). As well, during in-person surveys the level of supervision and control over the experiment improves considerably, and tape-recorded verbal protocol exercises could be carried out: this study found protocol analysis to be useful for probing cognitive processes during decision-making.

One of the drawbacks of in-person interviews, however, is that incentives would have to be used to pay for travel expenses, and to entice people to spend a few hours filling out a survey. This would add on expenses of between \$3,000-\$5,000 for a small sample survey, so cost becomes a factor.

ii) **Valuation Question:** The “shopping experience” valuation question was designed as a combination choice/iterative format to mitigate behavioral anomalies, and this strategy worked to some extent. As evidenced by the lack of high values, people appeared not to attach moral feelings or “warm glow” to the simulated shopping trip. As well, starting point bias was avoided by a technique that had respondents choosing, during the first stage, between a jug that contained cleaner, filtered water and another jug that had lower quality Winnipeg tap water. Thus the valuation question performed well in this respect.

However, the problem that did arise was related to an unexpected behavioral anomaly. There was a pronounced peak in the willingness-to-pay distribution at the \$10 bid-level, and this was interpreted as a tendency for respondents to focus on the *mid-point* of the first line of numbers. Unintentionally, two response modes were created in an effort to design a one-page question: one mode had choices and another had rows of

numbers, (see figure 5.1). Thus although attempts were made to mitigate behavioral anomalies, this proved to be a difficult.

As for an overall assessment of the valuation question: although measures taken to mitigate anomalies worked, the technique had shortcomings. It is clear that a more sophisticated research design is required such as the use of computer modules with paired comparisons, (Magat et al 1988) or a supervised experimental setting using conjoint analysis, (Desvousgnes et al 1997). However, bounded rationality provided a useful conceptual framework to understand the anomalies that *did* occur, and paves the way for similar exercises that can improve experimental techniques.

iii) **Protocol Analysis:** Of the several components of the research design, the protocol analysis proved to be the most promising. Although only 49 people completed the retrospective reports, the quality of the answers was good even though the protocol analysis was quite simple.

The purpose of this exercise was to test whether the information processing of respondents followed an economic trade-off model -- or other models such as charitable giving or symbolic bias that would invalidate the dollar figures elicited. To this end, the responses or protocols were broken into five categories: reference to economic trade-off; substitution effect; cost or income alone; water quality alone or symbolic nature.

The results indicated that the economic model *could not* be ruled out: only 8 out of 57 protocols exhibited symbolic bias and the remainder either followed the economic model or some fragment of it. One interesting finding of this study was that protocol analysis proved to be a good analytical tool to investigate substitution effects.

A recommendation of this study is to fund verbal protocol research that deals with a wide variety of environmental goods and services. To date, there is only one published contingent valuation study that uses protocol analysis.

iv) **Attitude Survey:** The attitude survey proved to be one of the most versatile aspects of this unique research design. In general, the contingent valuation literature treats survey questions other than the valuation question as extraneous: attitude scales are constructed that follow no received format, and answers are reported matter-of-factly as public opinion. As part of an interdisciplinary approach for this work, numerous aspects of an attitude survey were developed in line with modern techniques of psychological testing: Likert scales were used; a total score was derived, and factor analysis was used for screening purposes and to construct attitude indexes for an econometric model. The result was that the attitude survey used in this manner was a powerful analytical tool, and complemented other components of the research design. For example, during pretesting the willingness-to-pay question was poorly correlated within factor and with total score, and this indicated there were cognitive problems related to the elicitation. Within a boundedly rational framework, results of the attitude survey were reported as *feedback on the actual level of targets*, an aspect of a policy model presented in this study. Finally, attitude indexes were constructed using factor analysis and these were used as variables for the econometric model. This model performed well with a reasonably high  $r$ -squared (.469); four statistically significant variables, and no difficulties with autocorrelation or heteroscedasticity. Thus instead of



using socioeconomic variables to construct a model, as is the mainstream case, a consistent approach was used based on attitude indexes.

As for future research, the empirical methods for attitude surveys are well developed in the psychological sciences, however, there has been little work at integrating attitudes with economics from a conceptual viewpoint. Katona (1957, 1963) developed the index of consumer sentiments (or confidence) which has been an accurate predictor of aggregate output since the early 1960's, however, work in this area is thin especially in applications that deal specifically with contingent valuation. Based on the findings from this study, it is recommended that future interdisciplinary research (both conceptual and empirical) should be done on attitudes with emphasis on contingent valuation.

**v) Literature Review:** The literature review revealed that there has been substantial research done by psychologists and others in a satellite field that seeks, as one of its aims, to understand the decision-making process when individuals construct preferences. This field is called *behavioral decision research* and has its roots in the theory of bounded rationality developed by Herbert Simon. Although this field is rich in empirical work related to various applications - consumer research, gambles, psychological decision trees - there is a need to apply this framework more rigorously to contingent valuation, and economics generally, as this study has attempted to do. Work in this area is slim and led mostly by a group of psychologists but there is a need for academics with a background in economics to become interested in pursuing these

has been various sociological explanations as to why economists resist studying a wider set of behavioral theories (Knetsch 1999).

## **7.2 Some Final Thoughts**

Although this thesis has dealt primarily with bounded rationality and its use as a framework for contingent valuation, the environmental problem which was the focus of this study should not be underemphasized. As I write the final words to this thesis in June, 2000, 21 people (Canadian Press, 2000) were killed by contaminated drinking water in Walkertown, Ontario, and many hundreds more became ill. One of the causes of these deaths was funding cutbacks to the Ontario government water quality monitoring program. The cutbacks were short-sighted, and done primarily to reduce taxes.

As a methodology, contingent valuation provides a useful framework to help government understand how much the public is willing-to-pay for environmental improvements, and in turn, how to manage scarce public funds. In the case of Walkertown, if the Ontario government had a reasonable estimate of the public's value for a water quality program, it might not have made the cutbacks it did, and some deaths and illnesses may have been avoided. The case of Walkertown is not that dissimilar to Winnipeg and many other Canadian cities.

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**APPENDIX A**

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## Survey of the Importance of Home Drinking Water Quality to Winnipeggers

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### To the Respondent:

Thank-you for agreeing to participate in this survey. This survey is about your opinion of Winnipeg tap (drinking) water quality, and whether you want to pay more for improvements. Before answering the questions in the following pages, please take the time to read this short history of the issue.

In 1920, the City of Winnipeg decided to build a long aqueduct (a big pipe) from Winnipeg to Shoal Lake – about 100 miles east of the city – as a means of securing a pure source of water for residents to drink. Because the water quality has historically been so good, the city has never built a plant to extensively treat or filter the water. Only chlorine is added to kill bacteria that causes disease, and some fluoride is added to prevent tooth decay. Winnipeg is one of the few cities in Canada like this. In the last 20 years, however, tap water quality has been declining. One of the main reasons is development around the source, Shoal Lake. Recreational use by cottagers; mining and other activities have reduced the quality of the lake water. As well, there are two other problems:

1) The first is caused by algae build-up in reservoirs just east of the city. These reservoirs store water temporarily after it is pumped to Winnipeg from Shoal Lake. In the late summer and fall, the hot sun causes algae to grow and this causes tap water to taste and smell poorly. About five years ago, the problem got so bad in the fall that people were warned by health officials to boil their water if they had the flu or other stomach problems. However, in recent years, the city has begun to add more chlorine to improve the taste and purity. The problem is that recent research indicates there are harmful byproducts produced when chlorine is added. The concentration of these by-products in Winnipeg water only marginally meets federal health standards, which have recently been made more strict.

2) A second water problem is the cryptosporidium parasite which is detected in low concentrations periodically in the city's water supply. The parasite enters at Shoal Lake through animal feces. The general public isn't at risk; it only affects people with weak immune systems and can cause diarrhoea and nausea in those people.

The long-term plan is for the city to build a modern, \$200-million treatment plant to treat and filter out the impurities listed above. To pay for the plant, the city has begun to create a fund or reserve. City council has for the past five years increased water and sewer rates by just under 10 per cent per annum and placed these funds in a reserve.

### Ethical Standards and Consent

This survey is for research being done on water quality at the **University of Manitoba** – and meets all ethical standards specified by the Ethics Review Committee at the university. Your participation is voluntary. If you do not wish to answer any question(s) in the survey, or the entire survey – just tell the researcher and he/she will comply. Your name will be kept confidential: it will not be published in the study, and any lists of names will be destroyed. As a final precaution, the researcher will ask for your informed consent when he/she calls.

### Survey on the Importance of Home Drinking Water Quality

Please select the response that is closest to your attitude. There is no correct answer. Use a pencil or pen to fill in the appropriate circle.

					A lot	Somewhat	A little	None or Not at all	No Opinion
1) How much have you read or heard about the problem of home drinking water quality? (Not including this survey)									
2) How much information on home drinking water quality have you gotten from newspapers?									
3) How much information on home drinking water quality have you gotten from the radio?									
4) How much trust do you have in statements made by a city official or councillor about the quality of tap water you drink?									
5) Would you trust statements made by your friends about home drinking water quality?									
6) Different people have different interests. Would you describe yourself as a conservationist?									
7) Would you describe yourself as someone who wants to pay the cost of pollution control?									

					Extremely Safe	Somewhat Safe	Neutral	Somewhat Unsafe	Extremely Unsafe
8) How would you rate the quality of your drinking water in terms of contaminants such as algae or other pollutants you have read about.									
9) How dangerous or safe do you regard a diet of high cholesterol foods?									
10) How dangerous or safe do you regard low concentrations of the cryptosporidium parasite in drinking water?									
11) What is your opinion of how well you feel Winnipeg's drinking water supply is protected from contamination? This question deals with your feelings on the issue as outlined below.									
<p><b>Extremely safe</b> - I feel absolutely secure. I have no worries about the safety of the water supply.</p> <p><b>Somewhat safe</b> - I feel secure. I am confident the water supply is safe at present.</p> <p><b>Neutral</b> - I generally take for granted that the water supply is safe. I am not concerned about the water supply and assume it is safe.</p> <p><b>Somewhat unsafe</b> - I feel apprehensive. I am unsure of the water supply. I am uneasy about the future.</p> <p><b>Extremely unsafe</b> - I feel troubled. I am anxious about the water supply. I have doubts about the level of protection.</p>									

*Please select the response that is closest to your attitude.*

					Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
<p>12) Protecting the environment is so important that requirements and standards cannot be high enough. Continuing environmental improvements must be made regardless of the cost.</p> <p>○ ——— ○ ——— ○ ——— ○ ——— ○</p>									
<p>13) Stricter government regulations are needed to slow development around Shoal Lake so as to protect Winnipeg's drinking water supply even if these regulations cost jobs and recreational opportunities.</p> <p>○ ——— ○ ——— ○ ——— ○ ——— ○</p>									
<p>14) Everybody is making too much fuss about the environment</p> <p>○ ——— ○ ——— ○ ——— ○ ——— ○</p>									
<p>15) Most citizens in Winnipeg are willing to accept higher costs to improve drinking water quality in their homes.</p> <p>○ ——— ○ ——— ○ ——— ○ ——— ○</p>									
<p>16) Individual citizens have some responsibility for protecting air and water quality.</p> <p>○ ——— ○ ——— ○ ——— ○ ——— ○</p>									
<p>17) I support city plans to build a modern treatment plant to purify Winnipeg's drinking water supply no matter what the cost is.</p> <p>○ ——— ○ ——— ○ ——— ○ ——— ○</p>									

*Please circle the response on the right that is closest to your opinion.*

18) Are you more concerned with drinking water as an issue or drugs?	Drugs	Drinking Water Quality
19) Are you more concerned with taxes or drinking water quality?	Taxes	Drinking Water Quality
20) In the past six months, have you used a filtering device such as a Brita filter to purify your home drinking water?	Yes	No
21) In the past six months, have you either boiled your water to purify it or bought bottled water such as Evian water as a replacement for tap water?	Yes	No
22) Are you more concerned with the poor state of city roads or drinking water quality.	Drinking water Quality	Roads

## Survey on the Importance of Home Drinking Water Quality

Please circle the number that is closest to your opinion.

23) The city plans to spend around \$200 million to build a new water treatment plant. Construction is set to begin around the year 2006. The plant will get rid of contaminants such as algae and low concentrations of the cryptosporidium parasite - as well as improve the taste of drinking water. What priority do you place on this project? (1= Urgent, 2= Somewhat of a priority, 3=Neutral, 4=Not a priority, 5=Not goahead)

1 2 3 4 5

24) City council has for the past five years increased water and sewer rates by just under 10 per cent - and plans for similar increases until the year 2002 to pay for the treatment plant. Do you think these increases are: (1=Too high, 2=Somewhat high, 3=About right, 4=Somewhat low, 5=Too low.)

1 2 3 4 5

This section has questions about people's ability to buy higher quality water  
Please circle the response that is closest to your attitude

25) We are interested in how people are getting along financially these days. Would you say you and your family are better off, worse off or about the same financially that you were a year ago?

worse off about the same better off

26) Now, looking ahead, do you think that a year from now you will be better off financially, worse off or about the same as now?

worse off about the same better off

27) About the things that people buy for their homes - such as furniture, house furnishings, refrigerator, stove, TV and things like that. Generally speaking do you think now is a good time or bad time to buy major household items?

good time bad time

28) Please add up the before tax income of all the people who live in your house or apartment, and find a total. For example, if both husband and wife work, add their two incomes. Now, please circle the correct income group.

- a) under \$10,000
- b) \$10,000 to \$14,999
- c) \$15,000 to \$19,999
- d) \$20,000 to \$29,999
- e) \$30,000 to \$39,999
- f) \$40,000 to \$49,999
- g) \$50,000 to \$59,999
- h) \$60,000 to \$69,999
- i) \$70,000 to \$79,999
- j) \$80,000 to \$89,999
- k) \$90,000 to \$99,999

29) How many years of schooling do you have? For example, if you have a high school education that would be 12. If you have a university degree that would be 15, and so on. Please circle the correct number.

8 9 10 11 12 13 14 15 16 17 18 19 20



Please carefully consider the following scenario. Try to imagine you are experiencing the situation described. After reading it, please answer the questions that follow.

30) Currently, tap water is piped into your house continuously. To pay for that water, the city mails you a water bill every three months. Imagine that situation no longer exists. Instead, changes were made so that every Winnipegger has a choice of the type (quality) of drinking water they can buy.

There is a giant shopping centre near Polo Park owned by the City of Winnipeg and inside that store are different jugs - each jug contains a month's supply of tap water. Once you buy the jug you want at the check out stand, it is delivered to your home at no cost and hooked up so your faucets work the same way as they always have.

You can preorder one years' supply if you wish, and this is what you are about to do. Although this is an imaginary situation, try to think about your actual household costs when answering this question. Do you have mortgage payments, food costs, and is your Autopac bill due? Does your car need repairs?

Your current monthly water bill is comparable to your cable bill - about \$30 a month or \$360-a-year. The new store gives you a choice to pay more for better quality water. There are two types of jugs in the store for consumers to choose from: one jug is labelled Winnipeg Water and the other is labelled Filtered Water. Both contain a month's supply of water.

1) The WINNIPEG WATER JUG contains water the same as is currently supplied by the city. It is drawn from Shoal Lake and treated with some chlorine to eliminate bacteria that causes disease and with flouride to prevent tooth decay. It is a soft water and tastes fairly good most of the time. Every few years, however, there are low concentrations of the cryptosporidium parasite in the WINNIPEG WATER JUG but it only harms people with weak immune systems such as those with AIDS. As well, WINNIPEG WATER from time to time in the summer and fall tastes funny because of algae build up in reservoirs. More chlorine is added at the time but low concentrations of harmful byproducts are produced. Health authorities at the store tell you this water passes water quality standards but it could be better. In particular, something should be done to lower the amount of harmful byproducts created when chlorine is added. You are led to the aisle with FILTERED WATER.

2) The FILTERED WATER JUG is also drawn from Shoal Lake but it is extensively treated and filtered by a modern plant. It is cleaner and tastes better than Winnipeg but it contains more chemicals. A health authority explains the many steps that the water is put through by the plant. First, the water is filtered through a carbon filter similar to a Brita filter. This improves the taste and purity, and removes any traces of the cryptosporidium parasite. Steps are also taken so that any traces of algae are removed during the late summer and fall - so it tastes better during those periods. As well, harmful byproducts resulting from chlorination are removed. A health authority tells you FILTERED WATER passes water quality standards with flying colors.

Now, please circle the jug you would prefer to buy depending on the price charged. Recall, each jug contains a month's supply of tap water.

1) If the FILTERED WATER JUG has a price tag of \$30 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
2) If the FILTERED WATER JUG has a price tag of \$100 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
3) If the FILTERED WATER JUG has a price tag of \$31 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
4) If the FILTERED WATER JUG has a price tag of \$32 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
5) If the FILTERED WATER JUG has a price tag of \$33 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
6) If the FILTERED WATER JUG has price tag of \$34 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
7) If the FILTERED WATER JUG has a price tag of \$35 and the WINNIPEG WATER JUG has a price of \$30, which would you buy?	FILTERED WATER	WINNIPEG WATER
8) If you answered FILTERED WATER to questions 3 to 7, what is the highest price you would pay for the FILTERED WATER JUG before you would decide the price was too high and switch to WINNIPEG WATER for \$30	\$36 \$37 \$38 \$39 \$40 \$41 \$42 \$43 \$44 \$45 \$46 \$47 \$48 \$49 \$50 \$51 \$52 \$53 \$54 \$55 \$56 \$57 \$58 \$59	

31) Finally, try to recall what you were thinking about when you answered the last question, and jot those thoughts down. Please be as honest as possible. It doesn't matter how messy this answer is.

Thank-you for taking the time to answer this questionnaire. Your participation will aide research into drinking water quality at the University of Manitoba. There is not need to mail back this survey; a researcher will phone in a few days and ask you for the answers.

## **APPENDIX B**

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**Table B.1 - Assessment of Question Pool, Pretest Survey**

<b>Question Description</b>	<b>Discrimination</b>	<b>Correlation Total Score</b>	<b>Correlation Within Factor</b>	<b>Assessment</b>
Question 1 (heard about)	good	.474	.6038 high loading factor 1	good discrimination and correlation – keep
Question 2 (newspapers)	good	.554	.72879 high loading factor 1	good discrimination and correlation – keep
Question 3 (television)	good	.046	.40663 med. loading factor 2	poor correlation with total score – drop
Question 4 (radio)	good	.596	.59051 high loading factor 1	good discrim. and correlation – keep
Question 5 (friends)	good	.496	.67931 high loading factor 1	too many factor 1 questions – drop
Question 6 (government)	all but 3 same answer	.151	.65946 med. loading factor 2	poor discrimination and correlation – drop
Question 7 (More important than unemployment)	all but 2 same answer	.193	.28963 high loading factor 1	poor discrimination and correlation – drop
Question 8 (More important than crime)	all but 3 same answer	.472	.61638 high loading factor 1	poor discrimination and too many factor 1 questions – drop
Question 9 (More important than drugs)	good	.692	.82004 high loading factor 1	good discrimination and correlation – keep
Question 10 (More important than taxes)	good	.322	.27982 med. loading factor 3	good discrimination and okay correlation – keep
Question 11 (More important than education)	all but 2 same answer	.486	.60889 high loading factor 1	poor discrimination – drop
Question 12 (More important than traffic)	all but 1 same answer	.537	.54017 med. loading factor 4	poor discrimination rewrite for poor roads
Question 13 (More important than health care)	all but 1 same answer	.572	.60889 high loading factor 1	poor discrimination – drop

Question Description	Discriminate	Correlation Total Score	Correlation Within Factor	Assessment
Question 14 (Confidence in government)	good	-0.026 wrong sign	.25233 med. loading factor 4	poor correlation -- drop
Question 15 (Influence over government)	all but 3 same answer	-0.026 wrong sign	.47189 medium loading factor 2	poor discrim. and correlation --drop
Question 16 (Trust federal government)	good	-0.197 wrong sign	.10295 medium loading factor 3	poor correlation with total score -- drop
Question 17 (Trust newspapers)	all but 4 same answer	.052	-.00573 wrong sign high loading factor 1	poor discrimination and correlation -- drop
Question 18 (Trust Scientists)	all but 2 same answer	.318	.15399 high loading factor 1	poor discrimination -- drop
Question 19 (Trust City Officials)	good	-.054 wrong sign	.11193 medium loading factor 3	good discrimination -- keep
Question 20 (Trust friends)	good	.243	.31253 medium loading factor 3	good discrimination and fair correlation -- keep
Question 21 (Are you outdoors person)	good	.275	.41936 medium loading factor 4	poor correlation with total score -- drop
Question 22 (Are you conservation-ist)	good	.778	.84798 high loading factor 4	good discrimination and good correlation -- keep
Question 23 (Concerned about pollution)	good	.496	.59204 high loading factor 1	good but too many factor 1's -- drop
Question 24 (Pay Costs of Pollution)	good	.542	.77534 high loading factor 1	good discrimination and correlation -- keep
Question 25 (Are you environment.)	good	.510	.61896 high loading factor 1	good but too many factor 1's -- drop
Question 26 (Support Stricter Regulations)	all but 1 same answer	-0.055 wrong sign	.42516 medium loading factor 2	poor discrimination -- rewrite to improve this.
Question 27 (Interested in issue)	good	.289	.52070 high loading factor 1	good discrimination; poor correlation -- keep

Question Description	Discriminate	Correlation Total Score	Correlation Within Factor	Assessment
Question 28 (Rate quality of water)	good	-0.093 wrong sign	.73180 medium loading factor 2	poor correlation – drop
Question 29 (How contaminated)	good	0.598	.58561 high loading factor 1	good discrimination and correlation – keep
Question 30 (Chlorine is safe)	good	0.387	.47703 high loading factor 1	Good discrimination and poor correlation – too many factor 1's -- drop
Question 31 (algae is safe)	good	0.094	.34324 medium loading factor 3	poor correlation – important question, rewrite
Question 32 (Safe as high cholesterol)	good	0.573	.46350 medium loading factor 3	good discrimination and correlation – keep
Question 33 (Chryosporid. safe)	good	0.153	.44675 medium loading factor 3	good discrimination and poor correlation – important question – keep
Question 34 (Safe as smoking)	all but 3 same answer	0.192	.60925 medium loading factor 2	poor discrimination and correlation – drop
Question 35 (How safe from contam.)	good	0.351	.58742 medium loading factor 2	good discrimination and fair correlation – keep
Question 36 (How urgent)	good	0.551	.54091 high loading factor 1	good discrimination and correlation – keep
Question 37 (Put ahead)	good	0.241	.51965 medium loading factor 2	poor correlation – drop
Question 38 (Cost of treatment plant)	good	0.254	.42581 medium loading factor 4	good discrimination; okay factor correlation. Important for context – keep
Question 39 (Water use)	good	0.319	.65600 medium loading factor 4	good discrimination and factor correlation – keep
Question 40 (Willingness to Pay) *	good	0.166	.36272 medium loading factor 4	good discrimination poor otherwise – Reword: this is valuation question and important. Poor psychometric results indication need for major rewrite of scenario.
Question 41 (Economic Growth Important)	good	0.171	.14608 medium loading factor 2	poor correlation – drop
Question 42 (Protect Environment)	good	0.339	.45132 medium loading factor 3	good discrimination and factor correlation – keep

<b>Question Description</b>	<b>Discriminate</b>	<b>Correlation Total Score</b>	<b>Correlation Within Factor</b>	<b>Assessment</b>
Question 43 (Citizens Responsible)	good	0.409	.42385 medium loading factor 4	good discrimination and correlation -- keep
Question 44 (Accept High Cost)	good	0.179	.68721 medium loading factor 4	good discrimination and correlation within factor -- keep
Question 45 (Too much fuss about environment)	good	0.424	.477330 medium loading factor 4	good discrimination and correlation -- keep

\* The valuation question asked respondents to check off an amount from \$1 to \$11 in response to the following:  
 "How much more is your family willing-to-pay per month to fund a new treatment plant to improve the quality of your drinking water?"