HUMAN VALUE MEASUREMENT AND VALIDITY VERIFICATION

by

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STATEMENT OF AUTHOR

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ABSTRACT-

The problem of devising a method for measuring human values in the context of a particular situation is presented. The history of traditional value theory is discussed along with its application to this problem. Additional theory is derived and combined with portions of traditional value theory to form a basis for the construction of a paired comparisons questionnaire which is used to determine individual values. The results of the questionnaire are discussed and comments are made concerning the derivation of individual preference indifference regions based on the questionnaire results.

CHAPTER 1

INTRODUCTION

1.1. History of Value Theory.

The following represents a very brief history of value, or utility, and does not attempt to delve into the fine points of the theory. For a more detailed history of utility, especially with regard to the economics of risks, Arrow's review article (1) is a good reference.

The earliest mathematical studies of probability were largely concerned with gambling, particularly with the question of which of several available cash gambles was most advantageous. Early probabilists advanced the maxim that the gamble with the highest expected winnings was the best or, in terms of utility, that wealth measured in cash was a utility function. This has been referred to, although sometimes not too accurately in the literature by Savage, as the "principle of mathematical expectation." Daniel Bernoulli (1700-1782) in his paper (2) seems to be the first to point out that the above maxim was at best a rule of thumb and he suggested maximization of expected utility as a more valid principle. Bernoulli presented many examples to show that the "principle of mathematical expectation" was not universally applicable. In one

instance he cited: "To justify these remarks, let us suppose a pauper happens to acquire a lottery ticket by which he may with equal probability win either nothing or 20,000 ducats; and would he be acting foolishly if he sold it for 9,000 ducats?"

Appealing to intuition, Bernoulli said that the cash value of a person's wealth was not its true, or moral, worth to him. Therefore, according to Bernoulli, the dollar might be precious to the pauper and worthless to the millionaire, or even worthless to the pauper should he become a millionaire. Bernoulli then postulated that people do seek to maximize the expected value of moral worth, or moral expectation. Savage (13) called this moral worth of a person's wealth the utility of the wealth, and moral expectation the expectation of utility.

During this period when the "probability-less" idea of utility was popular with economists, they referred to not only the utility of money but also to the utility of other consequences or results such as commodities. The theory of choice among consequences at this time was that the person prefers, from among the available consequences, the one that has the highest utility for him. The "probability-less" idea of utility in economics was completely discredited in the eyes of almost all economists due to widely accepted arguments put forth by such individuals as Pareto (10). His argument pointed out that

utility must control acts as well as consequences. He argued that utility based on consequences increasing wealth alone could not be determined and that in fact any strictly monotonically increasing function would suffice, this provision assuming that almost nobody throws money away.

Somewhat later Ramsey (11) revived some interest in Bernoulli's ideas of utility by improving on Bernoulli by defining utility operationally in terms of the behavior of a person constrained by certain postulates. Ramsey's essays, though now much appreciated, seemed to have had relatively little initial influence.

Between the time of Ramsey and that of von Neumann and Morgenstern there was interest in breaking away from the idea of maximizing expected utility, at least so far as economic theory was concerned. von Neumann and Morgenstern initiated among economists and, to a lesser extent, also among statisticians an intense revival of interest in the technical utility concept by their treatment of utility (16). The von Neumann-Morgenstern theory of utility produced this reaction because it gave strong intuitive grounds for accepting the Bernoullian utility hypothesis as a consequence of reasonably well-accepted maxims of behavior. A somewhat detailed presentation of the von Neumann-Morgenstern theory is presented in Chapter 2 of this thesis.

It should be noted however, that the von Neumann-Morgenstern theory resulted in a great deal of criticism because of the rigidity of the theory. Typical of the type criticism directed at the von Neumann-Morgenstern theory is that offered by Fishburn (8).

> If these axioms are used as guides for consistency in judgment in measuring an individual's utilities or relative values for use in a normative decision theory, it should be noted that they impute to the individual exceptionally firm powers of discriminatory judgment, a supposition which defies common sense and which behavioral experiments have been refuting for years.

It should also be noted that von Neumann and Morgenstern were quite aware of this and other deficiencies in their theory.

The interest and criticism generated by the von Neumann-Morgenstern theory resulted in the appearance of other axioms and theories on value. Savage for instance, realizing that the von Neumann-Morgenstern theory did not account for the difficulty posed by personal probabilities (individual opinion as to the chance of an event happening) developed an axiomatic system into which was interwoven the notion of subjective or personal probability. Suppes & Winet (15), on the other hand, proceeded on a different foundation, using the notion of utility differences and not explicitly employing any probabilistic notions. Other recent axiomatic systems

have been developed by Luce and Raiffa (9), Chernoff and Moses (3) Debreu (6) and others.

1.2. Objective of Thesis.

The history of value, or utility, theory presented in the previous section gives an indication that existing axiomatic systems and their associated theories tend to be rigid to a point that exceeds practicality. From the introduction of the von Neumann-Morgenstern theory, which has very difficult practical utility applications, attempts have been made to devise an axiomatic system, or improvise on the von Neumann-Morgenstern system, in such a way as to reach a state where individual values can indeed be measured or determined. The immense worth of this goal can be readily seen in today's system structure. Suppose, for instance, that Alpha Company puts out a very expensive, complex product that goes through a rather lengthy production cycle. Further assume that upon completion of the production cycle that, on occasion, Alpha's product averages an 80 percent operational efficiency rather than 100 percent operational efficiency because of the complexity of the production cycle. Alpha realizes that if they can submit their product to a post-production systems check that lasts a period of 10 time units they can raise the operational efficiency of their product to 90 percent. Past records further show that if this systems check is

performed on their product for a period of 20 time units the operational efficiency can be placed at 100 percent. The problem that Alpha faces, of course, is that of attempting to determine the value their customers place on a delay in delivery date of a more efficient product as opposed to immediate delivery of a less efficient product. Specifically what, if anything, does the company lose in terms of such things as customer satisfaction and good will when it holds the product for a period of 10 or 20 time units for the systems check rather than delivering as scheduled?

Clearly some of Alpha's customers would be willing to wait for delivery with the knowledge that they would receive a more efficient product. On the other hand, some customers would perhaps feel that they ordered the product with the idea in mind that delivery would be made on a certain date and that any delay would prove most inconvenient. Therefore if there were some way for Alpha to measure these customer values, they could perhaps determine that the delivery delay costs the company enough in customer relations to warrant the expense of a revision in their production system to eliminate the possibility of turning out these inefficient products. On the other hand, they might discover that, distasteful as the delays may be, customer relations do not suffer enough to merit the production system change.

The application of the problem presented in this example to an engineering problem is perhaps not too clear and should be discussed at this time. In this instance, the primary concern is the proper and efficient functioning of the system, which is further classified as a production system. The efficiency of this system is primarily determined by its design and in this example the finished product is adversely affected by a design weakness. A design change can be incorporated at great expense by the company and their problem is attempting to determine if the loss in customer relationship and good-will suffered by the company is sufficient to warrant the implementation of the design change.

The design problem in this example can be defined as an engineering design problem although admittedly it can probably be more accurately described as an Operations Research problem where optimization of the system operation is desired subject to restraints dictated by customer reactions (values).

This thesis, then, proposes one method of human value measurement. As a case study, the author has designed a questionnaire that uses as its basis automatic washing machines. These washing machines are identical in features and conveniences with the exception of load capacity. A 10 pound load capacity machine at a selling price of $200 is used as a basis for comparison and through

the questionnaire, the range of values of an interviewee for both a 14 pound capacity washer and an 18 pound capacity washer is determined. The resulting value intervals for each interviewee is then verified through sales data made available to the author.

1.3. Method Used.

Several methods of measurement were considered by the author, including one method that did not utilize the questionnaire technique. The method finally used was that of a questionnaire composed of a series of adaptive paired comparisons. In most cases this method proved to be convenient and adequate although there were some isolated instances of interviewee confusion. A description of methods considered can be found in Chapter 3.

CHAPTER 2

ANALYSIS OF NECESSARY BACKGROUND INFORMATION

2.1. Introduction.

The subject of value, or utility, theory is very broad and to gain a true appreciation of the complexity of the subject, it is necessary to delve into such topics as decision theory and subjective probability theory, to mention just two of the associated subjects. It is not necessary for the reader of this thesis to be an expert in the above fields but there are certain topics in which his familiarity would aid in his understanding of this thesis. The next two sections are designed to provide helpful background information to the reader while the third section introduces some new ideas to the utility concept.

2.2. Measurement.

As stated previously, this thesis is concerned with the measurement of human values. Measurement, however, means little unless it is discussed with reference to some basis or scale of measurement. For example, the distinction between models and theories lies in the domain of measurement. A measurement scale, such as an ordinal, interval, or ratio scale is a model and needs only to be

internally consistent. As soon as behavior or data are measured by being mapped into one of these scales, then the model becomes a theory about that data that may be either right or wrong. The theory of von Neumann and Morgenstern for instance has as its basis an axiomatic system which sets forth the behavior pattern of an individual. If the individual fits into the mold described by this axiomatic system then value measurement in terms of an interval scale is valid. The reader should refer to the next section for a development of the von Neumann-Morgenstern system.

The first comprehensive classification of the mathematical models used in conventional measurement theory was made by Stevens (14). He classified scales of measurement into nominal, ordinal, interval, and ratio scales, the latter two christened by him. Because of the literature available on these scales they will be briefly summarized here only to provide a basis for understanding the scale forms resulting from axiomatic systems that are mentioned.

The mathematical model of measurement is said to be nominal if it merely contributes a listing of symbols in any order. In other words, measurement at its weakest level exists when numbers or other symbols are used simply to classify an object, person, or characteristic.

A nominal scale M may be subjected to any 1-1 transformation without gain or loss in information.

An ordinal scale of measurement is implied if there is a natural ranking of the objects of measurement according to some attribute. More precisely, the ordinal scale is appropriate if the objects of measurement can be partitioned into classes in such a manner that: a) elements which belong to the same class can be considered equivalent relative to the attribute in question; b) a comparative judgment or an order relation can be made between each pair of distinct classes (for example, class X is more preferable than class Y where the word preferable could be replaced by any applicable descriptive word implying an order relation); c) there is an element of consistency in these comparative judgments - namely if class X is more preferable than class Y and class Y is more preferable than class Z, then class X is more preferable than class Z (in other words, the established order relation is transitive). For example, the familiar socio-economic classes, upper, middle, and lower, imply the measurement of socio-economic status on an ordinal scale. These three classes could be represented by the numbers 1, 2, 3 without any gain or loss of information.

The measurement is said to be an interval scale, according to Stevens, when the set M consists of the real numbers and any linear transformation, $y=ax+b (a\neq 0)$, on M

is permissible. In other words, when a scale has all the characteristics of an ordinal scale and when in addition the distances between any two numbers on the scale are of known size, then measurement is an interval scale. Measurement on an interval scale is achieved with a constant unit of measurement and an arbitrary zero point. An example of an interval scale is the measurement of temperature. The scales commonly used are centigrade and Fahrenheit, both interval scales. The unit of measurement and zero point in measuring temperature are arbitrary; they are different for the two scales. However, both scales contain the same amount and the same kind of information because they are linearly related, i.e., F=9/5C+32.

If the set M consists of the real numbers subject only to the transformation group y=cx where c is any non-zero scalar, the scale is called a ratio scale. Measurement on a ratio scale is achieved with an absolute zero and a constant unit of measurement. The scalar c signifies that only the unit of measurement is arbitrary. In a ratio scale all the operations of arithmetic are permissible. Two of the most familiar examples of ratio scales are the measurement of length and weight.

2.3. The von Neumann-Morgenstern Axioms.

As indicated in earlier parts of this thesis, the von Neumann-Morgenstern theory ranks among the more popular decision-value theories developed in recent years. This theory stimulated a great deal of work in the value field from both the theory supporting and amplifying standpoint as well as the critical viewpoint. Since much of the written matter produced in the field of value theory has resulted from the von Neumann-Morgenstern theory, it is advisable to include a brief description of their postulates both to acquaint the reader with their theory and to illustrate the complexity of the value theory field.

The primitive notions of the axioms are as follows:

1. A set Ω of elements w, x, y,....
2. A binary relation $\succsim$ over Ω.
3. The set π of all real numbers $\alpha, \beta, \ldots$ strictly between 0 and 1 $(0<\alpha<1)$.
4. An operation $(\alpha, x; 1-\alpha, y)$ such that $(\alpha, x; 1-\alpha, y) \in \Omega$ if and only if $x, y \in \Omega$ and $\alpha \in \pi$.

With $x, y \in \Omega$, the following definitions hold:

1. $x \succ y$ if and only if $x \succsim y$ and not $y \succsim x$.
2. $y \prec x$ if and only if $x \succ y$.
3. $x \sim y$ if and only if $x \succsim y$ and $y \succsim x$.

In the context of a decision situation, the primitives should be interpreted as follows. The elements of Ω are the entities the worth of which to the individual we wish to measure. The elements of π are interpreted as probabilities. The following are read as indicated:

$x \succsim y$ as: y is not preferred to x by the individual.

$x > y$ as: x is preferred to y by the individual.

$x \sim y$ as: the individual considers x and y to be equally desirable (or undesirable).

$(\alpha, x; 1-\alpha, y)$ as: The combination of x with probability α, y with probability $1-\alpha$; or the gamble from which x results with probability α and y results with probability $1-\alpha$ (one and only one of these resulting).

With the understanding that w, x, y, $(\alpha, x: 1-\alpha, y), \ldots$, are elements of Ω and α and β are elements of π, the axioms (a) and their interpretations (i) are:

1.(a). For any two x, y, one and only one of the following holds: $x > y$, $y > x$, $x \sim y$.

(i). Any two elements of Ω are directly comparable. Either one is preferred to the other or the two are equally desirable (or undesirable).

2.(a). If $x > w$ and $w > y$, then $x > y$.

(i). The preference relation is transitive. If you prefer milk to coffee and coffee to tea, then you prefer milk to tea.

3.(a). If $x \succsim y$, then $x \succ (\alpha, x; 1-\alpha, y)$ for any α.

(i). If x is preferred over y, then x is preferred over any gamble involving x and y.

4.(a). If $x \prec y$ then $x \prec (\alpha, x; 1-\alpha, y)$ for any α.

(i). This is the dual of 3.(a).

5.(a). If $x \succ w \succ y$, then there is an α such that $(\alpha, x; 1-\alpha, y) \succ w$.

(i). If x is preferable to w and w preferable to y, then there is some gamble involving x and y that is preferable to w.

6.(a). If $x \prec w \prec y$ then there is an α such that $(\alpha, x; 1-\alpha, y) \prec w$.

(i). This is the dual of 5.(a).

7.(a). $(\alpha, x; 1-\alpha, y) \sim (1-\alpha, y; \alpha, x)$.

(i). The arrangement of alternatives in a gamble is irrelevant, or the other in which the alternatives in a gamble are presented or named is irrelevant.

8.(a). $(\alpha, (\beta, x; 1-\beta, y); 1-\alpha, y) \sim (\alpha\beta, x; 1-\alpha\beta, y)$.

(i). Compound gambles can be decomposed by the rules of the probability calculus without affecting their desirability.

9.(a). If $x \sim y$, then $(\alpha, x; 1-\alpha, w) \sim (\alpha, y; 1-\alpha, w)$ for any α and w.

(i). If x appears in any gamble, and if y is indifferent to x, then the gamble obtained from the original gamble by substituting y in place of x is indifferent to the original gamble.

These axioms are sufficient to guarantee the existence of a real-valued function ϕ defined on Ω such that:

1. $x>y$ if and only if $\phi(x)>\phi(y)$
2. $\phi(\alpha, x; 1-\alpha, y)=\alpha\phi(x)+(1-\alpha)\phi(y)$

These two properties are called the utility function properties. Moreover, if ϕ and ψ are two functions over Ω that satisfy (1) and (2), then they are related by

$$\psi(x)=a\phi(x)+b \quad a>0 \text{ for all } x\in\Omega$$

i.e., a von Neumann-Morgenstern utility function is unique up to a positive linear transformation.

Utility functions property (1) states that utility is monotonically increasing with preferability or desirability. If x is preferred to y, then the utility of x exceeds the utility of y, i.e., $\phi(x)>\phi(y)$. Property (2) states that the utility of a gamble equals the expected utility of that gamble, or that utilities combine with probabilities according to the rules of mathematical expectations.

Fishburn describes the interval measure of relative values as the exact value measure. As mentioned in Chapter 1 of this thesis, Savage and Suppes and Winet, in addition to von Neumann and Morgenstern, developed sets of axioms which are sufficient for the existence of a utility function unique up to a linear transformation (the same thing as that which results from the interval measure). It should be rather obvious to the reader that, in spite of the development of these theories, there remain great practical difficulties in actually trying to obtain a measure of relative value unique up to an increasing linear transformation. The von Neumann-Morgenstern axioms, for instance, in addition to Fishburn's criticism quoted earlier, have been under attack by investigators in several fields (primarily psychology and economics) because of the "rational behavior" pattern which their axioms imply. Churchman (4) has given perhaps the most thorough criticism of these behavioral suppositions.

2.4. The Applicability of Traditional Value Theory.

As indicated previously, utility theory literature since von Neumann and Morgenstern has been theoretical in nature. Weaknesses in the von Neumann-Morgenstern axiomatic system have been discovered and attempts have been made to supplement their system with additions that account for some of these weaknesses (for instance the work of Savage and Suppes and Winet referred to in

Chapter 1). It is apparent that this theory is important to the field of decision theory, specifically to that portion which deals with decision making under uncertainty. From the practical standpoint of the value theorist however, these axiomatic systems prove to be difficult to use. While the systems allow the use of an interval scale, the conditions under which the axioms apply make experimental value data quite difficult to obtain. Sanders (12) offers the interesting postulate that it would seem that for some applications, theorists such as von Neumann and Morgenstern have started at the wrong end, i.e., their theories are really too sophisticated. He states, for instance, that almost all utility theories require a transitivity postulate yet it has been successfully argued that in many decision contexts humans display intransitive behavior. In many instances, problems created by assumptions such as this are dismissed by the decision theorists by considering in their studies only "rational" decision makers. However, as indicated in the last section, the "rational" decision maker concept has come under criticism.

Although the subject of traditional value theory (von Neumann-Morgenstern era), its criticisms and contributions, is a fascinating and extensive topic, the purpose of this chapter was not to give a detailed analysis of the topic, but rather to give the reader a small

appreciation of its complexity. This thesis is primarily concerned with the actual measurement of human value rather than the conditions under which an individual's value can be measured. The next chapter introduces the method of measurement and its tie-in with traditional value theory.

CHAPTER 3

VALUE MEASUREMENT TECHNIQUES

3.1. Introduction.

The discussion in this thesis to this point has centered around a brief explanation of traditional value theory with a presentation of the von Neumann-Morgenstern axiomatic system. It was also mentioned that the traditional axiomatic systems and their associated postulates are very difficult for the value theorist to use in an applied sense. One possible alternative, mentioned earlier, stated that perhaps the value theory concepts recognized now are too sophisticated and that a simpler approach is required. This chapter goes into the human value measurement techniques considered for this thesis and refers to the value categories that are measured. In addition, it sets forth the assumptions that were made in order to make these measurements where these assumptions are in fact concerned with subject response patterns in a manner similar to the behavioral axioms devised by traditional value theorists. Also included are necessary definitions that will assist the reader in understanding the basis for the questionnaire.

3.2. Assumptions and Definitions.

Since it was not practical, or applicable, to use an established axiomatic system such as the von Neumann-Morgenstern system, there has been an attempt to modify this traditional value theory somewhat in order to form a basis for the questionnaire. It must be kept in mind that an individual behavior study is not the primary goal of this thesis nor is the complete development of a practical set of value postulates possible. In order to measure individual values certain assumptions and postulates must be used and it is these particular developments that will be discussed here.

It is perhaps best to start with the most controversial point in the field of value theory; that is, with the assumption of transitivity. The transitivity assumed here is essentially the same as that described by the von Neumann-Morgenstern axioms in that if the interviewee prefers A to B and B to C it is postulated that he then prefers A to C. The assumption of transitivity will be discussed further in connection with an assumption of monotonicity later in this section.

A second assumption that is made but one that may not be readily apparent from the questionnaire is that of the preference relations that can exist. The assumptions allows that for any two preference relations A and B, either A is preferred to B or B is preferred to A

or the interviewee is indifferent in his preference to A and B. The form of the questionnaire is such that the interviewee will have to select one of the two alternatives in this situation but it is possible in some of these situations to detect this indifference relation. As is explained in Chapter 4, questions 10, 11 and 12 form the consistency check portion of the questionnaire and it is possible in some cases to detect an indifference relation through these questions. The point here, however, is that the indifference relation on the part of the interviewee is allowed although the form of the questionnaire may not make it apparent.

The type of objects, or alternatives, that are applicable for the paired comparison questions is the next item of discussion. As indicated in Chapter 1, the foundation of the objects of comparison is the automatic washer at a certain load capacity and price. Essentially the interviewee is presented with a choice situation that involves a washer with certain load capacity and price to be compared with another washer at a different load capacity and price. It can be said then that the questionnaire is composed of pairs of alternatives with two measurable attributes, load capacity and price. It is possible to use alternatives that contain three or more attributes but in this case for purposes of simplicity the two attributes are used.

Let $X=\{x_i: i=1,n\}$ and $Y=\{y_k: k=1,m\}$ be non-empty sets and further let them be designated as attribute sets. In addition let $C_b=\{(x_b,y_b): x_b \epsilon X \text{ and } y_b \epsilon Y\}$ be referred to as the basis combination and $C=\{(x_i,y_k): i \text{ and } k \neq b\}$ be designated as the comparison combinations. Now define a function $f_b(.,.)$ as the individual preference relation function where the subscript b refers to the base reference point. This function f_b has as its domain the basis combination, C_b, and the combination, C. This means that f_b provides the means for determining individual preferences of the basis combination to the comparison combination where an output of 1 indicates preference and an output of 0 indicates non-preference of the basis to the comparison combination. There are three situations that can exist with reference to f_b, two of these three situations actually combining to make one. For instance, if the basis combination C_b is preferred ($>$) to the comparison combination C, the function yields a 1, i.e.,

$$f_b(C_b,C)=1 \text{ iff } (C_b > C).$$

If the basis combination is not preferred ($\leq$) or is equally preferred ($\sim$) to the comparison combination the output is a 0, i.e.,

$$f_b(C_b,C)=0 \text{ iff } (C_b \leq C).$$

A preference system P is then defined as $P=\{C_b, C, f_b(.,.)\}$ and is designated a complete preference system if and only if f_b is defined for all existing ordered pairs. A P-system is said to be structured if there exist two functions $f_x()$ and $f_y()$ such that:

$$y_i, y_j \in Y \Rightarrow \{[f_y(y_i, y_j)=0] \cup [f_y(y_i, y_j)=1]\} \neq 0 \ \forall \ i,j$$

and

$$x_i, x_j \in X \Rightarrow \{[f_x(x_i, x_j)=0] \cup [f_x(x_i, x_j)=1]\} \neq 0 \ \forall \ i,j.$$

The above states that there exists a rank ordering on the sets X and Y. P is then said to be a complete structured system when $P=\{C_b, C, f_b, f_x, f_y\}$ and f_b is defined for all the ordered pairs. X is defined as a monotone increasing scale if for C_b and $C_1 \subset C$ where $C_1=\{(x_1, y_k): k=1,m\}$ the following holds:

$$f_b(C_b, C_1)=0 \text{ when } f_x(x_b, x_1)=0$$

and

$$f_b(C_b, C_1)=1 \text{ when } f_x(x_b, x_1)=1$$

for $x_1 \in X$ and every $y_k \in Y$. If

$$f_b(C_b, C_1)=1 \text{ when } f_x(x_b, x_1)=0$$

and

$$f_b(C_b, C_1)=0 \text{ when } f_x(x_b, x_1)=1$$

then X is a monotone decreasing scale. If, in addition to the above, $C_2 \subset C$ where $C_2=\{(x_2, y_k): k=1,m\}$ and another function $f_2()$ is defined as taking on the values of 0 or

1 indicating non-preference or preference for each C_j and $C_k (j \neq k)$ and the following holds:

$$f_b(C_b, C_1) = 0$$
$$f_2(C_1, C_2) = 0$$
$$f_b(C_b, C_2) = 0$$

for $x_1, x_2 \in X$ and every $y_k \in Y$, then X is said to be a transitive scale. Now let P be a complete structured P-system and Y be a monotone increasing scale. Let $T_{P_b} = \{C_1, \ldots, C_n, \ldots\}$ and $C_n = \{(x_n, y_\lambda) n = 1, 2, \ldots\} \subset C$. When λ is the minimum value of j in column x_n such that

$$f_2(\{x_n, y_j\}), \{(x_n, y_{j-1})\}) = 1$$

then y is the minimum trade off point for Y_λ where

$$Y_\lambda = \{(x_i, y_{\lambda+n}) : \forall i \text{ and } n = 0, 1, 2, \ldots\}$$

T_{P_b} is called the P-NP (preference-non-preference) curve through P_b for the scale Y.

In essence then the above describes a P-NP curve which the value theorist would like to be able to determine for all of his subjects or interviewees. It states that if a complete structured P-system exists and Y is a monotone increasing scale then it can be assumed that there is a curve T_{P_b} called the P-NP curve that describes the interviewee's preference relationship to the basis set. As the interviewee indicates his preferences of C_b or C in a series of paired comparisons he reaches a value on the Y scale, y_λ, for each x which is the lower limit

of a series of y values at the particular x, all of which are preferred to the base point. Figure 1 shows a very simplified version of the P-NP curve. The small "x" points indicate those points preferred to the base point (x_b, y_b) and the small "o" points indicate those points not preferred to the base point. The y_λ point referred to previously is that y value for each x that is the minimum y value of all the points at the particular x value that are preferred to the base. Y_λ is defined previously as the set of all y_λ's along the scale for a particular x.

It is necessary at this point to explain a peculiarity of the P-NP curve. The P-NP curve generated by the questionnaire in this thesis is not an indifference curve; that is, it does not specify the exact point at which the interviewee expresses indifference to the base point. Consider Figure 2 which is a blow up of the points y_λ and $y_{\lambda-1}$ for x_1 and x_2. The P-NP curve goes through the y_λ values as indicated in Figure 2. Note however, that the y_λ value is the first point where preference to the base is indicated whereas the $y_{\lambda-1}$ value is the last point where non-preference to the base is indicated. Therefore, the P-NP curve does not reflect, in every case, the exact point where preference distinction is made. In reality, the exact curve should be thought of as existing somewhere between the y_λ and $y_{\lambda-1}$ values.

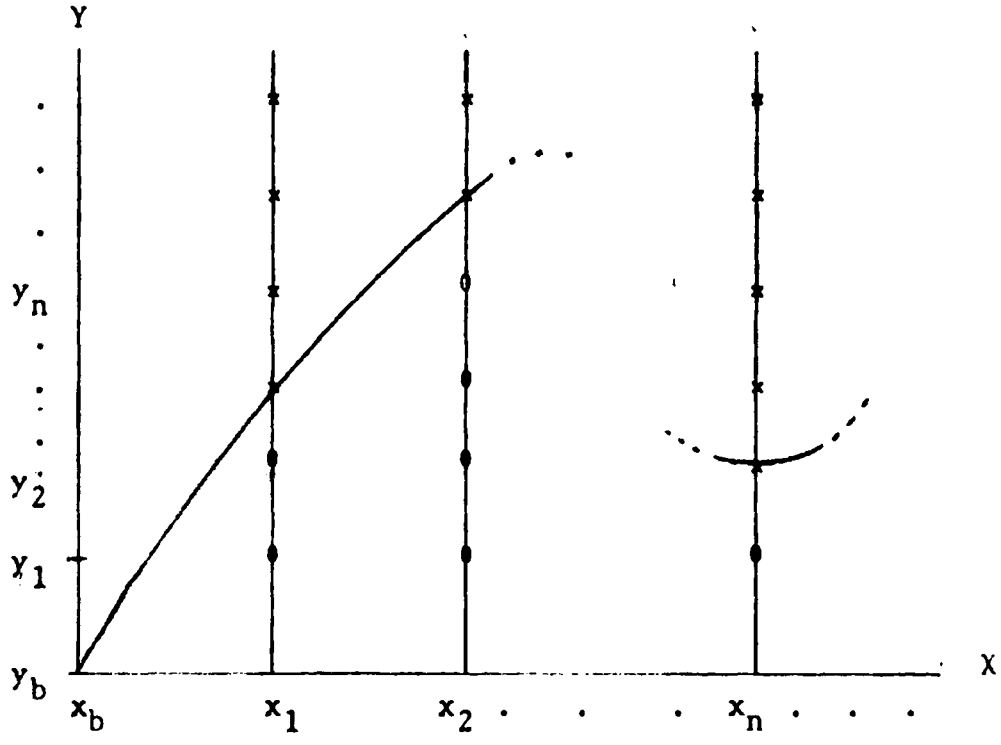

Figure 1

P-NP Curve

The questionnaire of this thesis determines a y_λ value where preference (non-preference) is first indicated but this is not necessarily the exact dividing line. The reader is cautioned to keep this in mind while reading Chapter 4.

The following describes the primary assumptions or postulates on which the questionnaire is based. These postulates are simply stated and are self explanatory based on the definitions previously cited. They will be further explained in the section which describes exactly what the questionnaire is trying to measure (4.2).

P1. Comparability: All attribute sets C presented to the interviewee are comparable to the base attribute set C_b in such a manner that one of the following is true:

a) $C_b > C$

b) $C_b < C$

c) $C_b \sim C$

P2. Monotonicity: The attribute axis designating washer price is a monotone decreasing axis.

P3. Transitivity: If the following conditions exist:

a) $C_i > C_b$

b) $C_j > C_i \quad (j \neq i)$

then $C_j > C_b$

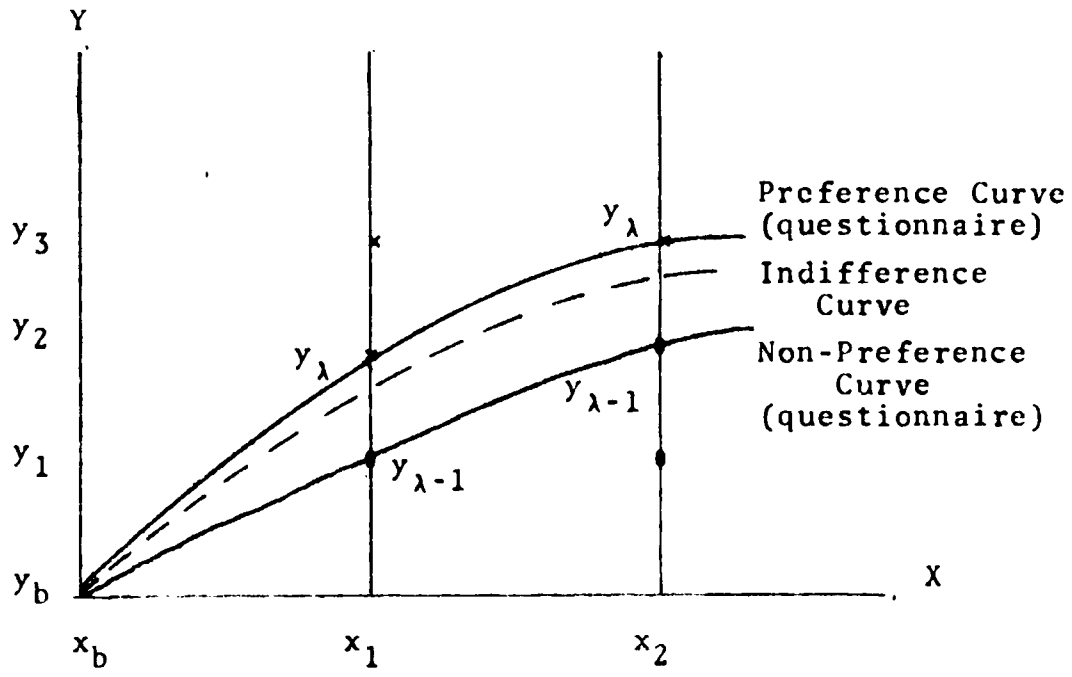

Figure 2

Indifference Curve

3.3. Questionnaire Techniques Considered.

It has been previously stated in an earlier part of this thesis that the questionnaire used is composed of a series of adaptive paired comparison questions. This means that each succeeding question to be answered is determined by the answer to the previously answered question. The purpose of this section is to give a brief synopsis of the different techniques that could have been used in the questionnaire. It is important to remember while reading this section that the purpose of the questionnaire is to determine individual values. The different types of techniques available were:

1) Ranking
2) Rating
3) Partial Paired Comparisons I
4) Partial Paired Comparisons II
5) Complete Paired Comparisons
6) Successive Comparisons

Robert T. Eckenrode (7) in his experiments discovered that 1-6 above, when tested under conditions defined in his experiment, yielded consistent results indicating that these methods were equally reliable for collecting judgment data. It was apparent then that convenience of use and meeting the objectives of the questionnaire would be the primary determining criteria for the final selection of method since it appeared that

any of the above methods could be used. In addition it was determined by the author that the questions used in the questionnaire should be simple and concise so that the interviewee would experience a minimum of difficulty in completing the questionnaire. An analysis of the possible methods listed above is as follows:

1) Ranking: In this situation it would be necessary to present to the interviewee all of the possible combinations of attribute sets for ranking. This would involve rank ordering about fifteen possible combinations of load capacity-price washers. The author decided against this method primarily because the comparisons would involve attribute sets consisting of more than one attribute. Ranking that involves more than one attribute can become quite confusing to the interviewee as he attempts to weigh the attributes one against the other in an attempt to consolidate his ranking (see 3.4 for further comments).

2) Rating: This method would also involve presenting all of the possible combinations of attribute sets to the interviewee. He would then rate the sets along some continuous scale, for instance 0 to 10. This method was not used for essentially the same reason as listed above. When more than one attribute is required to be

considered along with the task of assigning rated values, the difficulties created are too great for the purposes of this questionnaire (see 3.4 for further comments).

3) Partial Paired Comparisons I: This method involves the use of a partial matrix and the rating numbers 1 and 2. Consider for example four attribute sets A, B, C and D. The matrix would appear as in Figure 3.

	B	C	D
A	1		
B			2
C			

Figure 3

Partial Matrix

The method of rating is to consider the empty squares and placing either a 1 or 2 in the equare. For instance the 1 as shown in the above matrix indicates that A is preferred to B while the 2 shown about indicates that D is preferred to B. In this manner all combinations can be rated one to the other. Although this method seemed quite efficient and interesting, it was not utilized as it was considered too

difficult to be adequately explained in written instruction form.

4) Partial Paired Comparisons II: This method accomplishes the same purpose as the previous method except that the attribute sets are presented to the interviewee in written pairs, i.e., A - B and he is required to select the preferred set. A form of this method was selected for use and will be further explained in the next chapter.

5) Complete Paired Comparisons: This method is exactly the same as method 4 except in this case each attribute set appears twice, i.e., once as A - B and then as B - A. This method was excluded because the author decided to use an adaptive form of questioning.

6) Successive Comparisons: This is the method described by Churchman, Ackoff, and Arnoff (5). The method basically involves rank ordering of the attribute sets and then making a value assignment of 1.0 to the most important set and a value between 0 and 1 to all the other sets. Adjustments are then required to be made on these values by combination comparisons. This method was considered much too difficult for this particular questionnaire in view of the

requirement for comparisons of other than single attribute sets.

3.4. Synopsis.

As a brief extension of section 3.3, it should be explained why the failure to obtain an individual value grouping for each type washer constitutes a reason for rejection of methods (1) and (2) in addition to the rejection reason given in 3.2. These two methods do give a rank ordering of the attribute sets in question but do not really provide a means of obtaining the interviewee's values with respect to some basis for comparison. For instance, consider the case of three automatic washers A, B and C with respective load capacities a, b and c. If the interviewee prefers washer A with load capacity a, he could rank this washer at the lowest available price as first on his list. If this washer is his only real interest, his subsequent rankings may be very arbitrary. His value with respect to washer A is determined but there is no way to be reasonably sure that his other rankings constitute a realistic look at his values with respect to these washers. Consequently there exists a value grouping for washer A but questionable groupings for washers B and C. By presenting the series of paired comparisons to the interviewee he is forced to consider the alternatives in pairs rather than searching the

whole spectrum of possibilities for his first choice and then proceeding from there. The paired comparison method then at least forces the interviewee to consider all attribute sets with respect to a base set and a concise "value grouping" can be obtained for each type washer.

3.5. From Theory to Measurement.

Sections 3.2 and 3.3 have "set the stage" for the actual construction of a measurement technique which is, in this case, the questionnaire. The applicability of the theory from 3.2 to the method selected from 3.3 can be described as follows. The theory developed allows for the construction of a set of axes which constitute washer price on the vertical axis and load capacity on the horizontal axis (a detailed step-by-step development of these axes is illustrated in Chapter 4). This set of axes has as two of its properties monotonicity and transitivity as defined in 3.2. These two properties plus the stipulation that all combinations of washer load capacity and price are comparable permit the construction of an adaptive form of questionnaire containing a series of paired comparisons. If, in addition to the previously mentioned properties, there exists some ordering of values along the price axis and load capacity axis, then it is possible to construct individual curves which describe a series of points which indicate preference to the base

point and a series of points which describe non-preference to the base point.

As mentioned, Chapter 4 develops the axes and construction of the questionnaire in a detailed manner. The important point to realize here is that the theory developed in 3.2 allows for the construction of the axes which, in turn, contain certain properties. In addition, the theory permits a paired comparison questionnaire which is of the adaptive form.

CHAPTER 4

THE QUESTIONNAIRE

4.1. Background Information.

The primary problem existing in this thesis from the beginning was not so much the value measurements themselves, although this task was not simple by any means, but rather, once the value measurements were taken, how did one go about verifying the measurement results? It is possible, for instance, to obtain the price value that an individual places on a certain item merely by asking him his value, but it is not possible to state for certain that this individual would in fact buy or sell this item at the price he quoted. The problem therefore, was not just one of human value measurement but also one of verifying these measurements.

It was decided to attempt to discover a consumer product or item on which prices could be established and sales figues could be quoted. The idea was to question people about this item in an attempt to determine what price value they placed on the item and then attempt to find a way to disclose if this price value quoted was indeed the one they used as a basis for purchasing. As mentioned above, the real problem here was the validity

check and not so much the price value determination. One possible type commodity considered involved items of food and the prices paid for them. It was certainly considered feasible to obtain an individual's price value on these food items but unless the individual kept a complete itemized notation of where and how he spent his food money, the verification operation was extremely difficult to perform. Of course the test individual could have been accompanied on his shopping trips and an "on the spot observation" made of his purchases, but again this was ruled out as impractical. It became apparent then that the test item would have to involve something on which accurate sales data could be obtained. It was then decided to look into the field of larger consumer items, including among others, automatic washing machines. The problem was taken to a local outlet of Sears Roebuck & Company. The representative at Sears was interested in the problem as presented to him and revealed that applicable data could be made available on automatic washers. Specifically, he stated that sales data for an eight month period were available that included information on the various models of washers offered for sale to include their characteristics such as load capacity, cycles available, and water level settings as well as their selling prices. He also stated that numbers of washers purchased during this time period were available as well as names

and addresses of purchasers. With the knowledge that this data was available, the plan then became one of devising the questionnaire so as to determine the desired information and then either confirming or rejecting the information based on the sales records.

4.2. The Measurement.

It was obvious that before the actual questionnaire could be constructed it would be necessary to determine just exactly what was available, what was to be measured, and what portions of traditional value theory were applicable. As indicated in Chapter 3, certain parts of traditional value theory were extracted as applicable for this thesis and some theory was developed to allow for such things as monotonicity and value axes construction. It was not possible, though, to create a situation under which only traditional value theory could be applied.

It was decided to select for test purposes three of the more than ten washers available since it was concluded that sufficient information could be obtained from this combination. The three washers selected had identical features but different load capacities and prices. The washers were of 10, 14 and 18 pound capacities respectively and all contained the following features:

a) 5 wash-rinse settings

b) 2 agitation and spin speeds

c) 3 cycles

d) 3 water level settings

The features actually carried no significance other than to emphasize to the interviewee the similar capabilities of the washers and to give him an idea of the quality of the product about which he would be questioned.

The next item to be considered was the value that was to be measured for each interviewee. From the data made available by Sears, individuals who had purchased one of the three test washers were arbitrarily selected and listed as potential interviewees. At this point there were available test washers on which to base the questionnaire, potential interviewees to whom the questionnaire could be administered, and the data as to what type of the test washer they had purchased and the price of purchase. An important assumption to be noted at this stage was that each potential interviewee knew the washers available for purchase at Sears and that his purchase was made with this in mind as well as considering other factors such as family needs and finances. Therefore, it was determined that the questionnaire could extract from him his price values of the three washers and that the values could be verified by the data on his acutal purchase. This can be illustrated by referring at this point to

Figure 4. If a Price vs. Load Capacity scale is set up it can be seen that the Load Capacity scale has three points to denote the test machines. The price scale however can be considered a virtual continuum in that if the scale were to run from the figure of the lowest priced test model to the figure for the highest priced test model in increments of dollars and cents the axis would be finite but extremely large. Therefore, the first thing that had to be done was to make this axis discrete to a point where it could be made practical to use. In order to do this it had to be realized that the determination of true interviewee price values would not be possible and that some type of approximation would be needed. One other important point to be noted was that two attribute sets (price and load capacity) were being considered, the key word in this case being sets. It was decided therefore to make the Price axis finite by considering a range of $200 to $235 and marked off in the increments as shown in Figure 5. The increments made were based on the data available from Sears. It was now possible to measure interviewee price values within a certain range of values rather than at a specific price value. One interesting problem generated by incrementing this axis was the temptation to label the Price axis as an interval axis. It was not apparent at all that this axis met the requirements of an interval scale as described in Chapter 2.

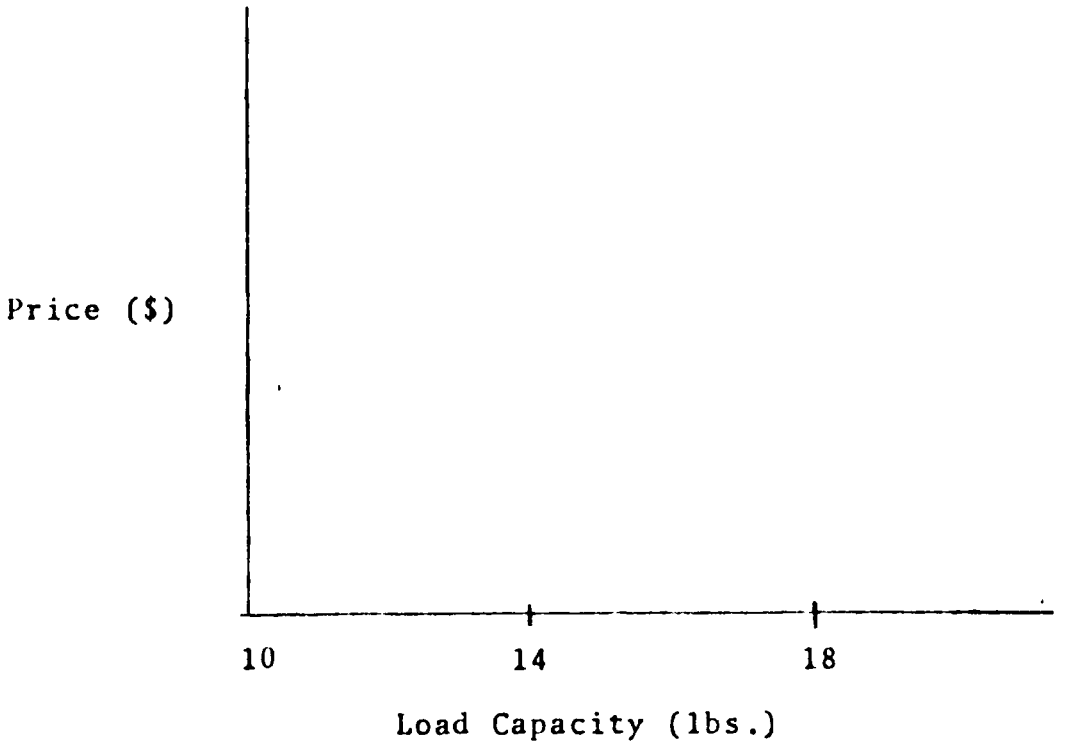

Figure 4

The Value Axes

Moreover it was obvious that the Load Capacity axis could not be considered an interval axis (scale) since not even monotonicity could be made to apply to the axis.

A solution to this measurement problem was brought about by referring again to the key word sets. The measurement actually involved "two attribute" sets and the requirement to measure them. Consider again the interviewee in his role of washer purchaser at Sears. If, from the three test machines, he knows the 10 pound washer at a price of $200 is the lowest priced machine available, he can start his purchase considerations there and either buy that machine or go to one of the others depending on his factors of purchase. If his factors of purchase were limited only to price and load capacity then the "two attribute" set situation exists. Therefore, it was decided to base the questionnaire on a series of paired comparisons of the base set, the 10 pound machine at $200, with various comparison sets. A graphical picture of this can be seen in Figure 6. This fugure shows the value set groupings which are indicated by the asterick numbers. As indicated, the basis set is the 10 pound machine at $200. Comparison sets involving the 14 and 18 pound washers are successively compared to the basis set and preferences indicated by the interviewee. Through this series of preference indications it was then possible to place each interviewee into one of the value set groupings

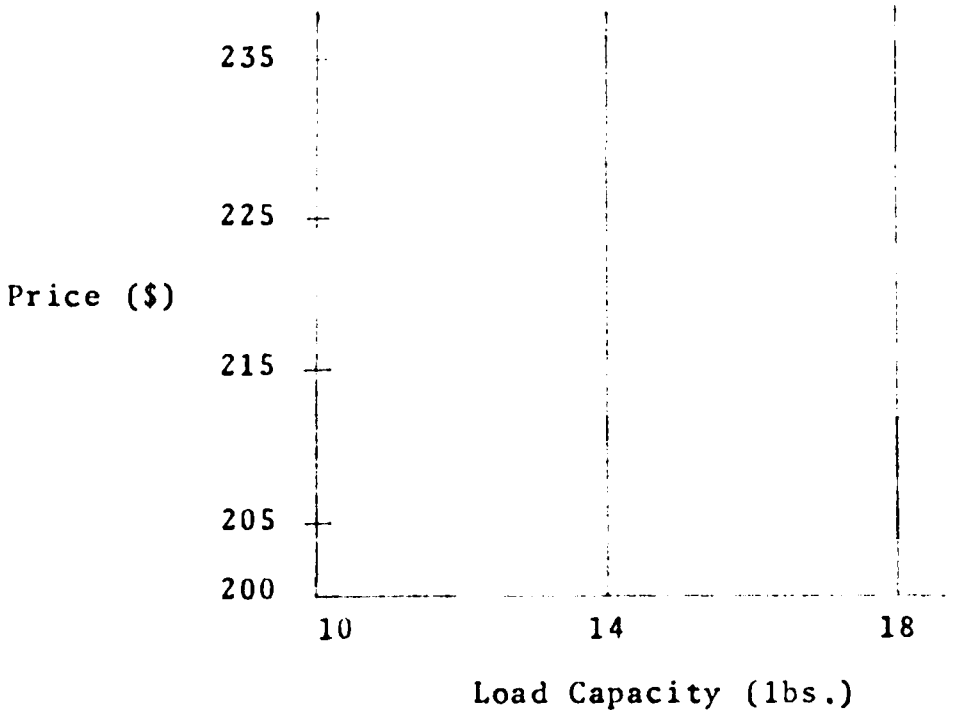

Figure 5

The Incremented Value Axes

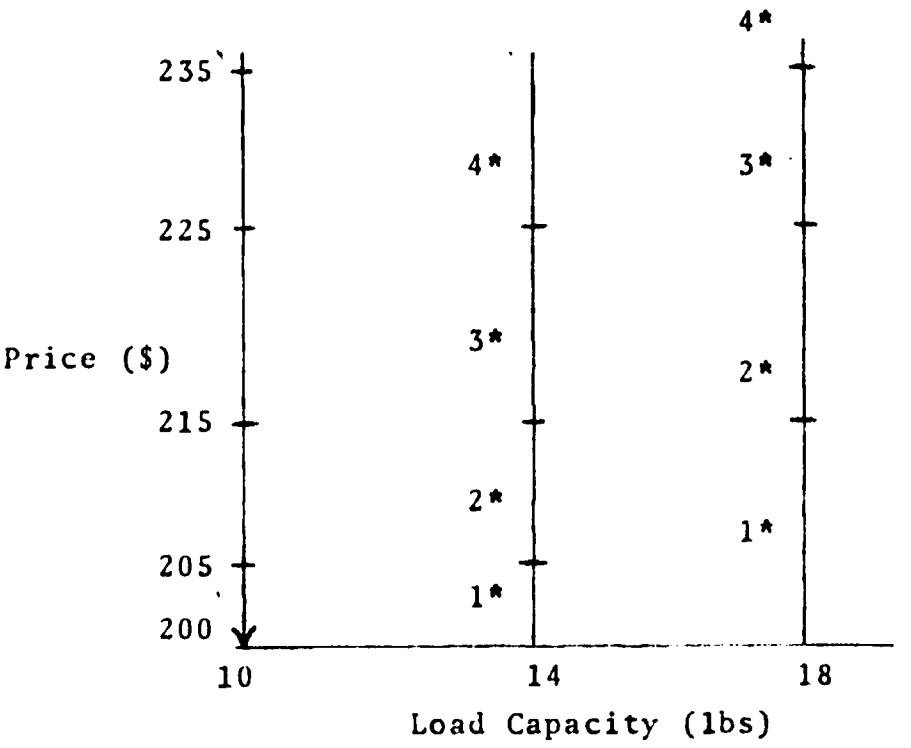

Figure 6

Value Set Groupings

for both the 14 and 18 pound machine as compared to the basis set. The measurement then made is that of set grouping rather than specific value price. In other words each interviewee is placed within one of the four set groupings as shown in Figure 6. One shortcoming to traditional value theory should be pointed out. When the interviewee is placed in one of the value set groupings, this is his set grouping as compared to the basis set, i.e., it is somewhere in this grouping that he is indifferent to the basis set. The explanations in this section offer no basis for comparisons within the 14 and 18 pound classifications. The questionnaire compares sets with the basis set and does not offer a means for any other comparisons. Traditional value theory, if applied in its entirety, would provide for preference relations of all the sets.

4.3. The Questionnaire Structure.

The structure of the questionnaire centers around the use of fourteen adaptive questions and the assumptions made by the author with regard to monotonicity and transitivity. The assumption of monotonicity can be denoted on Figure 6 by the arrow in the downward direction on the price scale. This arrow denotes a monotone decreasing axis. This assumption actually allows the use of adaptive questions. For instance, by referring to the

questionnaire (Appendix A), it can be seen that the first question presents the choice of the 14 pound washer at $225 or the base machine to the interviewee. Suppose that he chooses option 2 and is sent to question 2. He then selects option 2 of question 2 and is directed to question 10 which in turn will lead him through questions 11 and 12. These three questions, 10, 11 and 12 constitute a consistency check and will be discussed later. It is sufficient to note at this point that they contribute nothing to the interviewee's placement in a value set group. Therefore, this particular interviewee has indicated that he prefers the 14 pound machine at $235 to the base machine. By referring to Figure 6 it can be noted that in each case his preference indicates he is at the top of the scale for the 14 pound machine and the 18 pound machine. Since decreasing monotonicity of the price scale is assumed, there is no need to further question the interviewee. This is because monotonicity permits the author to assume that since the interviewee has indicated that he prefers the 14 pound machine at $225 he would also prefer the 14 pound machine to the base machine at any price less than $225. The same reasoning permits the author to assume that the interviewee would prefer the 18 pound machine at any price less than $235 to the base machine. This can be seen graphically in Figure 7. As indicated the interviewee has indicated

preferences that place him in group 4* for both the 14 and 18 pound machines. If "x" marks indicate preference relations it can be seen that his preference relation runs the length of both scales. If, for instance, his group is 2 for the 14 pound machine and 2 for the 18 pound machine and if "0" represent non-preferred values, the graphical picture is as seen in Figure 8. Once again the monotonicity assumption enables the x's to be extended down the scale. The use of adaptive questions therefore enables the interviewee to bypass questions that need not be answered because of the monotonicity assumption. While it can be assumed that decreasing washer prices are viewed favorably by a potential washer purchaser, it is not clear that this principle of monotonicity holds on the horizontal, or load capacity, scale. If all machine characteristics are the same, it cannot be necessarily assumed that people will automatically want "more pounds capacity for their dollar." Therefore, the assumption of monotonicity does not apply to the load capacity scale. In regard to this, questions 10, 11 and 12 follow the price monotonicity assumption and form the "consistency check" portion of the questionnaire. All of the interviewees, regardless of their question answering sequence, are directed through questions 10, 11 and 12 as their finishing questions. Specifically these questions merely check to see if the interviewee has behaved

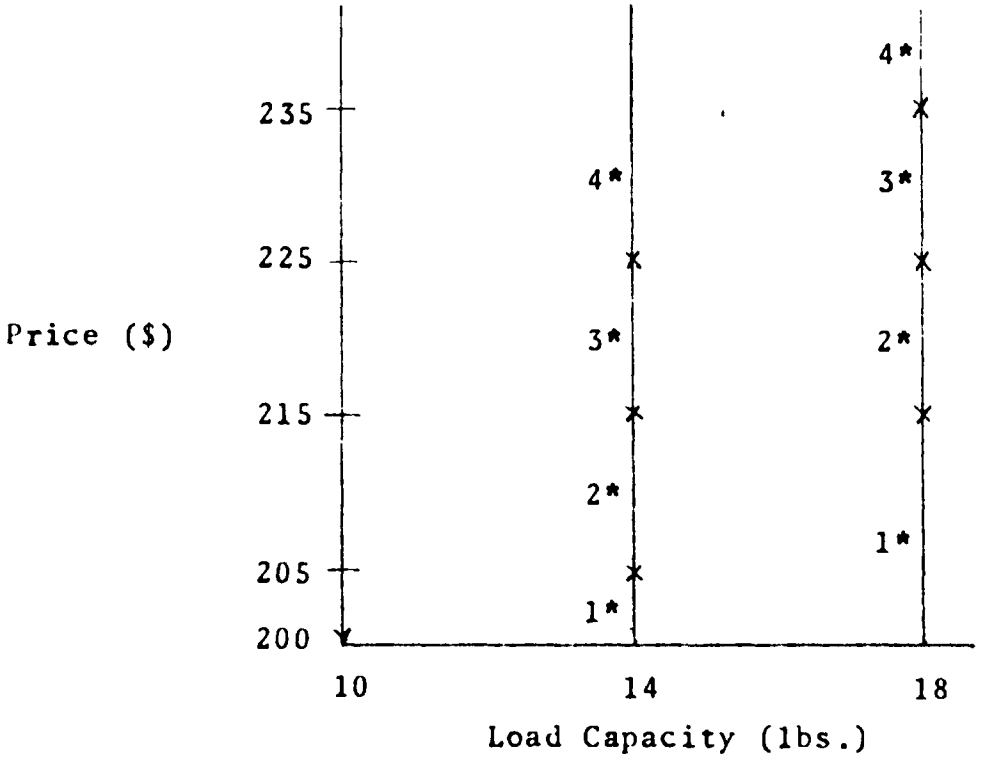

Figure 7

Preference Indications

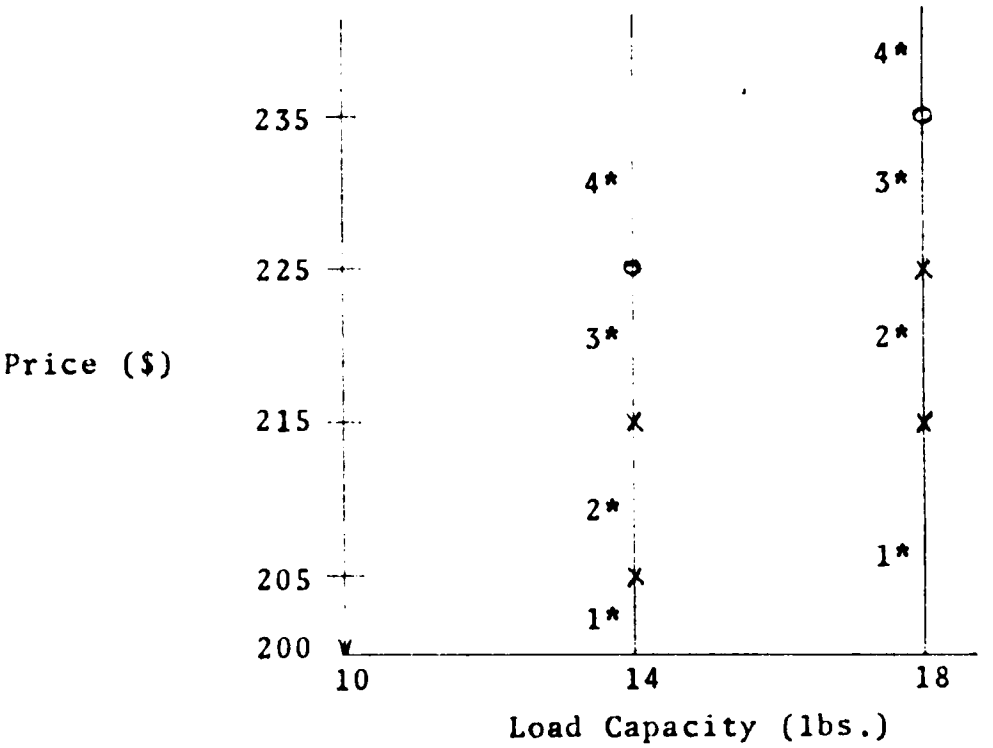

Figure 8

Preference Indications

according to the author's assumptions. Referring again to the example previously cited where it has been established that the interviewee prefers the 14 pound washer at $225 and the 18 pound washer at $235 to the base machine, he should then make his selections in questions 10, 11 and 12 to conform to the assumption of dollar value monotonicity. In other words, he should select either option 2 or option 3 of questions 10, 11 and 12. The word "either" is emphasized because monotonicity for the load capacity scale has not been established.

Since the questions in this questionnaire are of the adaptive form, there are a finite number of possible question sequences through which the interviewee can be directed. For the fourteen total questions in this questionnaire, there are ten possible sequence combinations. If V_1 stands for the value set group for the 14 pound washer and V_2 represents the value set group for the 18 pound washer, the list of sequences is as shown in Table 1. The numbers with astericks indicate that the option taken in response to that question designates into which set group the interviewee belongs.

4.4. Validity Verification.

As mentioned previously, the interviewees were selected from lists provided by Sears that designated recent purchasers of automatic wash machines. Specifically

Table 1. Questionnaire Sequences

Question Sequence	V_1($)	V_2($)
1-2-10-11-12	$V_1 > 225$	$V_2 > 235$
1-2-3-10-11-12	$V_1 > 225$	$V_2 > 215$
1-2-3-6*-10-11-12	$V_1 > 225$	$215 < V_2 < 225$ $225 < V_2 < 235$
1-5-4-10-11-12	$215 < V_1 < 225$	$V_2 > 235$
1-5-4-7*-10-11-12	$200 < V_1 < 205$ $205 < V_1 < 215$	$V_2 > 235$
1-5-8-9-6*-10-11-12	$215 < V_1 < 225$	$215 < V_2 < 225$ $225 < V_2 < 235$
1-5-8-13-7*-10-11-12	$200 < V_1 < 205$ $205 < V_1 < 215$	$225 < V_2 < 235$
1-5-8-13-14*-3-6-10-11-12	$200 < V_1 < 205$ $205 < V_1 < 215$	$215 < V_2 < 225$
1-5-8-9-10-11-12	$215 < V_1 < 225$	$V_2 < 215$

the interviewees were individuals who had purchased one of the test washers. It was possible to take their complete questionnaires and compare their results to what the sales record indicated they had actually purchased. This gave an indication of the validity of their response to the questionnaire.

4.5. Ultimate Goal.

If the reader refers once again to Figures 7 and 8, he will get a good indication of the ultimate goal of human value work as presented in this thesis. For instance, consider for purposes of graphical clarity the situation as depicted in Figure 9, In this case we have the "two attribute" set situation only more items are considered on both axes than are considered in this thesis' example. Once again the "x" markings indicate preference to the base set and "0" markings indicate non-preference to the base set. The curve shown in Figure 9 is the type curve generated by the work in this thesis. That is it becomes the "dividing line" between the "not preferred to the base" and the "preferred to the base" for this individual and this base. The ultimate objective, of course, would be to arrive at such a non-preference-preference curve, or indifference curve, for a user population based on some basis set that would be applicable for this basis set under varying conditions. By varying conditions this

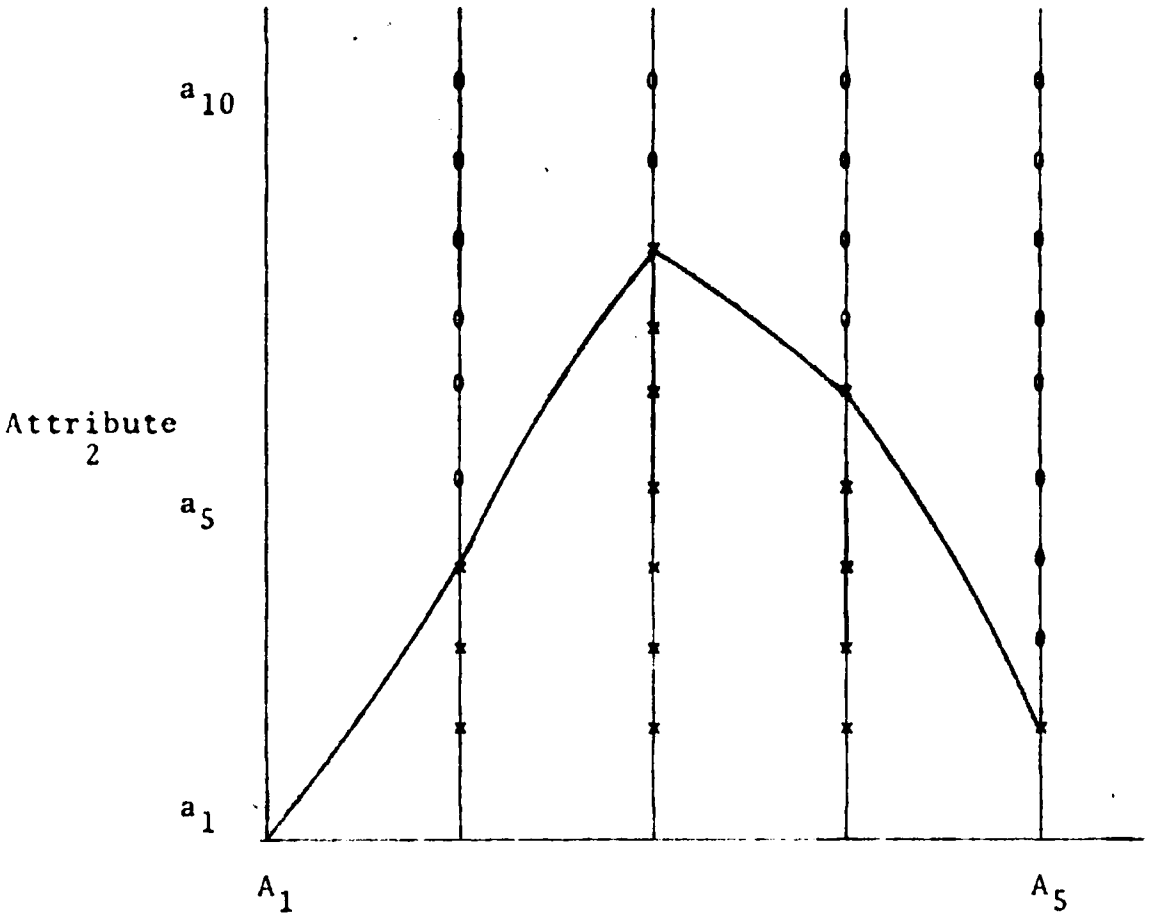

Figure 9

P-NP Curve

could mean such things as price fluctuations, location of consumer market, etc.

CHAPTER 5

RESULTS AND CONCLUSIONS

5.1. Introduction.

The purpose of this chapter is to discuss the selection of interviewees, their responses to the questionnaire, the results obtained, and the conclusions that can be drawn from these results. Although the results are discussed in some detail in the following sections, they can be briefly summarized as follows. A total of 50 questionnaires were sent through the mail. Of the 50 mailed, 35 responses were received within five weeks. Out of the 15 remaining, seven were subsequently received after some personal contact with the interviewee and eight were never returned. The final tally showed 42 responses out of the 50 originally mailed. The results of these 42 responses showed that the individuals could be placed into value groups and that only two responses failed the validity check while one failed the consistency check.

5.2. The Interviewees.

As indicated in Chapter 4, the interviewees for this questionnaire were all automatic washer buyers from Sears. The list, as presented by Sears for use in this

thesis, contained the names of individuals who had purchased an automatic washer from Sears during an eight month time frame within the past year. In conjunction with this list, sales data for this same eight month time frame covering all automatic washer sales by number and by washer model were also provided. The problem then became one of interviewee selection and selection of the washer models to be used as comparison models. Three models were selected as was also indicated in Chapter 4. It should be noted that a primary factor in the comparison model selection, in addition to load capacity and features, was the model selling price. The price of each model had to be such so as to lend itself to easy formulation of set groupings for later validity checks. Once the test models were selected, the interviewees were selected. The original list of buyers was broken down into a list of buyers who had purchased only test models. From this list 50 names were arbitrarily selected to be potential questionnaire interviewees. The word arbitrarily is used here for several reasons. In the first place, nothing at all was known about these buyers other than the fact that they had purchased automatic washers. It was realized however that a reasonable grasp of the English language would be needed to properly complete the questionnaire. Consequently, each name selected as a potential interviewee was considered

with the idea of eliminating for consideration those names with Spanish extraction which could indicate a language barrier of sorts. Of course this was purely conjecture but the foremost idea at this point was successful response to the questionnaire. As it turned out, this language difficulty was encountered anyway, as will be explained later. Another factor influencing the interviewee selection was the type model purchased. The list of models sold, for instance, showed a heavy proponderance of the 14 pound test model sold as compared to the 10 and 18 pound test models. Therefore the names ultimately selected had to have an adequate number of 10 and 18 pound models represented to go along with the 14 pound model.

5.3. Questionnaire Response.

Having selected the final 50 names as potential interviewees, the questionnaires were placed in an envelope along with an introductory letter (Appendix B) and a stamped, self-addressed envelope to be used for the return of the questionnaire. There was also included a very brief questionnaire concerning customer reaction to the washer and the service provided by Sears. This questionnaire was included as a courtesy to Sears and provided only information of interest to them and will not be discussed further.

Initial response to the questionnaire was very good with 11 questionnaires returned in the first three days and 15 in the first week. There were also two telephone calls during this time with questions concerning the filling out of the questionnaire. In all, 35 responses were received in a period of five weeks which left 15 questionnaires still outstanding. Subsequent inquiries into these 15 non-responses resulted in the following breakdown:

1. Six questionnaires sent to the wrong address
2. Nine questionnaires not returned for various reasons.

Of the six questionnaires sent to the wrong address, it was discovered that two were subsequently received by the interviewees and the other four were not received at all by the interviewees. The two interviewees who did receive the questionnaire indicated, after being telephoned, that they had no desire to complete the questionnaire. The other four interviewees were also telephoned and all indicated a willingness to complete the questionnaire, which they subsequently did. A check on the nine other non-respondents revealed that four of these interviewees did have an English language problem and they were unable to work their way through the questionnaire. The remaining five non-respondents were telephoned and three of these agreed to submit the questionnaire while the

other two indicated no desire to complete it. The responses to the telephone conversation from this last group showed that some of the people had intended to fill out the questionnaire but had forgotten; others had misplaced the questionnaire; and still others considered the questionnaire in the same category as third class mail and had thrown it away. The final result then showed 42 responses and 8 non-responses.

5.4. Results.

The results of the questionnaire can be broken down into three questions.

1. Value Grouping: Can the interviewee be placed in one of the four value groupings for both the 14 and 18 pound machine?
2. Validity Verification: Did the interviewee answer the questionnaire in such a manner that his actual washer purchase cross checked with the value grouping he indicated on the questionnaire?
3. Consistency Check: Are the answers checked by the interviewee in the questionnaire confirmed by monotonicity in questions 10, 11 and 12?

The results of question 1 were the easiest to check. If the interviewee did nothing more than follow directions and properly filled out the questionnaire,

he could be placed in one of the four value groupings for the 14 and 18 pound machine. Of the 42 questionnaires checked, all yielded results that would confirm a value grouping. This does not imply that all of these 42 questionnaires were flawlessly completed, this is not the case. The most common error under this part did not interfere with the value group placement. This error resulted from the interviewee checking more blocks than were required. In all instances recorded, the interviewee proceeded to indicate a value grouping and then in reality demonstrated monotonicity of the price axis by indicating additional preferences of machines at values lower than his indicated value group. For instance, several interviewees answered questions 1 and 2 in such a manner as to indicate their value grouping to be 4* for both the 14 and 18 pound machines. This is the highest grouping they could have. The interviewee then answered additional questions concerning one of the machines, in each case indicating a preference for that machine at a lower price than the indicated value group thereby following the assumption of monotonicity.

Question 2 is only slightly more difficult to check. The actual washer purchase was noted for each interviewee from the sales data provided by Sears. Included in this purchase notation was the pound capacity of the machine and its price. The interviewee's

questionnaire was then checked and his value group established. This value group was then checked against his actual purchase in an effort to determine if his value group was supported by his purchase. For instance, suppose an interviewee, through his responses in the questionnaire, was placed in the value group of less than $205 for the 14 pound washer. His actual purchase record was then checked and his value grouping was either confirmed or not confirmed based on his purchase. If he had in fact purchased a 14 pound washer for $220 there would be a question as to the validity of his results.

As indicated before, all 42 responses were placed in a value group and all but two of these groups were verified by actual purchase check of the interviewee. In the two instances that could not be verified, each interviewee indicated through his questionnaire that he preferred the 10 pound machine to either the 14 or 18 pound machine at any price. A check of their purchase record indicated, however, that each had in actuality purchased a 14 pound machine.

Question 3 of the results, the consistency check, is provided for by questions 10, 11 and 12 and the assumption of decreasing monotonicity of the price scale. Questions 10, 11 and 12 merely take the interviewee "down the price scale" for the 14 and 18 pound machines. For

instance, if he falls into value group 4* for both the 14 and 18 pound machine, he should then check response 2 or 3 of questions 10, 11 and 12. If he does not, he has violated the monotonicity assumption and his answers are not consistent. If he has indicated a preference for the 10 pound machine over the other two machines, then he should check response 1 of questions 10, 11 and 12. Of the 42 responses there was only one instance of a consistency violation. In this case the interviewee was placed in group 4* (highest) for the 14 pound machine and group 1* (lowest) for the 18 pound machine. His answer to both questions 10 and 11, however, was response 3 in each case both of which indicated preferences of the 18 pound machine to the base machine but at a higher price than his value group.

There were other results that proved interesting such as the indication by 11 interviewees that prices being equal, they would prefer the 18 pound machine to the 14 pound machine. This could be an indication of the "more pounds for the dollar" idea discussed earlier. These results, although interesting, are not pertinent to this thesis and will not be further discussed.

5.5. Conclusions.

The results of the questionnaire were very satisfying, both from the standpoint of response and questionnaire content. The fact that the content of these questionnaires with regard to the three questions concerning results was so good was not too surprising. The questionnaire dealt with a relatively large (price-wise) consumer item and the price intervals considered were not too large considering the overall prices of washers. The response in terms of numbers of questionnaires returned was surprising. As mentioned previously, of the 50 initially sent out, 35 were returned with no prompting needed. The additional seven responses were returned after a telephone call and, in some cases, a personal visit to the home of the interviewee. This good response can be attributed to the relatively simple construction of the questionnaire and the fact that it dealt with a subject that the interviewee had been concerned with during the past year.

In terms of the ultimate objective of obtaining individual indifference curves, this questionnaire was a success from the pilot study viewpoint. The idea of being able to establish value groupings for individuals is essential as a first step in the construction of an indifference curve. The fact that these groupings were achieved based on assumptions of monotonicity and, especially, transitivity may be a weakness but it is a

weakness that even traditional value theorists have had to concede. The biggest hurdle of all to overcome, however, may be in finding that "exact" point in the value group when indifference becomes an actual reality.

The result contained herein show that, at a minimum, an initial start can be made towards the establishment of an indifference curve. It would seem appropriate that both the good points and weaknesses of this thesis be considered and further studies undertaken towards the "ultimate objective."

APPENDIX A

QUESTIONNAIRE

QUESTIONNAIRE

The following questionnaire is designed to attempt to measure the values you place on three automatic washers using load capacity and price as a basis for comparison. The three washers are described below. Note that all features are identical with the exception of load capacity.

(1) 10 pound capacity automatic washer with:
   a) 5 wash-rinse settings
   b) 2 agitation and spin speeds
   c) 3 cycles
   d) 3 water level settings

(2) 14 pound capacity automatic washer with:
   a) 5 wash-rinse settings
   b) 2 agitation and spin speeds
   c) 3 cycles
   d) 3 water level settings

(3) 18 pound capacity automatic washer with:
   a) 5 wash-rinse settings
   b) 2 agitation and spin speeds
   c) 3 cycles
   d) 3 water level settings

The questionnaire is composed of 14 questions each of which requires only that you select your preference of

the two choices offered (questions 10, 11 and 12 have three choices). Your indicated preference will then direct you to another question, not necessarily the next numbered question. This is because it is not necessary for you to answer all of the questions. Regardless of your selections, however, the final question you will answer will be number 12 which carries a stop indication. Start with question 1 and then proceed according to the directions associated with the answer you mark.

1. It has been established that the selling price for the 10 pound capacity washer, as previously described, is $200. Suppose you had narrowed your choice to the following two options:

   Option 1 The 10 pound washer for $200

   Option 2 The 14 pound washer for $225

   Would you prefer Option 1 or Option 2? Check the appropriate box below and proceed to the question indicated under your choice.

   I prefer Option 1 ☐ go to question 5

   I prefer Option 2 ☐ go to question 2

2. Would you prefer:

   Option 1 The 10 pound washer for $200

   Option 2 The 18 pound washer for $235

I prefer Option 1 ☐ go to question 3

I prefer Option 2 ☐ go to question 10

3. Would you prefer:

Option 1 The 10 pound washer for $200

Option 2 The 18 pound washer for $215

I prefer Option 1 ☐ go to question 10

I prefer Option 2 ☐ go to question 6

4. Would you prefer:

Option 1 The 10 pound washer for $200

Option 2 The 14 pound washer for $215

I prefer Option 1 ☐ go to question 7

I prefer Option 2 ☐ go to question 10

5. Would you prefer:

Option 1 The 10 pound washer for $200

Option 2 The 18 pound washer for $235

I prefer Option 1 ☐ go to question 8

I prefer Option 2 ☐ go to question 4

6. Would you prefer:

Option 1 The 10 pound washer for $200

Option 2 The 18 pound washer for $225

I prefer Option 1 ☐ go to question 10

I prefer Option 2 ☐ go to question 10

7. Would you prefer:

Option 1 The 10 pound washer for $200

Option 2 The 14 pound washer for $205

I prefer Option 1 ☐ go to question 10

I prefer Option 2 ☐ go to question 10

8. Would you prefer:

Option 1 The 10 pound washer for $200

Option 2 The 14 pound washer for $215

I prefer Option 1 ☐ go to question 13

I prefer Option 2 ☐ go to question 9

9. Would you prefer:

Option 1 The 10 pound washer for $200

Option 2 The 18 pound washer for $215

I prefer Option 1 ☐ go to question 10

I prefer Option 2 ☐ go to question 6

10. Would you prefer:

Option 1 The 10 pound washer for $200

Option 2 The 14 pound washer for $225

Option 3 The 18 pound washer for $225

I prefer Option 1 ☐ go to question 11

I prefer Option 2 ☐ go to question 11

I perfer Option 3 ☐ go to question 11

11. Would you prefer:

Option 1 The 10 pound washer for $200

Option 2 The 14 pound washer for $215

Option 3 The 18 pound washer for $215

I prefer Option 1 ☐ go to question 12

I prefer Option 2 ☐ go to question 12

I prefer Option 3 ☐ go to question 12

12. Would you prefer:

Option 1 The 10 pound washer for $200

Option 2 The 14 pound washer for $200

Option 3 The 18 pound washer for $200

I prefer Option 1 ☐ stop

I prefer Option 2 ☐ stop

I prefer Option 3 ☐ stop

13. Would you prefer:

Option 1 The 10 puund washer for $200

Option 2 The 18 pound washer for $225

I perfer Option 1 ☐ go to question 14

I prefer Option 2 ☐ go to question 7

14. Would you prefer

Option 1 The 10 pound washer for $200

Option 2 The 14 pound washer for $205

I prefer Option 1 ☐

go to question 3

I prefer Option 2 ☐

go to question 3

APPENDIX B

INTRODUCTORY LETTER

Dear -

By way of introduction, my name is William R. Harnagel and I am a Captain in the United States Army. Presently I am attending the University of Arizona under the sponsorship of the Army and I am seeking a Master of Science Degree in Systems Engineering. The questionnaire that you find enclosed is a part of my thesis and I am requesting your assistance in filling it out. My thesis is concerned with Human Value Theory and through this questionnaire I am attempting to determine individual values with respect to automatic washing machines. I have received a great deal of cooperation from Sears Roebuck & Company in regard to this project and my questionnaire is based on figures that they have made available to me.

Enclosed you will find a questionnaire with an explanation page and 14 questions. I would greatly appreciate it if you would take a few minutes of your time to complete the questionnaire and return it to me in the enclosed self-addressed stamped envelope. In addition, if I have received your name from Sears, there is another questionnaire I have enclosed as a courtesy to them. This questionnaire is self-explanatory and concerns the washer you recently purchased.

I would sincerely appreciate any cooperation you could give me and if you have any questions you can reach me at the University phone number 884-1511, 1512 or 1513.

Sincerely,

William R. Harnagel
Capt. U. S. Army
Graduate Student, Sys. Eng.

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