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The Statistical Manipulation of  
Delphi Statements

by

Bradley William Nelson

A thesis submitted in partial fulfillment  
of the requirements for the degree of

Doctor of Philosophy  
in  
Systems Science

Portland State University  
June 1977.

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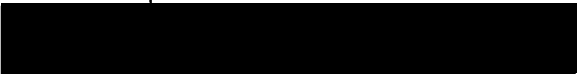
TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH

The members of the Committee approve the thesis of  
Bradley William Nelson presented June, 1977.


  
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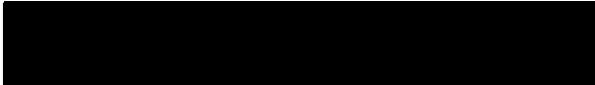
  
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AN ABSTRACT OF THE THESIS OF Bradley W. Nelson for the Doctor of  
Philosophy in Systems Science presented June, 1977.


Title: The Statistical Manipulation of Delphi Statements.

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Since its invention twenty years ago, the Delphi technique has been gaining wider and wider acceptance as a tool for forecasting technology; gathering expert opinion from a local to world wide "advice community" upon which government, industry, and other policy making bodies must so frequently rely; and providing judgmental input for studies (e.g., social sciences) where hard data are unavailable or too difficult to obtain. Accompanying this increased acceptance is an increased danger of manipulation of a Delphi to

produce the results desired by one certain individual or group of individuals. Manipulation is increasingly being mentioned in the literature as a danger but little has been done to study the problem.

Two groups of thirty United States Air Force Officers enrolled in a Masters of Business Administration program participated in a fact probing Delphi containing thirty statements. The participants of one group were given falsified statistical feedback on fifteen of the statements, while the participants of the other group were given falsified statistical feedback on the other fifteen statements. A similar study was done with another group of officers using a value probing Delphi.

The results of these studies showed a high degree of success in obtaining a desired value through the use of manipulated statistical feedback. This success was enhanced by running additional rounds. It was also found that the statistical manipulation had a significant effect on the convergence and stability of the Delphi statements.

The effects of statistical manipulation on confidence as measured by self-rating was also studied. It was found that there was a significant tendency for Delphi participants to shift their self-rating during later rounds toward the middle. The effect of the distance between a participant's original estimate and the median reported back to him on the amount the participant changed his self-rating was investigated. The results were inconsistent. Statistically manipulated participants showed an overall decrease in confidence, regardless of their original self-rating.

Suggestions for extending the research in the area of manipulation of Delphi statements plus a taxonomy of the variables that comprise the problem of manipulation are discussed.

## ACKNOWLEDGMENTS

The author first wishes to thank the members of his immediate family for tolerating an absentee husband and father who, when they did see him, was generally Mr. Grump.

Special thanks must also be given to Dr. Harold Linstone and the other members of my committee for their prompt response to my requests and for the encouragement and suggestions they supplied at the needed times.

One must also not forget the poor secretaries who must transform a barely decipherable draft into an aesthetic finished product in half the time necessary to do it. Thank you Debbie Fugleberg and Marie Baumgartner for tolerating me.

Finally, the author wishes to thank the United States Air Force Officers whose participation made this research possible.



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## CHAPTER I

### INTRODUCTION

Important policy decisions are being made every day in government, business, education, and other organizations. These decisions are heavily impacted by information obtained by the use of the Delphi technique. Our national drug abuse policy has received valuable input from a Delphi study run in 1975 [46]. The School of Education at the University of Virginia used a Delphi to establish the prime targets on which it should concentrate its energies and resources in the next decade [17]. DuPont has used the results of a Delphi study involving the entire adhesives industry to determine the future trends in adhesives in order to build up the technology and productive facilities to support the evolution of the adhesives industry [31].

Delphi's popularity and use is increasing to the point that the number of studies that have been run are counted in the thousands. The topics of such studies range from predicting functional capabilities of future technology to providing important sought-after input for policy making bodies. People are continuing to find new ways of using Delphis to suit their needs; thus, many new versions of the Delphi technique are appearing in literature. In addition, research is also being done to expand the concepts of Delphi into a general theory of group estimation [22].

However, in all the frenzied development of Delphi, no one has seriously addressed the problem of misuse of the Delphi technique.

This is especially surprising in light of the recent years during which there has been so much corruption in government and business (e.g. Watergate, the probes into the FBI and the CIA, the resignation of the President and Vice President of the United States, and Lockheed's foreign payoff scandal, to mention a few). Is it possible that an individual or a group of individuals could use the Delphi technique to achieve certain vested interests? Is it possible that organized crime could have influenced the drug abuse Delphi mentioned earlier in an effort to encourage policy that would have been favorable to their position? Is it possible that DuPont could have influenced the adhesives Delphi in an effort to convince the adhesives industry to develop along the lines that would have been best for DuPont?

This research is the first known serious attempt to examine the possibility of manipulating the results of a Delphi to produce results an individual or group of individuals desire. This study is not the final word on the topic but is instead a beginning point. The research has found that manipulation of factually-based and value-laden Delphi statements<sup>1</sup> via falsified statistical feedback was successful in achieving a desired value. Further, the results indicated this form of manipulation has an effect on the convergence and stability of the responses to Delphi statements and on the confidence participants have in their ability to respond to the Delphi statements.

While the reader is assumed to have some precursory knowledge of the Delphi technique, a brief sketch of the technique will be presented to assure a common starting ground.

<sup>1</sup>Refer to "Subject Matter of the Delphis" in Chapter IV for a definition of factually-based and value-laden Delphi statements.



## BACKGROUND

Murray Turoff defines the Delphi technique as a "method for the systematic solicitation and collation of informed judgments on a particular topic," [94:149] and describes the procedure as a "set of carefully designed sequential questionnaires interspersed with summarized information and opinions feedback derived from earlier responses."

[94:149] Norman Dalkey defines it as ". . . a method of eliciting and refining group judgements." [18:408] Harold Linstone and Murray Turoff in their book on the Delphi method state that "Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem." [56:3] All of these definitions tend to be a bit general and lack the nice closed picture that most of us would like to see in a definition. The reason for this is that the Delphi method is an evolving technique, and its definition is still developing. It started in the early 1950's (although it was not communicated widely until the middle 1960's) as a forecasting procedure. Since then, the Delphi method has been adapted and modified in many ways. It has found application in many diverse areas, some of which are:

- .Gathering current and historical data not accurately known or available
- .Examining the significance of historical events
- .Evaluating possible budget allocations
- .Exploring urban and regional planning options
- .Planning university campus and curriculum development
- .Putting together the structure of a model
- .Delineating the pros and cons associated with potential policy options

- .Developing causal relationships in complex economic or social phenomena
- .Distinguishing and clarifying real and perceived human motivations
- .Exposing priorities of personal values, social goals [56:4]

While the Delphi method has been adapted and modified in many ways, there tend to be three features that are common to the procedure: anonymous response, iterative and controlled feedback, and statistical group response. While each of these has been subjected to numerous studies and there have been many variations of each of them, they still tend to appear in the design procedures of most Delphis. The object of anonymous response is to eliminate many of the disadvantages of face-to-face communication. For example, committees often face the disadvantages of a dominant or charismatic individual, vested interest, reluctance to lose face by changing one's position, and group pressure to conform to a minority viewpoint. The use of anonymity can help circumvent these problems. Quantity versus quality of arguments often is the deciding factor in many committee meetings. To avoid this problem, but at the same time allow a free flow of arguments for and against or statements concerning a particular Delphi statement, controlled narrative feedback is often encouraged. This is done during several iterations of the Delphi process to encourage full exchange of ideas and comments. While being one of the most important features of Delphi, narrative feedback is also the feature that often receives the least attention because of the additional work it creates for the administrator. Statistical group response is the feature that probably has the most variations and has been investigated the most. The intent of this feature is to give the participants some concept of the group response. As discussed later, there has been a fair amount of

discussion concerning the effect this has on the degree of convergence, but without some statistical group response there tends to be little or no change in the responses over several rounds. Therefore, some statistical group response seems to be necessary.

The evolution and use of the Delphi procedure has been rapid and impressive. The first Delphi was run in the early 1950's by Dalkey and Helmer of the Rand Corporation to study ". . . the selection, from the point of view of a Soviet strategic planner, of an optimal U.S. industrial target system and to the estimation of the number of A-bombs required to reduce the munitions output by a prescribed amount." (19: 458] This work, however, was not published until 1963 due to its secret nature. A later paper by Gordon and Helmer in 1964 was the first published paper that brought the Delphi method to the attention of those outside the defense community. Since then, Delphi has behaved as a grass fire. It has been estimated there have been over ten thousand Delphis run. The results of some have been published, but many have merely served the purpose for which they were intended. Some of the articles have been oriented towards improving and evaluating the methodology while others have been concerned with applications of the Delphi method. (For the most complete bibliography of Delphi and Delphi related publications refer to [56]).

As with all useful methodologies, there exist some pitfalls.

Linstone [55] has registered the following list:

1. discounting the future
2. the prediction urge
3. the simplification urge
4. illusory expertise
5. sloppy execution
6. optimism-pessimism bias
7. overselling
8. deception

The last pitfall (deception) is the subject with which this report is concerned.

#### PURPOSE

The purpose of this research is to investigate empirically the statistical manipulation of factually-based and value-laden Delphi statements to see if a particular desired value could be achieved and to explore the effects such manipulation has upon the convergence and stability of the responses to Delphi statements. The effects of statistical manipulation upon the confidence of the Delphi participant (as measured by self-rating) is also explored.

#### RESEARCH HYPOTHESES

The above purpose of this research is more explicitly communicated in the research hypotheses:

- R1 - factually-based Delphi statements can not be successfully manipulated by the means of manipulated statistical feedback;
- R2 - value-laden Delphi statements can not be successfully manipulated by the means of manipulated statistical feedback;
- R3 - there is no difference between the manipulability of factually-based Delphi statements and the manipulability of value-laden Delphi statements, with respect to manipulation via statistical feedback;
- R4 - manipulation of statistical feedback will not result in a lesser degree of convergence for factually-based Delphi statements;
- R5 - manipulation of statistical feedback will not result in a lesser degree of convergence for value-laden Delphi statements;

- R6 - there will be no difference between factually-based and value-laden Delphi statements with respect to the effects manipulation of statistical feedback has upon the degree of convergence;
- R7 - manipulation of statistical feedback will not reduce the stability (and therefore not require an extra round(s)) in factually-based Delphi statements;
- R8 - manipulation of statistical feedback will not reduce the stability (and therefore not require an extra round(s)) in value-laden Delphi statements;
- R9 - there will be no difference between factually-based and value-laden Delphi statements with respect to the effect manipulation of statistical feedback has upon stability (and therefore the number of rounds necessary to obtain stability); and
- R10 - manipulation of statistical feedback in factually-based Delphi statements has no relationship to the changes in the respondents' self-rating of their knowledge of the subject matter for those Delphi statements.

Note that this research attempts to reject research hypotheses R1 and R2 and that research hypothesis R3 is conditional upon the successful rejection of R1 and R2. Similar statements can be made for the triads R4, R5, R6 and R7, R8, R9. An attempt is also made to reject research hypothesis R10.

#### ASSUMPTIONS AND CONSTRAINTS

An ideal design for this research would have resulted in a full description of the impact and characteristics of manipulation. This would have involved testing all possible forms of manipulation for all possible types of Delphis for all possible populations of participants. The above combinations also would have been replicated several times with different Delphi statements and participants. Obviously, due to resource constraints, this was not possible. Even if one had unlimited

resources, it would not have been possible since the Delphi technique is still an evolving technique. Therefore, it was not the goal of this study to investigate the entire question of manipulation of Delphi statements but instead to make an initial probe into the subject and to determine whether further studies in this area need to be made.

Since this research was not funded and had to be completed within six to ten months, it was necessary to use participants who were readily available, who could complete the Delphi within a short period of time, and who would not require remuneration to participate. It was thus decided to use United States Air Force officers who were enrolled in a Master of Business Administration program at Grand Forks Air Force Base,<sup>2</sup> North Dakota (the author was teaching in this program at the time of the study).

The only manpower available for this study was the author. This in combination with the time and money constraint limited the study to two Delphis. Since there are two broad classifications of Delphi (factually-based and value-laden), a Delphi representative of each of these classifications was run. An almanac Delphi was used for the factually-based Delphi and was assumed to be representative of factually-based Delphis. A policy Delphi was used for the value-laden Delphi and was assumed to be representative of value-laden Delphis.

The usual procedure in running a Delphi is first to design the Delphi and then select the panel members who would be appropriate for the Delphi. Since in this study it was desired to use the participants

<sup>2</sup>This program is funded by the Air Force Institute of Technology and is administered by the University of North Dakota.

just described the process was reversed. The Delphis were designed so the participants would be considered experts in the almanac Delphi and representatives of a point of view on the Policy Delphi.<sup>3</sup> Therefore, while the participants were perhaps not truly representative of the population of all panel members, it is assumed they were representative of the panel members one might choose for the Delphis that were run.

The form of manipulation chosen for this study was the manipulation of statistical feedback. There are many ways one can manipulate Delphi statements through statistical feedback. To explore all of these also would have required an enormous amount of time, effort, and cost. Therefore, a decision was made to explore the general success of statistical manipulation by choosing one combination that would have been most representative of how one might have gone about manipulating via statistical feedback and that intuitively would have had a high degree of success associated with it. Statistical manipulation was done by a relatively large amount. This assured that the movement was not just accidental. A strategy of manipulation by the full desired amount during the first round and then maintaining it around that point for each of the remaining rounds (thus manipulation occurs during all rounds) was used. Ranges were chosen that heuristically appeared to help accomplish the desired point. Manipulation was towards the true answer but beyond it or towards the true answer if the original response was too far from the true.<sup>4</sup>

<sup>3</sup>A further discussion of this is given in Chapter III under the heading "Subject Matter of the Delphis."

<sup>4</sup>A more complete discussion of the concept of the pull of the median and the pull of the true will be given in the latter portion of Chapter II.

This combined both the pull of the median as well as the pull of the true. The standard form of statistical feedback was used.

A further assumption must be made that the author was successful in eliminating bias and ambiguity in the wording of the Delphi statements. The statements were all pretested to eliminate these problems. There was no feedback during the study that indicated such problems existed.

An assumption was also made that the measures were valid measures of the variables being tested (success, convergence, stability, and confidence).

Since this was an empirical attempt to determine the ability to manipulate Delphi statements, no attempt was made to explain the psychological and sociological reasons why people respond in the manner they do.

#### SIGNIFICANCE OF THE STUDY

The problem of manipulation of Delphi statements has been mentioned in several places. Linstone states "Today the least acknowledged hazard in connection with Delphi is its potential use for deceptive, manipulative purposes. . . . The anonymity in such a situation may even facilitate the deception process: how can the participants in a Policy Delphi possibly detect distortion of the feedback they receive?" [55:585-6] Before this question can be asked, it is precursory to first understand something about the degree to which Delphis can be manipulated and the characteristics of this manipulability. Once these fundamental questions have been explored, then one can develop procedures to help circumvent this problem.



Linstone and Turoff also discuss the problem of manipulation as a "virtual" problem, a problem that does not in itself affect the utility of the technique. They indicate

A third virtual problem is the honesty of the monitor team, and it is of the same concern as the honesty of any study or analysis group. In fact, there is probably more likelihood in most instances of exposure of misrepresentation in a Delphi summary than in a typical group study report.  
[56:6-7]

What they are saying is that Delphis are as subject to manipulation by the administrators as any other form of group analysis; however, the risk of exposure may be higher. In personal correspondence, Dr. Turoff has indicated:

I do believe it is possible to manipulate numeric estimates except where the majority of the group has conviction about their estimates. I do think this becomes significantly more difficult where respondents are allowed to provide associated pieces of knowledge to support their estimate, and these are fed back . . . [The primary reason for this is] that it is going to be obvious to someone if you left his argument out or poorly worded it.

While the above may be true, one must realize there tends to be a lack of a unified group of people who are cognizant of what exactly has evolved during the Delphi and who have access to the final results. This, in turn, does allow the administrators a greater opportunity to misrepresent the results of the Delphi.

Whatever the situation, the results of a Delphi must ultimately rest on the integrity and honesty of the administrators. If they lack this integrity and honesty and are willing to take the risk of exposure, they could attempt to twist the results via two methods. They could try to shape the consensus through manipulation of feedback such that the

final round results are what they desire, or they could merely misrepresent the final results (i.e. report something other than what occurred). The fundamental difference is, in the former case, the administrator molds the respondents to answer in the manner he desires. In the latter case, the administrator merely lies about the results. Both are guilty of fraudulent misrepresentation of the results; but if the former is less subject to manipulation than one might assume, new credibility and assurance can be added to the Delphi procedure.

There also has been some concern about manipulation of Delphi statements by people who are using the Delphi in practice. One such example is John Ludlow's Delphi study on the Grand Traverse Bay watershed region, part of the Michigan Sea Grant Program. This concern was shown when he indicated several significant modifications and refinements were made to the basic Delphi methodology because of ". . . the perceived threat of a manipulated consensus. . ." [57:103] and several other reasons that are not pertinent to this report. He failed to mention, however, what changes were made relative to the question of manipulability.

Ludlow made one other mention of the power of the Delphi technique to manipulate opinion and policy.

The suggestion that the method "can result in a manipulated and arbitrary consensus" received a neutral judgment from all three groups, perhaps indicating that the respondents felt this danger to be no greater than it would be in alternative techniques for securing group judgments. However, it is this administrator's opinion that the Delphi techniques could be a powerful tool for manipulating opinion and policy. [57:119]

This point is somewhat exemplified by the effects polls can have on election trends and by the fact that media (e.g. radio and television)

cannot begin reporting the tallies of how people voted until after the polls have closed.

As will be shown in the review of the literature, little has been done to investigate this area and many questions remain unresolved. With increased use of the Delphi technique, especially in areas of policy and goal formulation, it is becoming even more critical to consider this point. The government has already used the Delphi technique to provide input into policy decisions in areas such as drug abuse [46], social policy planning and research [58, 91], and many others. Businesses have used Delphis to help establish policy decisions in areas such as marketing [47], manpower forecasting [64], and many unpublished areas. Universities have used it to establish objectives for programs and institutions [2, 16, 17, 43, 49, 50, 96]. The list of uses continues to grow and the Delphi technique shows promise in replacing instruments such as polls, questionnaires, and committees in important government, educational, and business organizations. To continue the use and expanded use of Delphi and not understand some of the underlying characteristics of manipulation is courting folly.

Murray Turoff in discussing Policy Delphi makes the following comment:

As with any policy process, there are many ways to abuse the use of the Policy Delphi: the manner in which comments are edited, the neglect of items, the organization of the results. However, such a process is a rather dangerous game and not likely to go unnoticed by some segment of the respondents. There are very few greater wraths than that of a respondent who discovers himself to be engaged in a biased exercise.  
[95:101]

While this author agrees with Turoff, one must realize we are dealing with people, one of the most open systems known, and thus we

can not dismiss the possible misuse of the Delphi technique. Our better understanding of how this misuse might behave may help us in discovering or avoiding its abuse; or if we find that the Delphi procedure is indeed more robust than we think, in trusting its results.

#### ORGANIZATION OF THE DISSERTATION

This study is presented in five chapters entitled: (1) Introduction, (2) Review of Related Literature, (3) Design of the Study, (4) Results, and (5) Conclusions and Extensions.

Chapter I has presented a brief background of Delphi, the purpose of this research, the research hypotheses to be investigated, the assumptions and constraints under which this research will be made, the significance of the problem, and the organization of this study.

Chapter II is a review of the literature related directly and indirectly to manipulation of Delphi statements.

Chapter III is devoted to the methods and procedures utilized by the investigator to secure, compile, and analyze the data.

Chapter IV contains the results of the analysis of the data concerning the success of statistical manipulation and the effects statistical manipulation has on the convergence and stability of the responses to Delphi statements and on the confidence of Delphi participants.

Chapter V presents a summary of the findings, some recommendations for avoiding statistical manipulation, and a discussion of some possible extensions of this work.

## CHAPTER II

### REVIEW OF RELATED LITERATURE

This chapter is composed of two sections. The first is concerned with the literature that directly discusses the topic of manipulation and applies it to at least one Delphi statement in a study. The second section discusses articles that do not mention the topic of manipulation but do implicitly generate pertinent questions worthy of consideration.

#### LITERATURE DIRECTLY RELATED TO MANIPULATION

There have been three attempts at exploring the effects of manipulation on Delphi statements. Two of these attempts [16,85] have only involved the manipulation of one Delphi statement in the entire Delphi. These were obviously not serious attempts at trying to look critically at the question of manipulation but were merely probes to see if the ability to manipulate did in fact exist. Both attempts were successful. The third attempt [98] was a conscious effort to test the manipulability of Delphi statements by the administrator. The conclusion was that the Delphi procedure was in fact more robust than one might expect and that it was not susceptible to manipulation. This was contradictory to the other two studies. As we shall see when we discuss these articles, the latter study was, however, poorly reported and only looked at part of the overall problem. It is interesting to note that the author ignored his findings when discussing the problem in a later paper [99] where he

mentioned the opposite of his findings as being true. Thus the three attempts to look at the problem of manipulability have not resolved the question but have merely added more uncertainty. A review of each of the articles and some of the questions generated by them will now follow. It should be noted that it is not the intent of this research to answer all the questions generated in the review of the following articles but merely to bring them to light.

Cyphert and Gant [16,17] were the first to test the question of manipulability of Delphi statements. The primary object of their policy Delphi exercise was to establish ". . . prime targets on which the School of Education [at the University of Virginia] should concentrate its energies and resources in the next decade." [16:273] During the Delphi process they attempted to test "the hypothesis that the technique can be used to mold opinion as well as collect it . . ." [16:273] They did this by taking an item that was ranked relatively low and fed back distorted statistical feedback indicating it had a high ranking. The result of this manipulation was that it was in the end ranked above average, although not in the top ten. These results indicate at least partial success in manipulating the results. The authors however did not indicate exactly where the item was ranked originally and where it was ranked at the end; thus the absolute movement cannot be determined. They also failed to indicate how the manipulation was done. Was it manipulated only in the statistical feedback returned in round three and then left to fend for itself or was it manipulated in both rounds three and four? It also was not mentioned whether there was a target for the manipulation. Were they trying to achieve a particular ranking for this item; and if so, how successful

were they in achieving their target? Would the use or lack of use of narrative feedback have helped achieve the target, i.e. what effect does narrative feedback have on achieving a manipulated target?

Cyphert and Gant also did not indicate the degree of consensus the bogus item had. Is it easier to manipulate a Delphi statement whose initial consensus is in low agreement or in high agreement or does it matter how much agreement there is? Do manipulated Delphi statements tend to have less consensus at the end than non-manipulated statements? While it was not the intent of Cyphert and Gant to answer these questions, they are questions that need to be answered before one can understand the characteristics of manipulability of Delphi statements.

Cyphert and Gant also mentioned that virtually all (99%) of the consensus occurred by the end of round three and thus questioned the need for a fourth round. One may ask the question here if the number of rounds affect the ability to manipulate Delphi statements? Since the feedback is contrary to what was reported and thus expected, might it take an extra round to establish stability and/or consensus? Could this be a means to help limit the degree of manipulability of a statement?

Scheibe, Skutsch, and Schofer also conducted a Delphi where they manipulated one Delphi statement. The subject matter of the Delphi was to develop and weigh ". . . a hierarchy of goals and objectives for use in evaluating a number of hypothetical transportation facility alternatives." [85:263] The objective, however, was not to come up with a viable set of goals and objectives but to test certain aspects of the Delphi methodology. Among these were:

1. the effect of using different scaling techniques to rank Delphi statements,
  2. the measurement of feedback effectiveness,
  3. the use of stability rather than consensus to determine the end point of a Delphi statement, and
  4. the use of high/low self-confidence ratings and other personal descriptive variables to improve the results of Delphi.
- 

The second of these aspects of Delphi methodology was of particular interest with respect to this paper in as much as it concerned the use of manipulated statistical feedback. In an effort to examine ". . . the round-by-round effect of feedback . . . [and to investigate] the manner in which the feedback affects the distribution of scores in a particular round," [85:270] the participants were provided with false feedback on one question during the first round and the effect on the distribution of priority-weighted scores was observed. A question which appeared to have a good consensus after the first round was chosen. A falsified distribution in the opposite direction was returned to the participants during the second round. There was no further manipulation. It was determined that the respondents would respond to this falsification in one of three ways. Since the falsified feedback was given in the opposite direction as the original consensus, the respondents could

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. . . ignore the feedback and keep their votes constant; they could rebel against the feedback and move their votes to the right in the interest of moving the group mean closer to their true desire; or they could acknowledge the feedback and move their votes nearer the false mean. If they had followed either of the first two options, it would indicate that the feedback was not effective in changing individuals attitudes. [85:270]

The result was the respondents shifted their positions away from the true mean and toward the falsified mean. However, since there was no more manipulation (the respondents were fed back the actual



distributions that resulted during round 2 and 3), the respondents slowly reverted back toward their original consensus, although there was some residual effect remaining (the distribution was shifted slightly toward the manipulated direction). This, the authors felt,

. . . suggests that the respondents are, in fact, sensitive to the feedback of distributions of scores from the group as a whole. These results seem to indicate that most respondents are both interested in the opinions of the other members of the group and desirous of moving closer to the perceived consensus. [85:272]

While the intent of the above was not to measure the ability of one to manipulate Delphi statements, it does lead us to a series of questions which are relevant to the topic of manipulability of Delphi statements.

1. What would be the effect of falsified feedback being given during the entire Delphi process (rather than just the first round)? Would the respondents tend to go back to the original consensus if falsified feedback were given during round 1 only, rounds 1 and 2 only, or during all rounds?
2. Would the respondents have a higher propensity to be manipulated on questions that have low consensus or does the degree of consensus have little effect on the propensity to be manipulated? The question chosen by Scheibe, Skutsch, and Schafer to manipulate was one that had a high degree of consensus. The results of round 2 showed a shift in the manipulated direction; however, the resulting distribution was rather flat, indicating a lack of consensus. Had they chosen a statement whose first round distribution was flat (lack of consensus) would the results of round 2 have shown a higher consensus in the falsified direction?
3. Would the use of manipulated narrative feedback have achieved even greater success in establishing a desired degree of manipulation? Could a higher degree of consensus around a desired manipulated point be achievable through the use of manipulated narrative feedback in combination with manipulated statistical feedback than manipulated statistical feedback alone?
4. What levels of success can one achieve for different levels of manipulation? Can one actually try to achieve manipulated consensus for a particular point? Does the success

of achieving this point depend on the direction from the true answer one is manipulating toward (i.e. would one be more successful in manipulating toward the true answer, toward the true answer but beyond it, or away from the true answer) and/or the distance from the original consensus (i.e. would one be more successful in moving the answer a little bit or a larger amount)?

5. Would manipulation be more successful if one manipulated the statistical feedback by small increments each round toward the desired manipulated point or by an initial large manipulation which is maintained or adjusted to accomplish the desired manipulated point? If one wishes to acquire a particular point, would it be easier to manipulate the respondents by a series of gentle manipulations until that point is reached or would it be easier to adjust manipulated results around that point in the beginning and merely adjust the manipulation to fit the respondents consensus but at all times maintaining the manipulation to encourage the desired point?
6. What level of success can one attain at achieving a desired distribution? Can one, through the use of manipulation, achieve a uniform distribution (lack of consensus), a normal distribution (consensus), and/or a bimodal distribution (conflicting consensus)?

Another area of interest in this study is the relationship between the degree of confidence (as measured by self-rating) and the degree of manipulability. Norman Dalkey [21] in his original study of the use of self-ratings to improve group estimates (and also in later works [8 and 23] concluded that one can substantially improve the performance of Delphi through the use of self-rating subgroups. Others such as Gordon Welty [97-101] repudiate the use of experts altogether. Scheibe, Skutsch, and Schofer add to this topic by saying:

Studies in the psychology of small groups, however, indicate that highly confident persons should be less influenced by group pressure than those with less confidence, and therefore it would be expected that highly confident individuals move less toward consensus than do others in the Delphi context. [85:275]

If the above is true, one would expect those who rate themselves as more confident would be less subject to manipulation. If this is

true, it would lend more credibility to the argument that the Delphi panelists should be experts and/or that some self-ratings procedure be used and that consensus of the high self-rated group be used over the consensus of the entire group.

While Cyphert and Gant and Scheibe, Skutsch, and Schofer both use manipulation in one of their Delphi statements, Gordon Welty [97-101] is the only person who has directly attacked ". . . the robustness of the Delphi exercise in withstanding deliberate manipulation of judgemental and deceitful opinion formulation." [98:377] He did this by running a Delphi on a portion of Nicholas Rescher's questionnaire study of American values by 2000 A.D. [76] The portion of Rescher's study he chose was Question 2, a list of 37 values. The participants were to indicate whether in their judgement each value would change in the direction of greatly increased emphasis, slightly increased emphasis, little or no change, slightly decreased emphasis, or greatly decreased emphasis. The respondents were also to indicate the desirability/undesirability of such a change using a similar five point scale.

It is rather interesting to follow the sequence of articles Welty published on his study. He set out to develop two hypotheses. The first dealt with whether there is a significant difference between the conclusions of a non-expert Delphi panel and an expert one. The idea was to shed some light on whether a Delphi panel should be composed of experts or not. His first article [97] stated his results and concluded that there was no significant difference. His following four articles merely restated the same results in a different manner. His second hypothesis, however, is of more interest in this study and

certainly has a more interesting (if not conflicting) development in his succession of articles. His second hypothesis deals with ". . . deliberate distortion of experts opinion by the managers of the Delphi exercise." [97:403] In article [97] he makes a case that the Delphi exercise is subject to "deliberate distortion" and that it appears impossible to control. He indicates that they have attempted to test this hypothesis and will report on it later. He concludes his article stating that for these two reasons the Delphi process is ". . . the antithesis of scientific forecasting." [97:407]

Three articles later [98], Welty reports on his efforts to test the second hypothesis. The results of his experiment show that ". . . the participants were not susceptible to influence and opinion formation . . .," [98:380] that "the Delphi technique appears, on the basis of our research, to be more powerful an institution in resisting willful and arbitrary manipulation than we might have been led to believe on the basis of Cyphert and Gant's work." [98:381] This is certainly a change of position from his previous comments.

Welty's most recent article [99] (published two years after the above study) is an impressive and flamboyant article drawing heavily from Greek mythology and philosophy. It is interesting to read his conclusions in light of the results of his above study. While he mentions Cyphert and Gant's work again, he fails to mention the results he published two years earlier. Either he must not believe, or lacks confidence in, his own results or he must have forgotten them. Of course, since the article was so heavily oriented to the concept of deception, to say the Delphi technique is otherwise would have been contrary to his laboriously developed theme.

Rather than belaboring this let us instead review the article [98] where he reported the results of his study. Welty's presentation of his study was at best inadequate. He spent two short paragraphs (nine sentences to be exact) explaining his methodology and analysis procedures. During these two paragraphs he failed to explain adequately both the dependent and independent variables (percent labelled deviant and average distance moved per item) of his regression analysis. By looking at Table 1 in his paper and referring to Rescher's paper [76], one can determine what he meant by distance moved, but confusion returns when it is obvious he only counts deviations in the percent labelled deviant responses but discusses it in terms of causing ". . . substantial shifts in group opinion . . ." (underline added) [98:380] Percent labelled deviant is subject to several interpretations, all of which are confusing. Without a full comprehension of the dependent and independent variables, it is impossible to draw any conclusions relative to its validity. To add to the inadequacies of his paper, Welty also neglects to indicate how he manipulated the respondents Delphi statements and how much he manipulated them. Without this, one certainly cannot draw any conclusions relative to the effect of manipulability of Delphi statements. The most that can be said for Welty's work is that it generated more questions than it answered and left the initial question he set out to answer even more puzzling. Perhaps this is why he ignored his results in his later publication.

#### LITERATURE INDIRECTLY RELATED TO MANIPULATION

The following articles while not directly attuning themselves to the problem of manipulation of Delphi statements do implicitly generate

pertinent questions worthy of consideration.

Skutsch and Schofer [91] discuss planning as a process involving two parts, (1) setting the goals and (2) reaching the goals. In recent years, many tools have been developed to attain the latter; however, little has been done relative to the former. Not only has this area lacked adequate development, but the methods and techniques developed for obtaining goals require even more explicitly and meticulously defined goals.

They suggest use of a "goals hierarchy" such that unwritten community "values and norms" may form the peak of the pyramid. Horizontal aspirations may be included as "goals" while at a lower level "objectives" are identified as specific intents and directions for action. For each value there may be many goals, and for each goal, many objectives . . . [91:305]

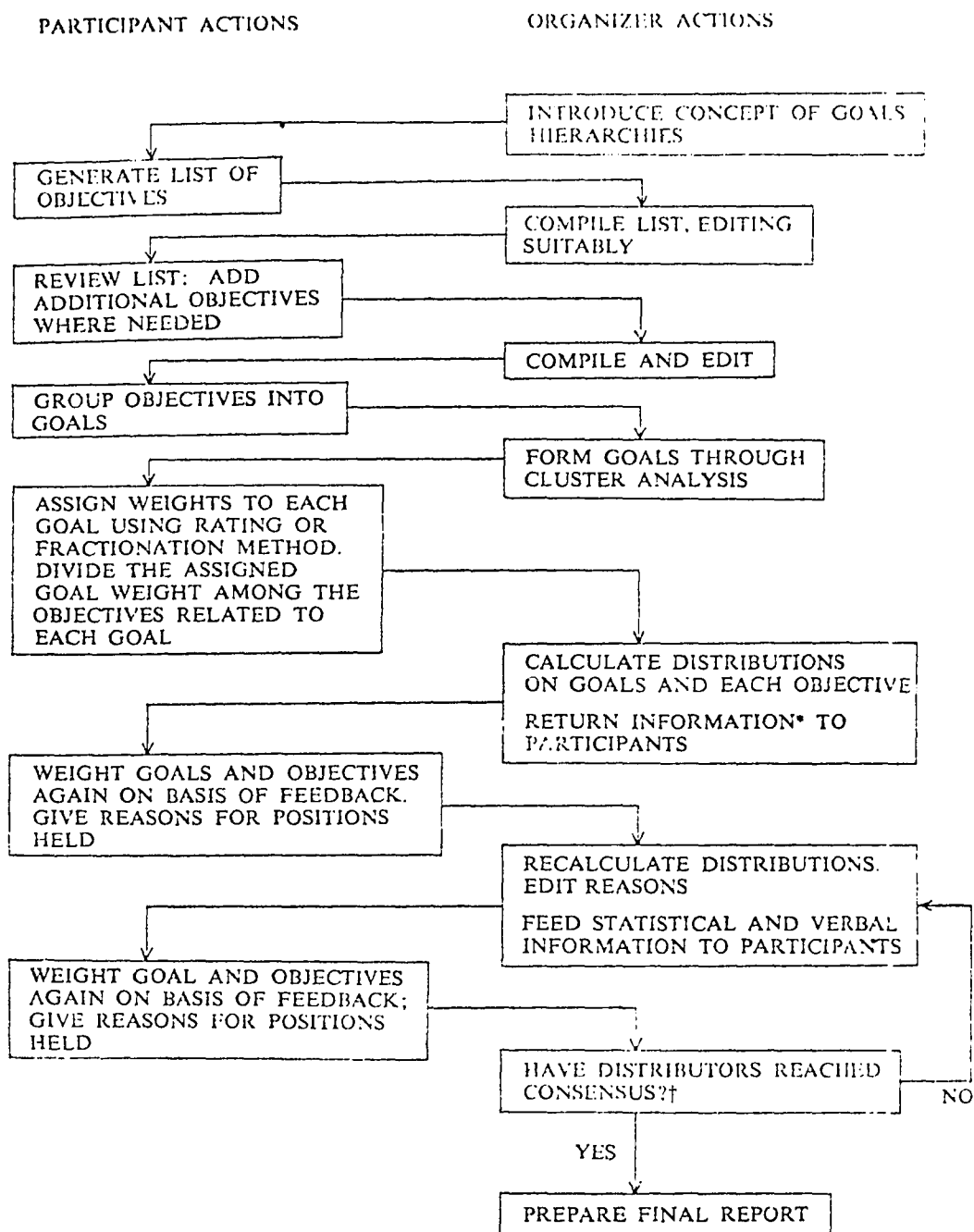
By accepting this "goals hierarchy" one thus enhances the specificity, directionality, measurability, and ability to weight goals or objectives according to their relative priority.

They suggest a Goals Delphi to develop a community consensus as to the goals hierarchy and to derive the weighting of the goals and objectives. Figure 1 gives a diagram of the procedure.

In addition they mentioned three principals upon which Delphi is based:

1. . . . group judgements are superior to individual ones;
  2. anonymity allows greater rationality;
  3. group pressure acts to consolidate group opinion.
- [91:306-8]

They agreed with the reasoning of the first two principles; however they felt not enough has been done by Delphi theorists on the last principle. They indicate that ". . . Delphi was developed, in part, as a means for identifying divergence of opinions as well as areas of consensus . . ."



\*Statistical feedback chosen will depend on design needs; could be a histogram, mode, mean and interquartile range, etc.

†Consensus may be defined in terms of stability

Figure I. Goals Delphi algorithm [91:307]

[91:308] Thus before one applies Delphi to the formulation of goals, one must understand the internal process of feedback and consensus to assure oneself that he is not developing a ". . . forced, and hence short-lived, consensus." [91:308]

Even though Delphi was initially designed to overcome conformity to the dominant opinion (Dalkey indicates the "use of a statistical definition of the group response is a way of reducing group pressures for conformity . . ." [21:16]), there exists a strong tendency to conform to the group opinion. The more clearly visible the majority opinion the greater the movement towards the center of opinion and the more likely the less confident members of the group will conform.

This implies that the development of a consensus need not necessarily be the result of logical coalescence of opinion through a learning process based on controlled group interaction, and, therefore that the consensus may not necessarily represent a judgment superior to the judgments of individuals. The effect of this phenomenon essentially militates against Principle 1 underlying the value of Delphi itself. [91:309]

To combat this problem, Skutsch and Schofer suggest the following three considerations:

1. reduce the visibility of group pressure to the participants,
2. use stability of opinion distributions as a stopping criteria rather than degree of consensus, and
3. use ". . . the entire distribution of opinion to describe the goal weights, rather than a single value of group opinion, such as the median . . . it provides considerably more information on the opinion of the group." [91:310]

One can reduce the visibility of group pressure by reducing the amount of statistical feedback one gives the participants. Skutsch and Schafer show this by the following:



High-group pressure effects  
Histogram of distribution  
Mode  
Mean and interquartile range  
Interquartile range  
Nonstatistical (verbal) only  
Low-group pressure effects. [91:309]

Dalkey, Brown and Cochran [28] and Dalkey and Brown [25] show some evidence contrary to this. Without getting into a prolonged discussion on the subject let us consider what one would have to do to test the possible effects of these different types of feedback on the manipulability of Delphi statements. If one accepted the hypothesis that the degree of manipulability of Delphi statements is affected by type of statistical feedback used, it seems clear that the form of statistical feedback which affects a high-group pressure will result in a better ability to manipulate. To test this, one would have to run the test Delphi using each of the statistical feedback methods suggested. Since this would enlarge the study considerably and produce an overburdening pressure on the resources available, a test of this hypothesis was not attempted.

Determining when to stop a Delphi has traditionally been centered around the number of rounds necessary to develop consensus. Skutsch and Schofer suggest that stability of a distribution might be a better measure for determining when to stop. While it was felt that the latter may be a better measure, four rounds were used in this study so that other hypotheses could be tested. There was an attempt, however, to review the degree of movement found between each round. It was viewed both in terms of movement towards consensus as well as stability of distributions.

Skutsch and Schofer also discuss the use of Delphi to develop judgments of values rather than facts. They distinguish between value-estimation (where the Delphi participants are called upon ". . . to 'estimate' the desires and needs of the community in weighting the goals" [91:311]) and value-election (where the ". . . participants are asked to express their own opinions on goal weights and to state their own reasons for these weights" [91:310]). While there exist possibilities for both, the value-estimation version holds the predominant position. "This must, in part, be due to the fact that decision making authority is generally concentrated in the hands of a few, while the Delphi usually is applied on a wider basis." [91:311]

Another area one might consider with respect to manipulability of Delphi statements is the interjection of bias by respondents to sway the statistical feedback in a manner that is favorable to their own bias. Chester Jones makes the following comment with respect to a group of Delphis he ran in the United States Air Force in an attempt to establish priorities for the System Concept Options.

One concern that is often raised about the credibility of Delphi results is that individual experts may bias their responses so that they are overly favorable towards areas of personal interest. This is of particular concern when experts are asked to evaluate areas in which they are presently working and when the final Delphi results could impact the importance attached to these areas. In this paper results will be presented that indicate that no such bias occurred in the Delphis reported on. It appears that the group of experts used were able to rise above the desire to protect personal interests. [48:160]

While this report is not conclusive for all situations, it supports the idea that a panel of experts would tend to hold the value of the results above their personal bias or interests. Since the nature

of this form of manipulation (i.e. voting overly favorable towards areas of personal interest) is different from the form of manipulation that was originally intended to be tested, it will not be considered in this paper.

In an article published long before Delphi was even conceived, Thomas Coffin [15] concluded:

1. ". . . there is a tendency for suggestibility on problems to increase with the difficulty of the problems" [15:16] and
2. those with more training (more expert) were less prone to suggestibility but were still subject to some suggestibility.

He used 16 mathematical problems of increasing difficulty (complexity) in his non-Delphi study. Included with each problem was a suggestion towards its solution (four of which were correct, twelve incorrect). Suggestibility was indicated when one accepted the suggestion in trying to solve the problem; non-suggestibility was indicated when one rejected the suggestion and did it his own way. Correctness of answer was not considered.

The above has several implications relative to self-rating and the degree of manipulability of Delphi statements. If one can accept the direct relationship between suggestibility (and thus manipulability) and the knowledge and training of the respondent, one could anticipate that an expert (one who has more knowledge and training relative to a Delphi statement) would be less susceptible to manipulation than a non-expert. This would add credence to the concept of having one's panel made up of experts.

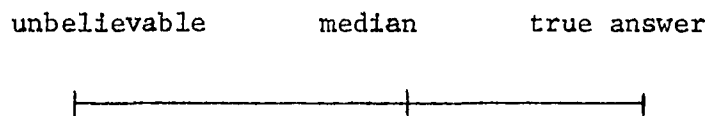
One can also develop another implication from the above. Since people either know something about a factually oriented Delphi statement

or have little or no knowledge concerning it, one would expect factually oriented Delphi statements to be either less or more manipulative, respectively, than value oriented Delphi statements (usually everyone has at least some opinion or familiarity with a value statement). However, Coffin's first point indicates a direct relationship exists between the suggestibility and the difficulty (complexity) of a problem. Often times, value oriented Delphi statements tend to be more complex due to their openness ("depends on how you look at it"). Self-rating by experts may again help alleviate or recognize when this problem exists.

In an effort to explain some of the forces that influence the improvement experienced between rounds by Delphi statements, Dalkey [19] discusses the "pull of the median" and the "pull of the true." He shows that the further an answer is from the median answer, the greater will be the likelihood of change. While those who are further from the median are more likely to change their answer, there also tends to be a magnetic effect towards the true answer; however, the pull of the true answer is considerably weaker than the pull of the median. Thus Dalkey attributes convergence to a combination of the pull of the median and the pull of the true answer with the former playing the predominant role. The result of this disequilibrium is that overconvergence occurs; ". . . the increase in accuracy is not commensurate with the reduction in spread . . ." [19:425]

Of special interest to this paper is whether these pulls can be manipulated in such a manner that one can arrive at a predesigned value. The pull of the true answer is present and can only be affected by falsifying the true answer itself (which obviously cannot be done).

Since the pull of the median is greater, by feeding back a falsified median, one should be able to achieve a greater movement in the direction desired. This leads us to two questions. The first question asks if there is a point where the pull of the true answer outweighs the pull of the median? That is, is there a point some distance from the true answer where the pull of the true answer equals or outweighs the pull of the median as the median travels further away from the true answer? This would indicate there is a point where people would not believe the median and would weight their answer more towards the true answer. This can be expressed by the following diagram:



As the median moves towards the unbelievable, the pull of the true answer becomes stronger and the pull of the median weaker, thus causing respondents to weight their answers toward the true answer. If this holds true, the question becomes, will this be a gradual movement or will people stick with the pull of the median until some threshold is reached and then abandon it radically for the pull of the true answer?

The second question generated is whether the pull of the median versus the pull of the true answer would be the same or different for a value Delphi versus an almanac Delphi. Since the value Delphi has no true answer per se, this is difficult to measure. If the value Delphi tends to be less manipulable than the almanac Delphi, one could, however infer that the pull of the median is less predominant in the value Delphi than in the almanac Delphi.

Dalkey also suggests another question, ". . . can the pull of the true be amplified and the pull of the median be dampened?" [19:425] He suggests that this might be done by ". . . feeding back something weaker than the three quartiles." [19:425] In a later work Dalkey, Brown, and Cochran [28] tried this by feeding back the percentile location of an individual's response rather than the median and quartiles. It was hypothesized that this would be a less specific "target" for changes in the individuals response, thus increasing the relative weight of the pull of the true answer.

The results of the experiment with percentile feedback would appear to indicate that the Delphi process is not very sensitive to the form of feedback as long as it involves some relatively precise summary of the group response on the previous round. The percentile feedback appears to be slightly less effective than medians and quartiles with respect to numerical improvement (average error), but neither form of feedback is very effective on this measure. [28:28]

Dalkey, Brown, and Cochran also considered a second variation in the form of feedback which dealt with ". . . presenting the respondent with a single additional relevant fact." [28:V] It was hypothesized that the respondents accuracy would improve if they were given an additional relevant fact for each question. The result of this "feed-in" was that it greatly increased the accuracy of the respondents. "The ability of the subjects to use essentially any fact, whatever the nature of its relevance to the question involved, is suggestive of the great flexibility of the human mind in dealing with fragmentary information." [28:28] They then went on and discussed the selection of relevant information, saturation of relevant facts, and the extension of the Delphi procedure to include "interaction of the panel with large exogenous sources of information . . ." [28:29]

The above presents a question that is relevant to this study. If feed-in can increase the overall accuracy of the Delphi responses, can false feed-in decrease the overall accuracy of the Delphi response. To go one step further, by controlling the degree of the falsity of the feed-in (i.e. by supplying statistical numbers or facts in the iterative feedback that express the range desired or by supplying only one side of a story) can one actually control and/or predict the response to a Delphi statement?

Jolson and Rossow lend some support to ". . . the assumption that the correct answer will continue to be an underlying force, even under the obvious attraction of the group median . . ." [47:446] They included two control questions in their attempt to test the Delphi process in assigning prior probabilities in a marketing decision under uncertainty. Both questions were the type where one group would have expert (large) knowledge and the other group would have little knowledge of the subject.

Half the responses to the second and third-round questionnaires for the validation study were closer to the true answer than to the median returned from the previous round. Also, the attraction of the true answer seemed to vary directly with the distance between the group median and true value. [47:446]

In both cases, the expert group was able to produce a much better estimate than the non-expert group. It was also noted that the knowledgeable, confident panel member was less likely to revise his prediction over iterations.

Dalkey indicates

. . . the average error on round one is a linear function of the dispersion of the answers. The average amount of change of opinion between round one and round two is a well-behaved function of two parameters - the distance of the first-round answer from the group median, and the distance from the true answer. [21:vi]

This statement attunes itself to the question of the strength of the pull of the median versus the pull of the true answer. Later in his paper, Dalkey demonstrates this relationship. Of concern to this paper is whether the above will hold true for both the control and the experimental groups or whether the effects of the manipulation will change the pattern of the relationships.

Dalkey's results show that iteration results in an improvement in accuracy; however, this is less dramatic than the amount of convergence. While iteration results in improvements in accuracy, its main effect lies in the increased convergence. One might next ask: will manipulated results show similar results? If manipulation was successful, movement towards the desired answer should occur and should be accompanied by an increase in convergence around the desired answer.

Does this really occur, or is the movement toward the manipulated answer less pronounced and the convergence less successful (perhaps even divergent)?

An additional implication that results from the increased convergence is that people desire to be within the range of the upper and lower quartile. If, for whatever reason, this is true, could the size of the range determine or affect the amount of manipulation that can be achieved? If people desire to be within the range, might one achieve better results if he used a small range versus a large range? The idea here is that people may tend to give an answer that is close to the end of a range because it satisfies their desire to be within the range but is closer to the value of their original



estimate (it is more believable). If this is true, smaller ranges would move the participants closer to the desired answer. However, if the endpoint of the range is too distant from their original estimate, the participants may question the validity of the feedback and stay closer to their original answer.

## CHAPTER III

### DESIGN OF THE STUDY

This chapter is concerned with the design considerations of this study. They can perhaps best be summarized by the flowchart found in Figure 2.<sup>5</sup> The structure of this chapter follows the general breakdown of the flowchart. The characteristics of the two populations (participants and Delphi statements, respectively) will first be discussed. A discussion of the general procedure for administering the Delphis will follow. Preceding the specific statistical procedures for each dependent variable (success, convergence, stability, and confidence) will be a discussion of the general design considerations.

### CHARACTERISTICS OF THE PARTICIPANTS

The participants who participated in the Delphis were all United States Air Force officers who were enrolled in a Master of Business Administration program at Grand Forks Air Force Base, North Dakota. The program is funded by the Air Force Institute of Technology and administered by the University of North Dakota. There were two groups of thirty volunteers for both Delphis administered. Thirty students volunteered for both Delphis. Thus out of a possible 151 students, 90 students participated in the Delphis. The two groups of students met for class on separate days and were therefore generally assigned different duty

<sup>5</sup>Figure 3, at the end of Chapter IV, gives a brief synopsis of the findings of the statistical tests indicated in Figure 2.

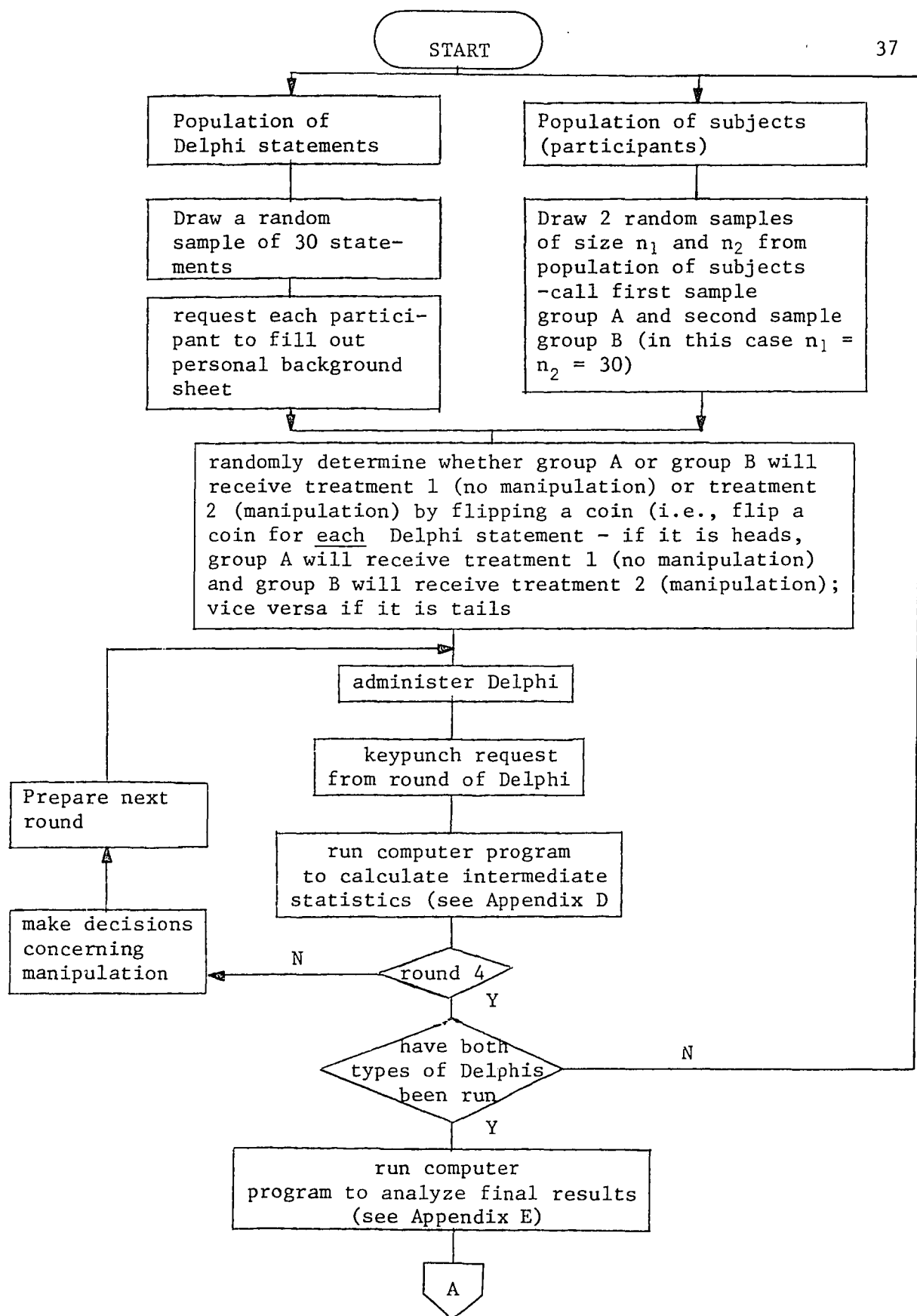
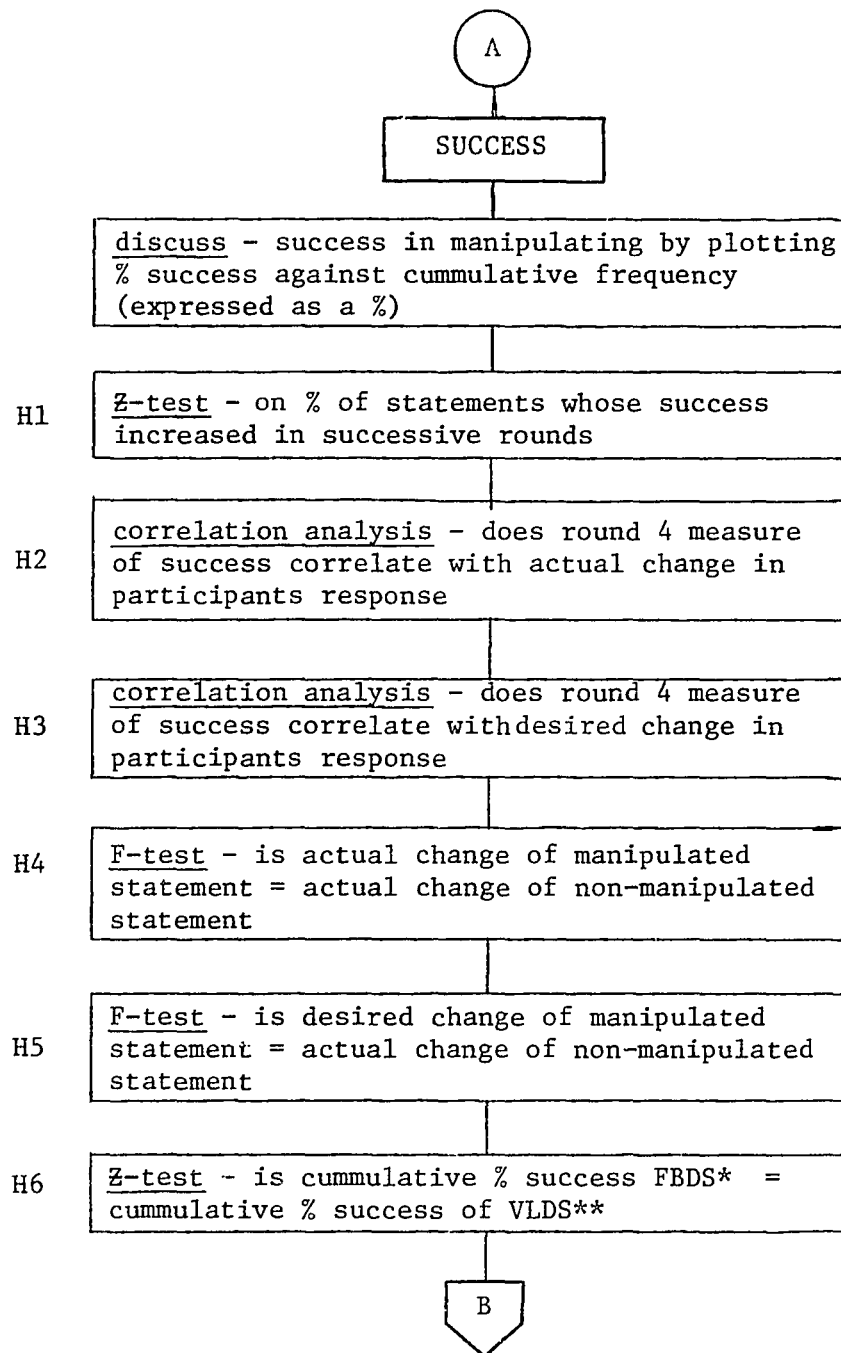
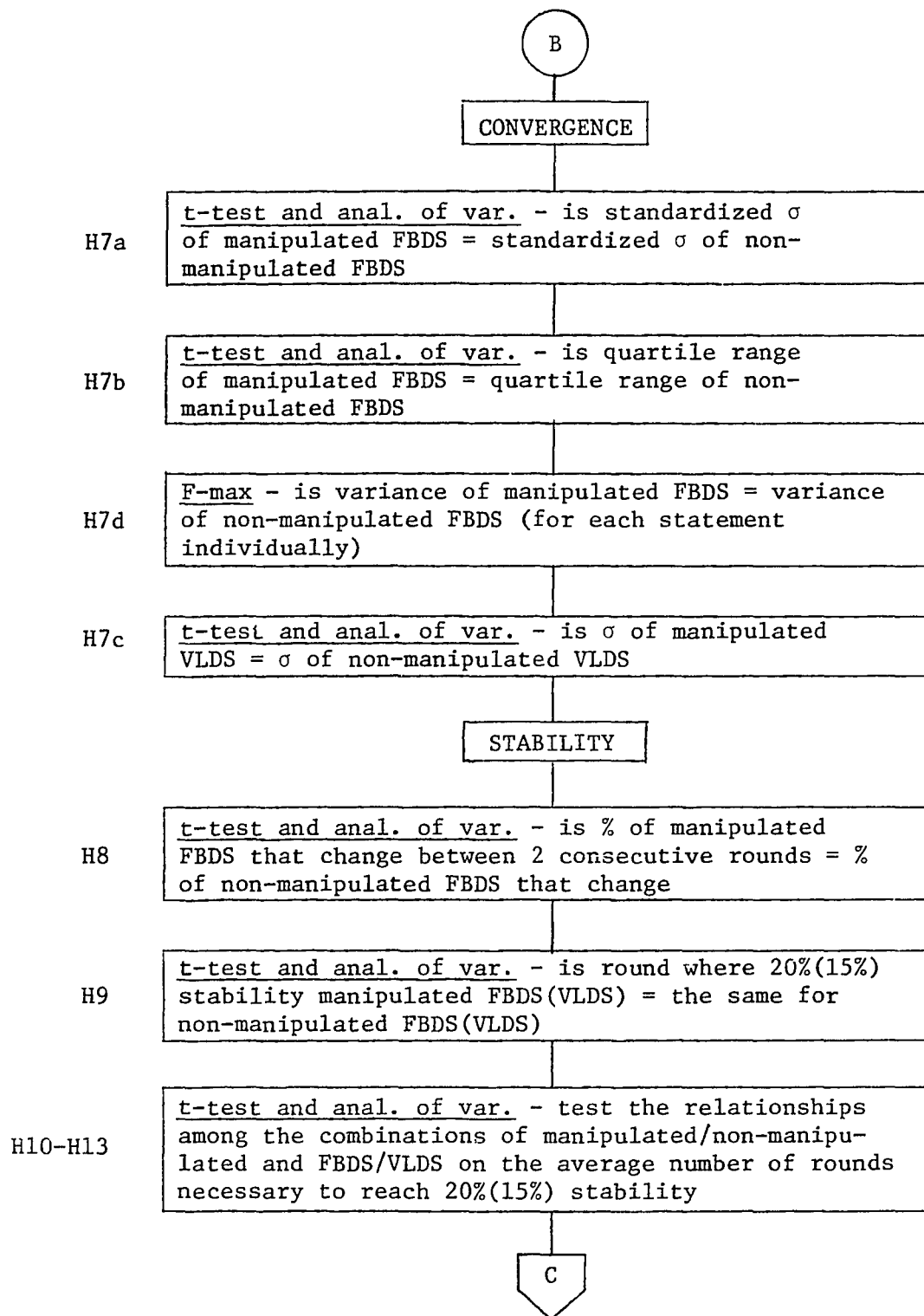


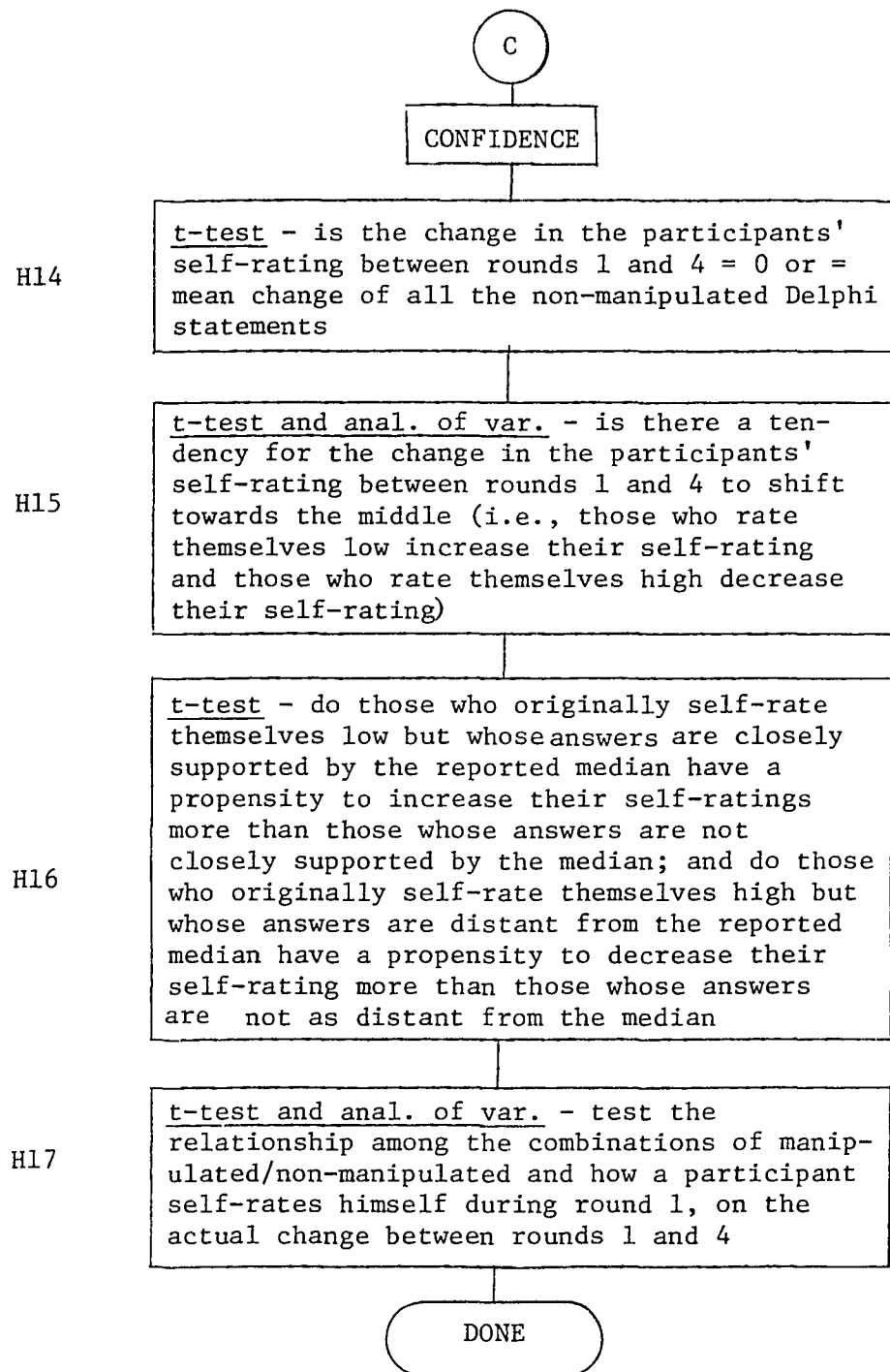
Figure 2. Flowchart of design considerations.



\*FBDS = factually-based Delphi statement

\*\*VLDS = value-laden Delphi statement





schedules. This limited the contact between the two groups. The participants were also instructed not to discuss the Delphis with anyone nor to research any of the Delphi statements.

Both groups were given the same Delphis under the same conditions for the same number of rounds. The only differences were 1) the statistical feedback given was for their group only and 2) if the first group was manipulated on a statement, the second group was not manipulated and vice versa (the assignment of which statements were manipulated for which group was random - a more complete discussion of this procedure will be given later).

Each participant was requested to fill out a personal background sheet. Table I gives the results of this background sketch for both groups for the factually-based Delphi. Table II does the same for the value-laden Delphi. Since they were participating in a MBA program, all of the participants had bachelor degrees. Their degrees ranged from the hard sciences (mathematics, chemistry, physics, etc.) to the soft sciences (philosophy, social science, political science, etc.) to the arts (music) to degrees in the business area from universities throughout the United States. Thus, the educational level was high. The tables also show that the age range was narrow and that most of the participants were married. While between groups they were similar with respect to rank, length in the airforce, number of courses taken in the MBA program, number of children, father's occupation, and responsibilities in the airforce, the within variance of these factors was large.

Mulgrave and Ducanis in an effort to test the propensity of Delphi participants to change their responses as a function of dogmatism found

TABLE I

## Background of Factually-based Delphi Participants

Rank	2nd Lt		1st Lt		Capt.		Major		Colonel										
Group A	10		3		15		1		1(retired)										
Group B	9		6		15														
How Long in Airforce	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	30	
Group A	6	2	1	0	4	2	3	4	3	1	1	0	0	1	0	0	1	1	
Group B	4	3	4	2	1	6	0	2	3	2	1	1	0	0	1	0	0	0	
Number of Completed Courses*	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Group A	4	1	2	3	4	1	4	1	1	1	0	1	0	0	4	1	0	0	2
Group B	2	2	3	3	0	2	2	3	3	0	2	2	2	1	1	1	0	0	1
Age	23	24	25	26	27	28	29	30	31	32	33	34	35	52					
Group A	1	5	3	4	1	3	5	2	1	2	1	0	1	1					
Group B	2	2	2	3	3	3	4	3	3	1	4	0	0	0					

\*includes prerequisite courses



TABLE I(Continued)

<u>Married</u>	<u>Yes</u>	<u>No</u>
----------------	------------	-----------

Group A	26	4
---------	----	---

Group B	23	7
---------	----	---

<u>Number of Children</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>12</u>
-------------------------------	----------	----------	----------	----------	----------	----------	-----------

Group A	15	8	5	1	0	0	1
---------	----	---	---	---	---	---	---

Group B	17	2	10	0	0	1	0
---------	----	---	----	---	---	---	---

<u>Father's Occupation</u>	<u>Group A</u>	<u>Group B</u>
----------------------------	----------------	----------------

Professional	2	2
--------------	---	---

Managerial	4	5
------------	---	---

Technical or Engineering	3	1
-----------------------------	---	---

Sales or Service	5	4
------------------	---	---

Government	2	2
------------	---	---

Armed Forces	2	4
--------------	---	---

Skilled Blue Collar	4	8
---------------------	---	---

Unskilled Labor	2	2
-----------------	---	---

Other	6	2
-------	---	---

TABLE II  
Background of Value-laden Delphi Participants

Rank	2nd Lt			1st Lt			Capt.			Major												
Group A	10			5			14			1												
Group B	13			6			11			0												
How Long in Airforce	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17					
Group A	5	5	2	2	3	1	2	2	2	3	1	0	0	1	0	0	1					
Group B	7	4	3	1	3	4	1	2	1	1	2	0	0	0	0	1	0					
Number of Completed Courses*	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	20		
Group A	1	2	5	6	0	0	6	1	1	0	0	0	1	2	2	1	0	0	1	1		
Group B	2	0	4	1	3	2	3	3	3	1	1	2	1	0	2	2	0	0	0	0		
Age	22	23	24	25	26	27	28	29	30	31	32	33	34	35								
Group A	1	4	2	4	5	1	1	4	1	3	1	1	1	1								
Group B	1	1	3	7	3	1	4	3	1	1	1	2	2	0								

\*includes prerequisite courses

TABLE II(Continued)

<u>Married</u>	<u>Yes</u>	<u>No</u>
----------------	------------	-----------

Group A	24	6
---------	----	---

Group B	22	8
---------	----	---

<u>Number of Children</u>	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
-------------------------------	----------	----------	----------	----------	----------

Group A	16	6	6	2	0
---------	----	---	---	---	---

Group B	17	2	9	1	1
---------	----	---	---	---	---

<u>Father's Occupation</u>	<u>Group A</u>	<u>Group B</u>
----------------------------	----------------	----------------

Professional	4	3
--------------	---	---

Managerial	8	7
------------	---	---

Technical or Engineering	3	2
-----------------------------	---	---

Sales or Service	5	4
------------------	---	---

Government	1	2
------------	---	---

Armed Forces	3	3
--------------	---	---

Skilled Blue Collar	4	5
---------------------	---	---

Unskilled Labor	2	2
-----------------	---	---

Other	0	2
-------	---	---

...that the High Dogmatism group is less likely to change an answer to a question on which they consider themselves expert than one on which they consider themselves less expert, but that in the presence of some "perceived" authority such as the group median, High Dogmatism groups will exhibit more change than Low Dogmatism groups. [66:290]

To circumvent the question that United States Air Force officers might have been highly dogmatic due to the nature of their training and work, the same test for dogmatism that Mulgrave and Ducanis used in their research (Berger's revision of Rokeach's Dogmatism Scale - the FCD Scale [4] - reference Appendix C for a copy of the scale) was administered to most of the officers who participated in this study. (The officers not tested were no longer available to be tested. They had either been transferred, were on leave, or were no longer in the AFIT program.) As Table III indicates the mean scores for each of the groups who participated in the Delphis were in the neighborhood of 122.

Interpreting the results of this test turned out to be a problem. Through personal correspondence, Mulgrave provided a copy of Berger's test. In an effort to administer the test at a time when the students were able to participate, the test was run before a copy of Berger's thesis arrived. When Berger's thesis arrived, it was discovered that he was primarily concerned with testing the effects of a certain phenomenon (when unsure of an answer, a participant will answer in the affirmative a larger percentage of the time) on several different psychological tests (the FCD scale being one of them). For this reason, Berger was not concerned with determining what ranges of scores represented low, medium, or high dogmatism. Since Berger used the statements in Rokeach's test

TABLE III  
Results of Berger's Revision of Rokeach's  
Dogmatism Scale (the FCD Scale)

	Number Tested	Mean Dogmatism Score
Section A factually-based Delphi	23	122.8
Section B factually-based Delphi	19	121.7
Section A value-laden Delphi	27	121.3
Section B value-laden Delphi	25	122.4
All participants	67	122.2

in devising his test, it was felt that it would not be possible to rerun Rokeach's test.

The procedure used to determine if a score of 122 represented high dogmatism was to calculate the scores of the participants in Berger's thesis to see what value they scored on Rokeach's test and Berger's test and to see if the scores for Rokeach's test represented high or low dogmatism. Berger's participants scored 124 on his test and 143 on Rokeach's test (medium dogmatism). Since Berger found there was a positive correlation between his test and Rokeach's test, a score of 122 should also be considered as representing medium dogmatism.

After doing the above analysis, Dr. Berger was contacted and asked whether the analysis appeared proper. His remark was that, while it had been a long time since he had done anything with that test and its main purpose was other than what I was doing, my analysis seemed proper. Therefore, while the results were not conclusive, it appeared as though the United States Air Force officers who participated in these Delphi studies were not highly dogmatic.

It should be cautioned that the panel of experts participating in this study was not representative of all possible panels of experts. For example, the panel was somewhat of a homogeneous group (more so than one might have wanted to see in a Policy Delphi). Another example is the lack of women on the panel. The panel was, however, representative of a group of experts who would have participated in the Delphis since the Delphis were designed to fit the area of expertise of the panel members.

## SUBJECT MATTER OF THE DELPHIS

Factually-based Delphis are fact probing Delphis which are used to project quantitative values for statements that will eventually prove to be true or false. Examples are the forecasting Delphis used to project when a certain capability will occur or what capability will exist at a point in the future. Almanac Delphis are of a similar nature to forecasting Delphis, except they project something that has already occurred. Projecting something that has already occurred has the distinct advantage of allowing one to verify immediately certain aspects of the Delphi technique such as accuracy. For this reason, almanac Delphis have been used in many Delphi experiments. For the purpose of this study, it will be assumed that an almanac Delphi will be representative of factually-based Delphis.

In choosing the subject matter for the statements to be used in the almanac Delphi, primary consideration was given to choosing statements of which the participants would have some knowledge. Thus the statements were all concerned with Grand Forks, North Dakota, Grand Forks Air Force Base, United States Air Force, and the MBA program of which the participants were a part. The data was gathered from various resources such as The World Almanac, Air Force Almanac, brochures published by Grand Forks, and the MBA program's record. Out of forty questions developed, thirty were chosen to be used in the study. Appendix A contains a sample of the Almanac Delphi used.

Value-laden Delphis are value probing Delphis which cannot eventually be judged as true or false (who is to say one man's values are right or wrong). While factually-based Delphis tend toward the

objective, value-laden Delphis are highly subjective in nature. Most Policy Delphis are value-laden Delphis in that they subjectively rate the necessity, desirability, importance, etc., of some statement. For this reason, a Policy Delphi rating the importance of a list of objectives for the MBA program in which the participants were participating was used as the value-laden Delphi. It is assumed it is representative of a value-laden Delphi. The subject matter was chosen in that it was something in which all the participants were currently involved and was thus something about which they had some ideas or concerns.

The statements were developed by reviewing a series of similar studies which tried to identify institutional goals [2, 12, 16, 17, 39, 43, 49, 50, 69, 89, 96] and by selecting from their results a series of statements that appeared applicable to the MBA program. Appendix B contains a sample of the value-laden Delphi used.

#### GENERAL PROCEDURE FOR ADMINISTERING THE DELPHIS

As indicated, there were two groups of participants for each Delphi (group A and group B). The personal contact of the participants of one group with the participants of the other group was minimized since they attended classes on different days and as a result were generally assigned to their Air Force duties on different schedules. This minimized the interaction between groups. The interaction within a group was minimized by requesting that the participants not discuss the Delphi with anyone. Several students who were not participating in the study and who were aware of what was being done reported they did not detect any violation of this request.



The selection of the Delphi statements that were manipulated for each group was done randomly by flipping a coin. If the coin landed heads, the statement was manipulated in group A and not manipulated in group B. Vice versa if it landed tails. Thus, all thirty almanac Delphi statements were both manipulated and not manipulated. The same procedure was used for the value-laden Delphi except a Monte Carlo technique was used to select thirty of the total number of statements. The coin flipping procedure was then applied to these thirty statements. The Delphi participants were not told they were being manipulated and to the best of this authors knowledge they were unaware of it throughout the study.

The process used to determine the desired value (that value which one is attempting to obtain through manipulation of statistical feedback) was very subjective. It was originally desired to use the objective procedure of manipulating the first round response by plus or minus one as measured by the error form of measurement. (The error form of measurement is discussed in a later section in this chapter entitled "Measurement of Success.") Problems were experienced by this procedure, however, since it did not take into consideration the distribution of the participants answers and the range of believability of the answers to a Delphi statement. For example, if the median response to the almanac Delphi statement "The highest temperature ever recorded in North Dakota was \_\_\_\_ (°F)," was 115, one would have to try to achieve a median of 312 or 42 to accomplish manipulating the response by plus one or minus one respectively using the error form of measurement. Obviously neither of these values was believable. For this reason, a more subjective procedure was used. It involved the following steps:

1. determine the range of believable answers for each statement before the Delphi is run;
2. after considering the above range and the distribution of responses for round 1, chose a value that takes into consideration the following:
  - a. the value should be in the direction of the true answer but beyond it unless the true answer is sufficiently distant from the initial response (this will combine the pull of the true as well as the pull of the median);
  - b. the value chosen should be sufficiently distant from the initial response so that the movement cannot be attributable to accident; and
  - c. a strategy of manipulation by the full desired amount during the first round and then maintaining it around that point for each of the remaining rounds should be used.

One should notice this procedure used the distribution of responses from round 1 to decide the desired value rather than deciding it before the Delphi was run. The primary reason for this was to avoid creating a desired value that the participants might have achieved at the end of round 1 (i.e. to avoid problems with 2.b above).

In hindsight, a prospective algorithm which might have been used to calculate the above desired answer might have looked like the following:

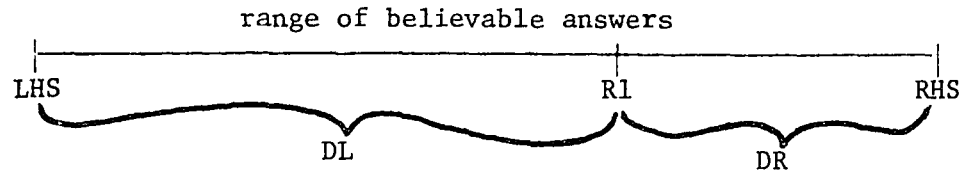
- 1) Calculate the range of believable answers where

LHS = left-hand side of range  
 RHS = right-hand side of range

- 2) Calculate the distance between the round 1 median or index (R1) and the range of believable answers

$DL = |LHS - R1|$

$DR = |RHS - R1|$



3) Determine which distance is larger

if  $DL > DR$       then  $D = LHS - R1$   
                          otherwise  $D = RHS - R1$

4) Calculate the desired answer (AD)

$$AD = R1 + 80\% \text{ of } D$$

The above algorithm has the disadvantage that it does not take into consideration the direction of the true answer. It is possible, however, that one could modify the algorithm to include a preference for the direction of the true answer. One such modification might be as follows:

2a) add preference to the end of range which contains the true answer (T)

if T is between LHS and R1 and  
 $|T - R1| > 10\% \text{ of } DL$   
     then  $DL = DL + 20\% \text{ of } DL$   
 if T is between RHS and R1 and  
 $|T - R1| > 10\% \text{ of } DR$   
     then  $DR = DR + 20\% \text{ of } DR$

The percentages used in the above algorithm (80%, 10%, and 20%) were subjectively chosen. Another researcher might prefer to use a different set of percentages that better fit his Delphi.

Appendices A and B contain copies of the factually-based and the value-laden Delphis respectively and the instruction sheets that were used in the Delphis. As can be seen, there were four rounds.

(Four rounds were used to allow the more complete testing of the

hypotheses concerning convergence and stability). The Delphis were administered in an eleven day period. The first and second rounds were completed on days one and two respectively. Rounds three and four were completed on days ten and eleven. (This schedule was dictated by the class schedule of the MBA program.) Upon completion of each round by the participant, the answers were punched on cards and read into a computer which computed the actual statistics and produced several reports that were useful in analyzing the results (see Appendix B). After analyzing the reports, the appropriate decisions were made as to what statistical feedback was to be used for the next round. The forms for the next round were then prepared and things were readied so the material necessary for the next round would be available by 8:30 the next morning.

The participants were allowed to pick up the current round any-time between 8:30 A.M. and 5:00 P.M. during the day and to fill it out at their convenience. It was to be returned by 5:00 P.M. that evening. There was a 100% completion rate.

#### GENERAL DESIGN CONSIDERATIONS

As indicated, this research explored the effects that manipulation of statistical feedback had on the success, convergence, and stability of Delphi statements and on the confidence of the participants. With this in mind one can recognize three basic independent variables (treatments, (i.e. manipulation and non-manipulation), participants, and Delphi statements) and four dependent variables (success, convergence, stability, and confidence).

The usual objective of an experimental design is to derive the statistics of the responses of the dependent variables and to determine if the statistics are significantly different. One of the steps in determining their statistical significance is to look at the variances of the responses. In a properly designed experiment, it is assumed that the variances of the responses are due to differences among the treatments (i.e., one treatment is more successful than another) and due to experimental error. That is, the variations in the responses may be due to the variances within each treatment as well as the variances among treatments. The design considerations and randomization used for each experiment will now be discussed.

The within variances of the participants and the Delphi statements resulted mainly from variations in the affinity of participants and/or Delphi statements to be subjected to manipulation. This variation was minimized by randomly selecting large samples of the appropriate populations. Since the samples were large and were randomly selected, they should have been representative of the populations.

The variance between the participants and the Delphi statements was neutralized in that all the participants responded to all the Delphi statements. Thus the variances caused by participants only answering some of the Delphi statements was eliminated. The variance between the treatment (manipulation and non-manipulation) and the Delphi statements was neutralized in a similar manner. The entire sample of Delphi statements was subjected to both treatments.

The participants were divided into two groups (each representative of a random sample of the population). A coin was flipped to determine randomly which group would receive which treatment for a particular Delphi

statement. The coin flip was done separately for each Delphi statement. Thus group A received treatment 1 for 14 (15) random factually-based (value-laden) Delphi statements and group B received treatment 1 for the other 16 (15) statements. If group A received treatment 1 for a Delphi statement, group B received treatment 2 for that statement.

A treatment group error also could have affected the variance among treatments. This form of error would have resulted from the effects of extraneous factors affecting all the members of a group in a similar manner but not affecting another group in the same manner. For example, an individual participant might have added to or taken away from the conscientiousness of the group; or certain environmental conditions under which the Delphi was run might have affected the results. The only effective way to have combated this variation was to have replicated the entire experiment a number of times in a manner that would have hopefully randomized these effects. Since this experiment was bounded by resource constraints (time frame, cost, and number of participants who will cooperate), this was not attempted.

With the above in mind, two experiments were run. The first experiment used an almanac (factually-based) Delphi made up of thirty almanac Delphi statements of which USAF officers would normally have some preknowledge. The second experiment used a Policy (value-laden) Delphi which attempted to establish a ranked set of goals and objectives for an MBA program. Thirty items on this Delphi were used in the experiment. Since the participants were all MBA students, they should have had some interest and knowledge about the subject.

It was assumed that a sample of thirty Delphi statements was a large enough sample and that the Delphi statements were representative of the appropriate populations of the Delphi statements. This hopefully eliminated the within variance of the Delphi statements.

The between variances were minimized as previously indicated. All participants responded to all the Delphi statements. The participants were divided into two large randomly selected groups (group A and group B). A coin flip for each Delphi statement determined whether it was manipulated in group A or group B. Thus each statement was manipulated in one group and non-manipulated in the other group, and each participant was randomly manipulated and non-manipulated.

The officers participating were representative of the population of USAF officers enrolled in MBA programs and a sample size of thirty for each group for each Delphi was considered amply large.

#### STATISTICAL PROCEDURES

This section is basically divided into two parts. The first part presents a description (and the mathematical formulation where appropriate) of the measures used in the statistical analysis. The second part presents the null hypotheses used to test the research hypotheses specified in Chapter I.

The purpose of this section is not to justify the experimental design of this research but rather to present the experimental design in as clear and precise terms as possible (i.e. to enhance another researcher's ability to replicate the experiment). The reasons for designing the experiment in this manner should become evident when one reads the analysis of the results presented in Chapter IV.

### Measurements Used in Statistical Tests.

The measures used in expressing and testing the null hypotheses of this study will be discussed under their appropriate topic areas (success, convergence, stability, or confidence). Included for each measure will be a general description of the measure; the abbreviated form of the measure; and, where appropriate, a mathematical formulation for the measure. The above discussions will be preceded by a description of the subscript notation used to delimit the measures.

Subscript Notation. Each variable (measure) that is discussed in this section is delimited by the set of subscripts (o, p, q, r, t, u, w, x, y, z). Each subscript specifies the variable in more detail. The absence of a subscript indicates that it is not necessary to be specified. The presentation of each subscript will follow the following general format:

```
subscript = brief description of meaning of subscript
           list of values subscripts may assume = description of value
```

The subscripts are as follows:

```
o = participant
  blank = unimportant or self-evident in considering this
          variable or averaged over this variable
  k = the indicated value for each participant was
      used as input into the statistical procedure

p = type of Delphi
  blank = unimportant or self-evident in considering this variable
  a = factually-based (almanac) Delphi
  v = value-laden Delphi

q = form of measurement for success
  blank = unimportant or self-evident in considering this variable
  s = non-standardized form
  e = error form
  v = index form
  v1 = index-1 form
  v2 = index-2 form
```



r = manipulated or non-manipulated  
     blank = unimportant or self-evident in considering this variable  
         m = manipulated  
         nm = non-manipulated  
         b = both of the above

t = measure of convergence  
     blank = unimportant or self-evident in considering this variable  
         q = quartile range in error form  
         σ = standard deviation  
         d = standardized standard deviation  
         v = variance

u = form of individual response  
     blank = unimportant or self-evident in considering this variable  
         a = unaltered form, factually-based  
         e = error form, factually-based  
         v = unaltered form, value-laden

w = statement  
     blank = unimportant or self-evident in considering this variable  
         i = the indicated value for each statement was used as  
             input into the statistical procedure

x = round  
     blank = unimportant or self-evident in considering this variable  
         j = the indicated value for each round was used as input  
             into the statistical procedure  
         1 = round 1  
         2 = round 2  
         3 = round 3  
         4 = round 4

y = percent successfully manipulated  
     blank = unimportant in considering this variable  
         y = percent must be specified individually for complete  
             specification (this represents the individual entries  
             in the "% SUCCESS" column of Table IV)

z = how a participant self-rates himself during round 1  
     blank = unimportant in considering this variable  
         1 = self-rates himself 1 during round 1  
         2 = self-rates himself 2 during round 1  
         3 = self-rates himself 3 during round 1  
         4 = self-rates himself 4 during round 1  
         5 = self-rates himself 5 during round 1

Measurement of Success. The success in achieving a desired answer through statistical manipulation was expressed as the ratio of the distance one desired the participants to move to the distance they actually moved. The general form used for the measurement of success was  $S_{qwx}$ .

$$S_{qwx} = \frac{\text{desired change}}{\text{actual change}}$$

Since the units which were used to express the answers to factually-based (almanac) and value-laden Delphi statements were different, there were several ways  $S_{qwx}$  was calculated. These will now be developed.

The measure of success ( $S_{qwx}$ ) for factually-based (almanac) Delphi statements was expressed in two different forms, the non-standardized form and the error form. The non-standardized form used the actual values resulting from each round. The error form converted the actual values to what Dalkey [21] called their "error" values. He defined the "error" of a question as the natural log of the absolute value of the result of the Delphi answer divided by the true answer. This had the advantages of (1) normalizing the values and (2) ". . . if the panelist gave a response which is half of the true answer, he has made an error of the same size as though he gave an answer twice the true answer." [62:33] A third form (the standardized form) was also printed on the computer listings. It standardized each of the values  $[(\text{value} - \text{mean}) / \text{standard deviation}]$  before they were used to calculate the measure of success. As it turned out, the standardized and non-standardized (actual) values were the same (this can be shown algebraically). The standardized form will not be discussed further

with respect to the measure of success.

With the above in mind, the non-standardized form of  $S_{qwx}$  was calculated in the following manner:

$$S_{six} = \frac{A_{aix} - A_{ail}}{D_{ai} - A_{ail}}$$

where

$S_{six}$  = the non-standardized form of the degree of success achieved in manipulating almanac (factually-based) Delphi statement  $i$  in a particular round;

$D_{ai}$  = the desired median to which almanac Delphi statement  $i$  was being manipulated; and

$A_{aix}$  = the actual median of almanac Delphi statement  $i$  in a particular round.

The error form of  $S_{qwx}$  was calculated in the following manner:

$$S_{eix} = \frac{A_{eix} - A_{eil}}{D_{ei} - A_{eil}}$$

$S_{eix}$  = the error form of the degree of success achieved in manipulating almanac (factually-based) Delphi statement  $i$  in a particular round;

$D_{ei}$  = the error form of the desired median to which almanac Delphi statement  $i$  was being manipulated

$$D_{ei} = \ln \left| \frac{\text{desired median}}{\text{true answer}} \right| \text{ for statement } i; \text{ and}$$

$A_{eix}$  = the error form of the median of almanac Delphi statement  $i$  in a particular round

$$A_{eix} = \ln \left| \frac{\text{round } x \text{ median}}{\text{true answer}} \right| \text{ for statement } i.$$

The use of errors could not be used to measure the success of manipulating value-laden Delphi statements because (1) the statistical response was expressed as a frequency distribution rather than a median and quartiles and (2) a true answer does not exist. Therefore, an alternative measure had to be developed to calculate the degree of success of manipulating value-laden Delphi statements.

Since the statistical feedback of value-laden Delphi statements was expressed as a frequency distribution on a five point scale of importance, the mean of this frequency distribution was used in the success calculations. The index<sup>6</sup> was calculated in the following manner:

The frequency distribution contained the following five classes of importance:

- 1 - no importance
- 2 - low importance
- 3 - medium importance
- 4 - high importance
- 5 - extremely high importance

The index was calculated by summing the frequency of each class times its class value and dividing by the total frequency.

An example will help illustrate. If a value-laden Delphi statement resulted in the following frequency distribution:

1	2	3	4	5	class of importance
2	5	18	3	2	frequency,

the index would be calculated

$$((2)(1) + (5)(2) + (18)(3) + (3)(4) + (2)(5))/30 = 2.93$$

<sup>6</sup>To alleviate any confusion with means of other distributions, the mean of a frequency distribution for a particular statement will be referred to as the "index" for that statement.

The use of an index to represent the frequency distribution of a value-laden Delphi statement had the advantage of being a single value that could be directly compared with the index of another statement or with the index of a statistically manipulated statement. It did, however, have an important drawback that should be mentioned. A single index could represent many frequency distributions. Thus, throughout this report we will be discussing the success of achieving a mean of a frequency distribution rather than achieving a particular distribution.

The success of manipulating value-laden Delphi statements was calculated in the following manner:

$$S_{vix} = \frac{A_{vix} - A_{vil}}{D_{vi} - A_{vil}}$$

$S_{vix}$  = the degree of success achieved in manipulating value-laden Delphi statement  $i$  in a particular round;

$D_{vi}$  = the desired index to which the value-laden Delphi statement  $i$  was being manipulated; and

$A_{vix}$  = the actual index of value-laden Delphi statement  $i$  in a particular round.

An additional problem arose with the above calculation. It was possible to have more than one hundred percent success. That is, the index was, in some cases, successfully moved beyond the desired index. This allowed two possible interpretations. If the objective was to achieve a particular index, 125% success would have been the same as 75% success since both were 25% from the desired success. If the objective was to move the index beyond a desired index, anything beyond that index would have been considered "icing on the cake" and would have

been considered 100% successful.  $S_{vij}$  was therefore further specified to differentiate between these two interpretations.

$$S_{v1ix} = \begin{cases} S_{vix} & \text{if } S_{vix} \leq 1.00 \\ 1.00 - (S_{vix} - 1.00) & \text{if } S_{vix} > 1.00 \end{cases}$$

$$S_{v2ix} = \begin{cases} S_{vix} & \text{if } S_{vix} \leq 1.00 \\ 1.00 & \text{if } S_{vix} > 1.00 \end{cases}$$

There are some additional forms of the above measures of success that will also be used in the ensuing discussion. A brief identification of these will now be given.

$S_{qzk}$  = cumulative percent of statements that were k percent successfully manipulated as measured by  $S_{qwx}$  (reference Table IV)

$R_{urwjo}$  = individual response in the appropriate form for a statement in round j for a participant

$$R4-R1_{urwo} = R_{urw4o} - R_{urw1o}$$

$$AD-R1_{urwo} = D_{uw} - R_{urw1o}$$

Measurement of Convergence. When one discusses the convergence of a Delphi statement, one normally refers to the change in some measure of dispersion. While convergence of a factually-based (almanac) Delphi statement is usually measured by the shrinking of the difference between the upper and lower quartile (the quartile range), this study also viewed it from the viewpoint of its standard deviation and standardized standard deviation. Convergence of a value-laden Delphi is usually implied as a narrowing of the frequency distribution such that near-normal distribution

results. The standard deviation, therefore, appeared to be a proper measurement. The general form used for the measurement of convergence was  $C_{prtwx}$ . A development of the specific forms for the measurement of convergence used in this study will now be given.

In order to compare quartile ranges with each other, they must be normalized. That is, one cannot effectively compare a quartile range of 5000 for the question "How many women Marines were there in 1945?" with a quartile range of 60 for the question "What was the in-orbit weight in pounds (weighted at sea level) of the Telstar 1 satellite?" They must first be converted to a common base. To alleviate this problem, the values of the quartiles were converted to their "error" form. Thus the measure of the quartile range of factually-based Delphi statements was calculated as follows:

$$C_{arqix} = |UQ_{rix} - LQ_{rix}|$$

where

$C_{arqix}$  = a quartile range measure of the convergence for almanac (factually-based) Delphi statement  $i$  for a particular round;

$UQ_{rix}$  = the error for the upper quartile for almanac Delphi statement  $i$  for a particular round

$$UQ_{rix} = \ln \left| \frac{\text{upper quartile}}{\text{true answer}} \right| \text{ for statement } i; \text{ and}$$

$LQ_{rix}$  = the error for the lower quartile for almanac Delphi statement  $i$  for a particular round

$$LQ_{rix} = \ln \left| \frac{\text{lower quartile}}{\text{true answer}} \right| \text{ for statement } i.$$

The second form used to measure the convergence of a factually-based (almanac) Delphi statement can be expressed as:

$C_{ar\sigma ix}$  = standard deviation ( $\sigma$ ) of the participants' answers in a particular round of almanac (factually-based) Delphi statement i.

Again, since standard deviations cannot be directly compared (for the same reasons the quartiles cannot be compared), a standardized form of the standard deviations was developed. It was calculated in the following manner:

$$C_{ardix} = \frac{C_{ar\sigma ix} - \bar{X}_{arix}}{C_{ar\sigma ix}}$$

$C_{ardix}$  = a standardized standard deviation measure of the convergence for almanac (factually-based) Delphi statement i, for a particular round;

$C_{ar\sigma ix}$  = same as defined earlier;

$\bar{X}_{arix}$  = mean of the participants' answers of almanac (factually-based) Delphi statement i for a particular round.

Since the convergence of a value-laden Delphi statement usually implies a narrowing of a frequency distribution, the simplest and most straight forward means of measuring this change in the distribution is via its standard deviation. Therefore, in this study, the convergence of value-laden Delphi statements was measured as:

$C_{vr\sigma ix}$  = standard deviation ( $\sigma$ ) of the frequency distribution in a particular round of value-laden Delphi statement i.

#### Measurement of Stability. Scheibe, Skutsch, and Schofer [85]

measured stability by the following algorithm:

- (1) take the absolute differences between the frequency distributions of a question for two consecutive rounds,
- (2) sum these absolute differences,
- (3) divide by two (since any one participant's change of opinion is reflected in the histogram by two units of change), and



(4) divide by the number of participants.

The result was the percent change in the frequency distribution. They empirically decided a percent change of less than 15% represented a stable condition.

One immediately runs into a problem when one tries to use this algorithm to measure stability for factually-based Delphi statements (i.e., a frequency distribution does not exist). The concept of stability, however, still can be used by merely measuring the percent change in the individual responses from round to round rather than the percent change in the frequency distribution. Therefore, in this study, a factually-based Delphi statement was considered stable when 20% or less of the participants changed their responses (or, if you prefer, when 80% or more participants did not change their responses).

In order to maintain a level of consistency between measuring stability for value-laden and factually-based Delphi statements, the same procedure was used to measure stability for value-laden Delphi statements. This allowed direct comparison between the two types of statements.

The percent movement used here was 20 percent instead of the 15 percent as suggested by Scheibe, Skutsch, and Schofer. Their method merely subtracted the frequency distributions of one round from another round and did not allow for a double shift. A double shift can occur two different ways. The first way is if participant A changes his response from 1 to 2 and participant B changes his response from 2 to 3. This would result in a change in the frequencies for 1 and 3 and thus only be counted as one change (from 1 to 3). The other way a double shift could occur is if participant A changes his response from 1 to 2

and participant B changes his responses from 2 to 1. There would be no change in stability recorded. Since looking at each individual participant's movement would avoid these problems (would count them as two changes), it is reasonable to assume a larger value than what Scheibe, Skutsch, and Schofer recommend.

In particular, the following measures will be used in the ensuing discussion:

$\%C12_{prw}$  = percent of participants who changed their responses between rounds 1 and 2;

$\%C23_{prw}$  = percent of participants who changed their responses between rounds 2 and 3;

$\%C34_{prw}$  = percent of participants who changed their responses between rounds 3 and 4;

$S20\%_{prw}$  = round where 20% stability first occurred;

$S15\%_{prw}$  = round where 15% stability first occurred;

$CLQ_r$  = number of factually-based Delphi statements whose lower quartile changed between two rounds;

$CM_r$  = same as  $CLQ_r$  except for medians;

$CUQ_r$  = same as  $CLQ_r$  except for upper quartiles;

$\overline{S20\%_{pr}}$  = average round where 20% stability first occurred; and

$\overline{S15\%_{pr}}$  = average round where 15% stability first occurred.

Measurement of Confidence. The effects statistical manipulation had upon the confidence of Delphi participants was measured by the use of self-rating. Before the procedure is discussed, it will be useful to review the self-rating scales used.

Self-rating scale 1 (used during rounds 1 and 4):

<u>Self-rating</u>	<u>Explanation</u>
1	Possess little or no knowledge on the subject, answer would basically be a guess.
2	Possess a limited amount of knowledge on the subject, answer would basically be an educated guess.
3	Possess enough knowledge to make a reasonable estimate of the answer.
4	Know some pertinent details about the subject or have more than an average amount of experience in the subject that would make my estimate better than most people.
5	Considerable knowledge, either know the answer or have available knowledge that directly pertains to the statement and can make a reasonable close estimate of the actual true value.

Self-rating scale 2 (used during rounds 2 and 3):

<u>I</u> <u>If You</u> <u>Changed Your Answer</u>	<u>II</u> <u>If You Did Not</u> <u>Change Your Answer</u>
A. I had misread the question.	F. I believe my original estimate.
B. I made a mistake in computation.	G. The other members of the group are not likely to know more about the question than I do.
C. I remembered some additional facts.	H. No good reason to change.
D. My estimate was too far from the group median.	I. My estimate was close to the group median.
E. The other members of the group are likely to know more about the question than I do.	J. It would be more effort than it's worth to rethink the answer. [8:36]

All participants were requested to use self-rating scale 1 to rate their expertise on each question during round 1 and round 4. By comparing the self-rating for rounds 1 and 4, it was possible to determine if there was a change in how a participant rated his expertise.

The participants also were requested to use self-rating scale 2 during rounds 2 and 3. How participants responded to scale 2 gave insights into the reasons why the participants changed their responses and how they rationalized rerating their expertise.

The primary units of measure were the round 1, round 4 difference in a participant's self-rating and the round 1, round 4 difference in his answer. As before, a participant's round 1 answer and round 4 answer were, for comparison reasons, represented by their error values (i.e., the natural log of the absolute value of the results of the answer divided by the true answer). The following abbreviations will be useful:

$SR4-SR1_{rz}$  = the mean difference between round 4 self-rating and round 1 self-rating;

$SR1_w$  = how participants self-rated themselves on a particular statement for round 1;

$LR1_r$  = the  $SR4-SR1_r$  for those responses that fit the following criteria:  
( $SR1_i = 1$  or  $SR1_i = 2$ ) and  $R4-R1_{eri} \leq 0.25$ ;

$LR2_r$  = same as  $LR1_r$  except  $R4-R1_{eri} \leq 0.15$ ;

$LR3_r$  = same as  $LR1_r$  except  $R4-R1_{eri} \leq 0.10$ ;

$UR1_r$  = the  $SR4-SR1_r$  for those responses that fit the following criteria:  
( $SR1_i = 5$  and  $R4-R1_{eri} \geq 0.4$ ) or  
( $(SR1_i = 4$  or  $SR1_i = 5)$  and  $R4-R1_{eri} \geq 0.8$ );

$UR2_r$  = same as  $UR1_r$  except  $R4-R1_{eri} \geq 0.5$  and  $1.0$  respectively;

$UR3_r$  = same as  $UR1_r$  except  $R4-R1_{eri} \geq 0.75$  and  $1.25$  respectively;

$NLR1_r$  = the  $SR4-SR1_r$  for those responses that do not meet the  $LR1_r$  criteria;

$NUR2_r$  = the  $SR4-SR1_r$  for those responses that do not meet the  $UR2_r$  criteria; and

$\overline{R4-R1_{qrz}}$  = the mean of the  $R4-R1_{eriz}$  averaged over  $i$

### Statistical Methodology.

This section will present the statistical hypotheses used to test the research hypotheses specified in Chapter I. A more complete discussion of why these statistical hypotheses were chosen and of what they are trying to prove will be given in Chapter IV when the results and the interpretation of the tests are given. The procedure will be to present the following for each of the major topic areas of this research (success, convergence, stability, and confidence): 1) a general narrative discription of the null hypotheses (this will give the reader a conceptual idea of what the null hypotheses are about), 2) the null hypotheses using the abbreviations described in the previous section (this will explicitly define the variables used to assure there is no confusion as to which variables were used), 3) the testing statistic to be used, and 4) the decision criteria used to reject or to indicate non-rejection of the statistical hypothesis.

Statistical Design for Success. The first topic area to be considered is the success of statistical manipulation. That is, can one successfully manipulate a Delphi statement through falsified statistical feedback? Success here means more than just changing the responses in some direction. It means how successful one can be in achieving a desired median (or index) for a factually-based (value-laden) Delphi statement.

The research hypotheses stated earlier for success are as follows:

- R1- factually-based Delphi statements cannot be successfully manipulated by the means of manipulated statistical feedback;
- R2- value-laden Delphi statements cannot be successfully manipulated by the means of manipulated statistical feedback; and
- R3- there is no difference between the manipulability of factually-based Delphi statements and the manipulability of value-laden Delphi statements, with respect to manipulation via statistical feedback.

The null hypotheses that were used to address these research hypotheses will now be presented.

Narrative H1: The percentage of statements whose success increased by more than 3% in a successive round is greater than 30% (i.e. success is enhanced by additional rounds).

Hypothesis H1: (In general)  $\frac{x}{n} = 30\%$

where n is the number of statements (30) and x is defined as

H1a: number of  $S_{ei3} - S_{ei2} > .03$  for  $i = 1$  to  $n$ ,  
 H1b: number of  $S_{ei4} - S_{ei3} > .03$  for  $i = 1$  to  $n$ ,  
 H1c: number of  $S_{vli3} - S_{vli2} > .03$  for  $i = 1$  to  $n$ , and  
 H1d: number of  $S_{vli4} - S_{vli3} > .03$  for  $i = 1$  to  $n$ .

Testing Statistics:  $Z$ -statistic from  $Z$ -test to compare two population proportions,  $Z = (P_1 - P_2) / \sigma_{\Delta p}$ .

Decision Criterion: Reject if significant at  $\alpha = 0.05$ , one-tail test.

Narrative H2: The round 4 measure of success (positively or negatively) correlates with the actual change in the participants' response (i.e., there is a correlation between the success of statistical manipulation and the amount the participants changed their answers).

Hypothesis H2a: The correlation between  $S_{ai4}$  and  $R4-Rl_{ami}$  =  $|0.9|$ .  
 H2b: The correlation between  $S_{ei4}$  and  $R4-Rl_{emi}$  =  $|0.9|$ .  
 H2c: The correlation between  $S_{vi4}$  and  $R4-Rl_{vmi}$  =  $|0.9|$ .

Testing Statistic: F-statistic from correlation analysis.

Decision Criterion: Reject if Pearson's coefficient  $\leq |0.90|$  , one-tail test.



Narrative H3: The round 4 measure of success (positively or negatively) correlates with the desired change in the participants' responses (i.e., there is a correlation between the success of statistical manipulation and the amount the administrator wishes to change the results).

Hypothesis H3a: The correlation between  $S_{ai4}$  and  $AD-Rl_{ami}$  =  $|0.9|$   
 H3b: The correlation between  $S_{ei4}$  and  $AD-Rl_{emi}$  =  $|0.9|$ .  
 H3c: The correlation between  $S_{vi4}$  and  $AD-Rl_{vmi}$  =  $|0.9|$ .

Testing Statistic: F-statistic from correlation analysis.

Decision Criterion: Reject if Pearson's coefficient  $\leq |0.90|$ , one-tail test.

Narrative H4: The actual change of a statement when it is manipulated is equal to the actual change of that statement when it is not manipulated (i.e., the median (index) of a statement when it is statistically manipulated will not move to a significantly different place than if it were not manipulated).

Hypothesis H4a:  $R4-R1_{emik} = R4-R1_{enmik}$

H4b:  $R4-R1_{vmik} = R4-R1_{vnmik}$

Testing Statistic: F-statistic from analysis of variance.

Decision Criterion: Reject if significant for  $\alpha = 0.05$ , two-tail test.

Narrative H5: The desired change of a statement that is manipulated is equal to the actual change of that statement when it is not manipulated (i.e., the desired change in the median (index) is not significantly different than the actual change of the non-manipulated statement).

Hypothesis H5a:  $AD-R1_{emik} = R4-R1_{enmik}$

H5b:  $AD-R1_{vmik} = R4-R1_{vnmik}$

Testing Statistic: F-statistic from analysis of variance.

Decision Criterion: Reject if significant for  $\alpha = 0.05$ , two-tail test.

Narrative H6: The cumulative percent success of factually-based Delphi statements is equal to the cumulative percent success of value-laden Delphi statements (i.e., factually-based Delphi statements are either easier or harder to manipulate than value-laden Delphi statements).

Hypothesis H6a:	$S_{a4y} = S_{v14y}$	}	do separately for $y = 50\%$ increment by 5% to 100% (see Table VIII)
H6b:	$S_{a4y} = S_{v24y}$		
H6c:	$S_{e4y} = S_{v14y}$		
H6d:	$S_{e4y} = S_{v24y}$		

Testing Statistic: Z-statistic from Z-test to compare two population proportions,  $Z = (P_1 - P_2) / \sigma_{\Delta p}$  (see Table VIII).

Decision Criterion: Reject H6 if fifty percent of the tests performed by H6a through H6d are significant at  $\alpha = 0.1$ , two-tail test.

Statistical Design for Convergence. While the previous section dealt with the success of achieving a particular point (i.e., measured the success of manipulating the median or index), this section will be concerned with the effects statistical manipulation has upon the convergence (i.e., the dispersion) of the responses. Again consideration must be given to the two types of Delphis recognized in this study, factually-based and value-laden Delphis.

The research hypotheses stated earlier for convergence are as follows:

- R4- manipulation of statistical feedback will not result in a lesser degree of convergence for factually-based Delphi statements,
- R5- manipulation of statistical feedback will not result in a lesser degree of convergence for value-laden Delphi statements, and
- R6- there will be no difference between factually-based and value-laden Delphi statements with respect to the effects manipulation of statistical feedback has upon the degree of convergence.

The null hypotheses that were used to address these research hypotheses will now be discussed.

Narrative H7: The following null hypotheses investigate whether manipulation of statistical feedback will affect the convergence of Delphi statements.

Hypothesis H7a:	$C_{amdix} = C_{anmdix}$	} do separately for $X = 1, 2, 3,$ and 4 (do H6d separately for each statement (i.e., $W = 1, 2,$ ....., 30)
H7b:	$C_{amqix} = C_{anmqix}$	
H7c:	$C_{vm\sigma ix} = C_{vn\sigma ix}$	
H7d:	$C_{amvwx} = C_{anmvwx}$	

Testing Statistic: F-statistic from analysis of variance and t-statistic from t-test for H7a through H7c. In this case, these two tests produce the same results. Therefore, one needs only to run one of them. Both have been included in this study to satisfy those who prefer to use one test over the other. This redundancy is used throughout this study.  $F_{max}$  test is run for each statement for H7d.

Decision Criterion: For H7a through H7c, round 1 should not be significant at  $\alpha = 0.1$ ; while rounds 2, 3, and 4 should be significant at  $\alpha = 0.1$ , two-tail test. For H7d, reject the hypothesis for individual items if significant at  $\alpha = 0.1$ , two-tail test. If the variances of statistically manipulated statements were significantly greater (or less), one would expect a significant number (90%) of the individual  $F_{max}$  tests to indicate this.

Statistical Design for Stability. Scheibe, Skutsch, and Schofer [65] suggest that stability is a better means of measuring consensus than convergence. It is felt that both parameters are important in considering the effects of manipulation of Delphi statements. The previous section dealt with the effects statistical manipulation has on convergence. This section will deal with the effects statistical manipulation has on stability. In particular, the question being asked is will statistical manipulation reduce the stability of Delphi statements and therefore increase the number of rounds necessary to achieve stability.

The research hypotheses stated earlier for success are as follows:

- R7- manipulation of statistical feedback will not reduce the stability (and therefore not require an extra round(s)) in factually-based Delphi statements,
- R8- manipulation of statistical feedback will not reduce the stability (and therefore not require an extra round(s)) in value-laden Delphi statements, and
- R9- there will be no difference between factually-based and value-laden Delphi statements with respect to the effect manipulation of statistical feedback has upon stability (and therefore the number of rounds necessary to obtain stability).

The null hypotheses that were used to address these research hypotheses will now be presented.

Narrative H8: The percentage of manipulated factually-based (value-laden) Delphi statements that change between two consecutive rounds is equal to the percentage of non-manipulated factually-based (value-laden) Delphi statements that change between the same two consecutive rounds. (i.e. There is no difference between manipulated and non-manipulated factually-based (value-laden) Delphi statements with respect to the percent change between rounds.)

Hypothesis H8a:	$%C12_{pmi} = %C12_{pnmi}$	} do separately for p = a and v
H8b:	$%C23_{pmi} = %C23_{pnmi}$	
H8c:	$%C34_{pmi} = %C34_{pnmi}$	

Testing Statistic: F-statistic from analysis of variance and t-statistic from t-test.

Decision Criterion: Reject if significant at  $\alpha = 0.1$ , two-tail test.



Narrative H9: The round where 20% (15%) stability is first achieved in manipulated factually-based (value-laden) Delphi statements is equal to the round where 20% (15%) stability is first achieved in non-manipulated factually-based Delphi (value-laden) statements (i.e., there is no difference between manipulated and non-manipulated factually-based (value-laden) Delphi statements with respect to the round where stability is first achieved).

Hypothesis H9a: $S_{20\%pmi} = S_{20\%pnmi}$	}	do separately for p = a and v
H9b: $S_{15\%pmi} = S_{15\%pnmi}$		

Testing Hypothesis: F-statistic from analysis of variance and t-statistic from t-test.

Decision Criterion: Reject if significant at  $\alpha = 0.1$ , two-tail test.

Narrative H10: The average number of rounds necessary to reach 20% (15%) stability for factually-based Delphi statements is equal to the average number of rounds necessary to reach 20% (15%) stability for value-laden Delphi statements (i.e., there is no difference between factually-based and value-laden Delphi statements with respect to the average number of rounds necessary to obtain stability).

Narrative H11: The average number of rounds necessary to reach 20% (15%) stability for manipulated Delphi statements is equal to the average number of rounds necessary to reach 20% (15%) stability for non-manipulated Delphi statements (i.e., manipulation of statistical feedback has no effect on the average number of rounds necessary to obtain stability).

Hypothesis H10a:  $\overline{S20\%_{am}} = \overline{S20\%_{vm}}$

H10b:  $\overline{S20\%_{anm}} = \overline{S20\%_{vnm}}$

H10c:  $\overline{S15\%_{am}} = \overline{S15\%_{vm}}$

H10d:  $\overline{S15\%_{anm}} = \overline{S15\%_{vnm}}$

Hypothesis H11a:  $\overline{S20\%_{am}} = \overline{S20\%_{anm}}$

H11b:  $\overline{S20\%_{vm}} = \overline{S20\%_{vnm}}$

H11c:  $\overline{S15\%_{am}} = \overline{S15\%_{anm}}$

H11d:  $\overline{S15\%_{vm}} = \overline{S15\%_{vnm}}$

Testing Statistic: F-statistic of 2x2 analysis of variance run on the following sets of values:

	20% Stability		15% Stability	
	non-manip.	manip.	non-manip.	manip.
Factually-based	$\overline{S20\%}$	$\overline{S20\%}$	$\overline{S15\%}$	$\overline{S15\%}$
Value-laden	$\overline{S20\%}$	$\overline{S20\%}$	$\overline{S15\%}$	$\overline{S15\%}$

t-statistics from t-test to test two means on each of the above pairs (see Table XVIII). It is assumed the sample size is large enough to counter the problem that the distribution may be skewed to the right.

Decision Criterion: Reject if significant at  $\alpha = 0.05$  two-tail test.

Narrative H12: The average number of rounds necessary to reach 20% (15%) stability for non-manipulated factually-based Delphi statements is equal to the average number of rounds necessary to reach 20% (15%) stability for manipulated value-laden Delphi statements.

Narrative H13: The average number of rounds necessary to reach 20% (15%) stability for manipulated factually-based Delphi statements is equal to the average number of rounds necessary to reach 20% (15%) stability for non-manipulated value-laden Delphi statements. (Where H10 and H11 compared stability of factually-based verses value-laden and stability of manipulated verses non-manipulated, H12 and H13 try to rank the stability of manipulated factually-based, non-manipulated factually-based, manipulated value-laden, and non-manipulated value-laden Delphi statements.)

$$\text{Hypothesis H12a: } \overline{S20\%_{anm}} = \overline{S20\%_{vm}}$$

$$\text{H12b: } \overline{S15\%_{anm}} = \overline{S15\%_{vm}}$$

$$\text{Hypothesis H13a: } \overline{S20\%_{am}} = \overline{S20\%_{vnm}}$$

$$\text{H13b: } \overline{S15\%_{am}} = \overline{S15\%_{vnm}}$$

Testing Statistic: t-statistic from t-test to test two means (see Table XVIII). It is assumed the sample size is large enough to counter the problem that the distribution may be skewed to the right.

Decision Criterion: Reject if significant at  $\alpha = 0.05$ , two-tail test.

Statistical Design for Confidence. It was suggested in Chapter II that manipulation of statistical feedback may affect the confidence that Delphi participants have in their responses. It was also suggested that changes in self-rating could be used as a measure of changes in confidence. This was expressed in Chapter I as the following research hypothesis:

R10- manipulation of statistical feedback in factually-based Delphi statements has no relationship to the changes in the respondents' self-rating of their knowledge of the subject matter for those Delphi statements.

The null hypotheses that were used to investigate this research hypothesis will now be presented.

Narrative H14: The following null hypotheses deal with the question of whether the participants' confidence in their ability (as measured by self-rating) to respond to a Delphi statement increases as a result of the Delphi process. This is measured both in terms of the change in self-rating being different from zero and from the mean of all the non-manipulated Delphi statements.

Hypothesis H14a:  $SR4-SR1_b = 0$

H14b:  $SR4-SR1_m = 0$

H14c:  $SR4-SR1_{nm} = 0$

H14d:  $SR4-SR1_m = 0.47$  (value of  $SR4-SR1_{nm}$ )

H14e:  $SR4-SR1_m = SR4-SR1_{nm}$

Testing Statistic: t-statistic from single-mean t-test for H14a through H14d. t-statistic from t-test to test two means for H14e.

Decision Criterion: Reject if significant at  $\alpha = 0.5$ , one-tail test.

Narrative H15: The following set of null hypotheses investigate whether there is a tendency for Delphi participants to shift their self-rating toward the middle after having participated in several rounds and whether there is a tendency for participants to shift their self-rating less at the lower end of the self-rating scale and more at the higher end of the scale on statements that have been statistically manipulated than on statements that have not been statistically manipulated.

- Hypothesis H15a:  $SR4-SR1_{mz} = 0$  do separately for each z  
 H15b:  $SR4-SR1_{nmz} = 0$  do separately for each z  
 H15c:  $SR4-SR1_{mz} = 0.47$  do separately for each z  
 (0.47 is value of  $SR4-SR1_{nm}$ ).  
 H15d:  $SR4-SR1_{nmz} = 0.47$  do separately for each z  
 H15e:  $SR4-SR1_{mz} = SR4-SR1_{nmz}$  do separately for each z  
 H15f:  $SR4-SR1_{b1} = SR4-SR1_{b2} = SR4-SR1_{b3} = SR4-SR1_{b4} =$   
 $SR4-SR1_{b5}$   
 H15g:  $SR4-SR1_m = SR4-SR1_{nm}$

Testing Statistic: t-statistic from single-mean t-test for H15a through H15d. t-statistic from t-test to test two means for H15e. F-statistic from two-way analysis of variance for H15f and H15g.

Decision Criterion: Reject if significant at  $\alpha = 0.05$ , two-tail test.

Narrative H16: The following null hypotheses examine whether those participants who originally self-rated themselves low but whose answers were closely supported by the reported median will have a propensity to increase their self-ratings more than those whose answers were not closely supported by the median and whether those participants who originally self-rated themselves high but whose answers were distant from the reported median will have a propensity to decrease their self-rating more than those whose answers were not as distant from the median.

Hypothesis	H16aa: LR1 <sub>r</sub>	= 0	}	do separately for r = m and nm
	H16ab: LR2 <sub>r</sub>	= 0		
	H16ac: LR3 <sub>r</sub>	= 0		
	H16ad: UR1 <sub>r</sub>	= 0		
	H16ae: UR2 <sub>r</sub>	= 0		
	H16af: UR3 <sub>r</sub>	= 0		
	H16ag: NLR1 <sub>r</sub>	= 0		
	H16ah: NUR2 <sub>r</sub>	= 0		
	H16ba: LR1 <sub>r</sub>	= 0.47	}	do separately for r = m and nm (0.47 is value of SR4-SR1 <sub>nm</sub> )
	H16bb: LR2 <sub>r</sub>	= 0.47		
	H16bc: LR3 <sub>r</sub>	= 0.47		
	H16bd: UR1 <sub>r</sub>	= 0.47		
	H16be: UR2 <sub>r</sub>	= 0.47		
	H16bf: UR3 <sub>r</sub>	= 0.47		
	H16bg: NLR1 <sub>r</sub>	= 0.47		
	H16bh: NUR2 <sub>r</sub>	= 0.47		
	H16ca: LR1 <sub>m</sub>	= LR1 <sub>nm</sub>		
	H16cb: LR2 <sub>m</sub>	= LR2 <sub>nm</sub>		
	H16cc: LR3 <sub>m</sub>	= LR3 <sub>nm</sub>		
	H16cd: UR1 <sub>m</sub>	= UR1 <sub>nm</sub>		
	H16ce: UR2 <sub>m</sub>	= UR2 <sub>nm</sub>		
	H16cf: UR3 <sub>m</sub>	= UR3 <sub>nm</sub>		
	H16cg: NLR1 <sub>m</sub>	= NLR1 <sub>nm</sub>		
	H16ch: NUR2 <sub>m</sub>	= NUR2 <sub>nm</sub>		
	H16da: LR1 <sub>m</sub>	= NLR1 <sub>m</sub>		
	H16db: LR1 <sub>nm</sub>	= NLR1 <sub>nm</sub>		
	H16dc: UR2 <sub>m</sub>	= NUR2 <sub>m</sub>		
	H16dd: UR2 <sub>nm</sub>	= NUR2 <sub>nm</sub>		

Testing Statistic: t-statistic from single-mean t-test from H16aa through H16bh. t-statistic from t-test to test two means for H16ca through H16dd.

Decision Criterion: Reject if significant at  $\alpha = 0.05$ , one-tail test. Since there are a large number of tests here and an  $\alpha = 0.05$  is being used, one would expect 5% of the tests to fail.



Narrative H17: The following null hypotheses investigate whether the average shift in responses between round 1 and round 4 for those participants in each of the self-rating classifications will decrease as the self-rating classification increases and whether the average shift in responses between round 1 and round 4 in each of the self-rating classifications for participants manipulated via statistical feedback will be greater than those for non-manipulated participants.

Hypothesis H17a:  $R4-R1_{eb1} = R4-R1_{eb2} = R4-R1_{eb3} = R4-R1_{eb4} = R4-R1_{eb5}$

H17b:  $R4-R1_{em} = R4-R1_{enm}$

H17c:  $R4-R1_{emz} = R4-R1_{enmz}$  do separately for each  $z$ .

Testing Statistic: F-statistic from two-way analysis of variance for H17a and H17b. t-statistic from t-test to test two means for H17c.

Decision Criterion: Reject if significant at  $\alpha = 0.5$ , one-tail test.

## SUMMARY

This chapter has presented the experimental design and methodology for this research. It began with a discussion of the characteristics of the participants and the subject matter of the Delphis to be used in this study. A review of the general procedures for administering the Delphis was then given. This was followed with a discussion of the design considerations that were used to reduce the within and between variances of the independent variables. This in turn was followed by a detailed discussion of the measurements used in the statistical tests and the statistical methodology (which included the null hypotheses tested).

The next chapter will discuss the results of the experiment.

## CHAPTER IV

### RESULTS

The purpose of this research was to investigate empirically the success of statistical manipulation of factually-based and value-laden Delphi statements in achieving a desired point and to explore the effects such manipulation had upon the convergence and the stability of the responses to Delphi statements and the confidence of Delphi participants. The presentation of the results of the experiments and their analysis will follow the order of the major topic areas presented in the purpose and the research hypotheses stated in Chapter I (success, convergence, stability, and confidence). Each of these sections will contain a brief restatement of the research hypotheses, a discussion of the factually-based Delphi results, a discussion of the value-laden Delphi results, and a comparison of the two types of Delphis. A brief synopsis of the results will be given in flowchart form at the end of the chapter.

#### SUCCESS AND STATISTICAL MANIPULATION

The major purpose of this study was to investigate the success of statistical manipulation of Delphi statements in achieving a particular desired value. It was hypothesized that the success may be different depending on whether the Delphi was factually-based or value-laden. This was expressed in Chapter I as the following three research hypotheses:

- R1 - factually-based Delphi statements can not be successfully manipulated by the means of manipulated statistical feedback,
- R2 - value-laden Delphi statements can not be successfully manipulated by the means of manipulated statistical feedback, and
- R3 - there is no difference between the manipulability of factually-based Delphi statements and the manipulability of value-laden Delphi statements, with respect to manipulation via statistical feedback.

### Factually-based Delphi Results

The success of statistical manipulation of factually-based Delphi statements is summarized in Table IV. Using the "error" measure of success, 100% success was achieved in thirteen percent (four) of the cases. This means that the median of thirteen percent of the statements were successfully manipulated to the desired value. In fifty percent of the statements, the medians were successfully manipulated at least ninety percent of the desired distance (i.e. ninety percent of the distance between the first round median and the desired median). Eighty-five percent or more of the desired distance was accomplished in two-thirds of the cases.

There were only three statements (ten percent) that were not moved at least fifty-five percent of the desired distance. As it turned out, these were bad questions in as much as the range of reasonable answers was small and the desired answer chosen was at the outer end of these ranges. This, combined with a high amount of knowledge for these questions, made them difficult to manipulate. With the above in mind, each of the three statements will be discussed.

TABLE IV

## Success of Manipulation - Round 4

% SUCCESS	FACTUALLY BASED - $(RI-R1)/(AD-R1)$						VALUE LADEN			
	STANDARDIZED		NON-STD.		ERROR		INDEX-1		INDEX-2	
	FREQ	CUM %	FREQ	CUM %	FREQ	CUM %	FREQ	CUM %	FREQ	CUM %
100	4	0.13	4	0.13	4	0.13	3	0.10	13	0.43
95-99.9	4	0.27	4	0.27	6	0.33	5	0.27	2	0.50
90-94.9	5	0.43	5	0.43	5	0.50	5	0.43	3	0.60
85-89.9	5	0.60	5	0.60	5	0.67	0	0.43	0	0.60
80-84.9	4	0.73	4	0.73	0	0.67	3	0.53	3	0.70
75-79.9	0	0.73	0	0.73	2	0.73	6	0.73	3	0.80
70-74.9	1	0.77	1	0.77	3	0.83	2	0.80	2	0.87
65-69.9	2	0.83	2	0.83	1	0.87	2	0.87	2	0.93
60-64.9	2	0.90	2	0.90	0	0.87	3	0.97	1	0.97
55-59.9	0	0.90	0	0.90	1	0.90	0	0.97	0	0.97
50-54.9	0	0.90	0	0.90	0	0.90	0	0.97	0	0.97
45-49.9	0	0.90	0	0.90	0	0.90	0	0.97	0	0.97
40-44.9	1	0.93	1	0.93	2	0.97	0	0.97	0	0.97
35-39.9	1	0.97	1	0.97	0	0.97	0	0.97	0	0.97
30-34.9	0	0.97	0	0.97	0	0.97	1	1.00	1	1.00
25-29.9	0	0.97	0	0.97	0	0.97	0	1.00	0	1.00
20-24.9	0	0.97	0	0.97	1	1.00	0	1.00	0	1.00
15-19.9	1	1.00	1	1.00	0	1.00	0	1.00	0	1.00
10-14.9	0	1.00	0	1.00	0	1.00	0	1.00	0	1.00
5-9.9	0	1.00	0	1.00	0	1.00	0	1.00	0	1.00
0-4.9	0	1.00	0	1.00	0	1.00	0	1.00	0	1.00

Statement six (see Appendix A) was the statement with the least degree of success. It was concerned with the altitude of Grand Forks, North Dakota. The actual altitude was 834 feet. The desired altitude was 1400 feet. The resulting median was 910 feet. The altitude of Grand Forks Air Force Base is 911 feet. This coupled with the fact that the country between the air base and the city makes a pool table look lumpy indicates that many of the participants knew the altitude of the air base. Since many of the participants were pilots (or navigators), the result was not surprising.

Statement fourteen was concerned with the average age of an Air Force officer. It was surprising that the success of this statement was forty percent. The vast majority of officers in the Air Force are second or first lieutenants, with captains being the next most numerous rank. These were the same ranks that made up the majority of the participants. The participants knew their age and the relative age of those around them. They therefore had a fairly good idea of the average age (first round median = 31, last round median = 34, true answer = 33.2). A desired answer of 39 was too far from the range of acceptable answers.

Statement twenty-four dealt with the highest temperature ever recorded in North Dakota. Its success was forty-one percent. This was another example of a bad choice of a desired answer in that it was too close to the outer edge of believability. North Dakota is known for its severe cold winters. Only five states have had as cold or colder a recorded low temperature ( $-60^{\circ}$  F). This Delphi was run at the end of one of these winters. While only four states

have had as high or higher a recorded temperature (121° F), temperatures over 100° F are not common, thus it was difficult to make the participants believe the desired value of 130° F. (It is interesting to note that the -60° F and the 121° F were recorded in the same year, 1936.)

If one disqualified these three statements, the success of moving the first round answer 85% or more of the distance to the desired answer would be 74%. This certainly would be indicative of the manipulability of factually-based Delphi statements by statistical manipulation. Even if one does not eliminate these three questions, a 67% success of moving the median 85% or more of the desired distance is indicative of successful manipulability.

#### Value-laden Delphi Results

The success of statistical manipulation of value-laden Delphi statements is also summarized in Table IV. As the table indicates, there are two ways one can interpret the success of statistical manipulation of value-laden Delphi statements. Index-1 specifies anything over 100% will be deducted from 100% since the objective is to achieve a particular index exactly (i.e., 110% success would be considered 90% success). Index-2 specifies anything over 100% will be considered 100% since the objective is to achieve at least the desired index (i.e., 110% success would be considered 100% success).

Using Index-1 as a measure of success, 100% success was achieved in ten percent (three) of the statements. This means that the index

of ten percent of the statements was successfully manipulated to the exact desired index. In forty-three percent of the statements, the indexes were successfully manipulated to within at least ninety percent of the desired distance (i.e., ninety percent of the distance between the first round index and the desired index). As was in the case of the factually-based Delphi statements, eighty-five percent or more of the desired distance was accomplished in two-thirds of the cases.

Using Index-2, the success was even more dramatic. 100% success was achieved in forty-three percent of the statements. This means the index was successfully manipulated to or beyond the desired index in forty-three percent (thirteen) of the statements. In sixty percent of the statements, the indexes were successfully manipulated to within at least ninety percent or more of the desired distance. Ninety-three percent or more of the desired distance was accomplished in two-thirds of the cases.

There was only one statement that was not moved at least sixty percent of the desired distance. Unlike the three statements that were under fifty percent success in the almanac Delphi, no clear explanation can be made as to why this statement did not respond to the manipulation.

While the success of Index-1 obviously was less than Index-2, both demonstrated a high level of success of manipulability of value-laden Delphi statements by statistical manipulation.



### Additional Results Using the Success Data

By arranging the data into the format shown in Table V, one can determine how the success of each question changed during each round. By further examination of the table, one can calculate for the factually-based Delphi that success increased in 93% (28) of the statements for round 3 and 60% (18) of the statements for round 4. For the value-laden Delphi, success also increased in 93% (28) of the statements for round 3 and 80% (24) of the statements in round 4. This indicates that success was enhanced by additional rounds. (Hypothesis H1)

Also included in Table V are the actual and desired movements of the medians. Correlation analyses were run to see if there were correlations between the degree of success and the amount of movement that occurred or was desired to occur. This would test if it was more difficult to achieve success when the range was limited, or put another way, if the statements with the greatest movement desired were also the most successful. Table VI shows the results of the correlations. In all cases, the analyses showed a low to median correlation. (Hypotheses H2 and H3)

Another form of analysis run was an analysis of variance on the actual change of the manipulated statements for each participant by the actual change of the non-manipulated statements for each participant. Table VII shows that the results were significant at the .001 level for both the factually-based Delphi and the value-laden Delphi. This would indicate that the medians (indexes) of the manipulated

TABLE V  
Success of Manipulation - Detail

SUCCESS OF MANIPULATION - DETAIL																				
ALMANAC	FACTUALLY BASED DELPHI -- (RI-R1)/(AD-R1)									----- TOTAL MOVEMENT -----						VALUE LADEN DELPHI				VALUE
	STANDARDIZED			NON-STANDARDIZED			ERROR			FACTUALLY BASED			VALUE LADEN			INDEX				
STATEMENT NUMBER	SUCCESS R2	FOR R3	ROUND R4	SUCCESS R2	FOR R3	ROUND R4	SUCCESS R2	FOR R3	ROUND R4	STANDARDIZED R4-R1	AD-R1	STANDARDIZED R4-R1	AD-R1	INDEX R4-R1	AD-R1	SUCCESS R2	FOR R3	ROUND R4	STATEMENT NUMBER	
1	0.71	0.83	1.00	0.71	0.86	1.00	0.79	0.90	1.00	0.49	0.49	0.88	0.88	-0.37	-0.53	0.81	1.00	1.25	1	
2	0.31	0.31	0.62	0.31	0.31	0.63	0.38	0.38	0.69	0.31	0.50	0.41	0.59	-0.63	-0.60	0.89	1.06	1.06	2	
3	0.42	0.57	0.67	0.42	0.67	0.67	0.47	0.72	0.72	0.39	0.50	0.34	0.47	-0.70	-0.50	1.27	1.60	1.40	4	
4	0.45	0.72	0.72	0.45	0.72	0.72	0.50	0.76	0.76	0.32	0.44	0.30	0.40	-0.63	-0.83	0.32	0.64	0.76	5	
5	0.83	0.85	0.92	0.83	0.85	0.92	0.80	0.81	0.91	-0.65	-0.71	-0.41	-0.45	0.60	0.57	0.55	0.88	1.06	5	
6	0.08	0.13	0.16	0.08	0.13	0.16	0.10	0.15	0.20	0.14	0.23	0.08	0.43	-0.80	-0.67	0.70	0.90	0.90	8	
7	0.78	0.87	0.91	0.78	0.87	0.91	0.36	0.92	0.95	1.09	1.19	1.13	1.19	-0.90	-0.90	0.93	1.15	1.00	9	
8	0.56	0.69	0.83	0.56	0.69	0.83	0.65	0.77	0.88	0.97	1.16	0.69	0.79	0.30	0.57	0.18	0.73	0.82	11	
9	0.82	0.88	0.94	0.82	0.88	0.94	0.78	0.85	0.92	-0.41	-0.43	-0.51	-0.55	0.83	0.67	0.43	0.95	1.25	12	
10	0.33	0.67	0.67	0.33	0.67	0.67	0.26	0.58	0.58	-1.04	-1.55	-0.41	-0.69	-0.67	-0.63	0.32	0.84	1.05	13	
11	0.48	0.86	0.95	0.48	0.86	0.95	0.56	0.89	0.97	1.02	1.07	0.69	0.72	-0.67	-0.70	0.81	1.00	1.24	15	
12	0.91	0.99	1.00	0.91	0.99	1.00	0.69	0.97	1.00	-0.39	-0.39	-2.68	-2.68	-0.63	-0.77	0.52	0.57	0.83	16	
13	0.67	0.72	0.83	0.67	0.72	0.83	0.76	0.80	0.89	1.43	1.71	0.81	0.92	0.63	0.63	0.53	1.11	1.00	18	
14	0.13	0.38	0.38	0.13	0.38	0.38	0.14	0.40	0.40	0.93	2.21	0.09	0.23	0.50	0.50	0.80	0.93	1.00	22	
15	0.71	0.83	0.86	0.71	0.83	0.86	0.76	0.86	0.89	0.83	0.97	0.47	0.53	-0.53	-0.73	0.27	0.33	0.73	23	
16	0.63	0.63	0.86	0.63	0.63	0.86	0.70	0.70	0.70	1.00	1.16	0.65	0.73	0.50	0.63	0.32	0.42	0.79	24	
17	0.36	0.66	0.86	0.36	0.66	0.86	0.41	0.83	0.80	0.72	0.84	0.36	0.41	-0.57	-0.77	0.35	0.65	0.74	27	
18	0.57	0.64	0.64	0.57	0.64	0.64	0.35	0.71	0.71	0.53	0.86	0.49	0.69	-0.40	-0.60	0.14	0.61	0.67	31	
19	0.50	0.80	0.80	0.50	0.80	0.80	0.42	0.74	0.74	-0.34	-0.42	-0.51	-0.64	0.50	0.60	0.51	0.56	0.83	32	
20	0.43	0.65	0.87	0.43	0.65	0.87	0.53	0.73	0.71	0.60	0.69	0.69	0.77	-0.50	-0.80	0.42	0.67	0.62	33	
21	0.76	0.95	0.95	0.78	0.95	0.95	0.93	0.98	0.98	0.94	0.99	3.14	3.19	-0.63	-0.67	0.80	0.85	0.95	34	
22	0.76	0.95	0.95	0.76	0.95	0.95	0.82	0.97	0.97	0.55	0.57	0.69	0.72	0.77	0.83	0.44	0.68	0.82	36	
23	0.63	0.87	0.87	0.63	0.88	0.88	0.73	0.92	0.92	1.15	1.32	0.80	0.96	-0.77	-0.73	0.25	0.95	1.05	38	
24	0.20	0.33	0.40	0.20	0.33	0.40	0.21	0.35	0.41	0.88	2.19	0.05	0.12	-0.20	-0.63	0.21	0.24	0.32	41	
25	0.56	0.93	1.00	0.50	0.93	1.00	0.73	0.96	1.00	0.22	0.22	1.35	1.35	-0.57	-0.73	0.50	0.68	0.77	42	
26	0.54	0.72	0.91	0.54	0.72	0.91	0.47	0.66	0.88	-0.47	-0.52	-0.48	-0.54	0.43	0.63	0.32	0.58	0.68	44	
27	0.77	0.93	0.93	0.77	0.93	0.93	0.83	0.95	0.95	0.87	0.93	0.69	0.73	-0.50	-0.53	0.81	0.81	0.94	46	
28	0.57	0.86	0.97	0.57	0.86	0.97	0.63	0.88	0.98	0.78	0.80	0.45	0.46	-0.97	-0.70	0.81	1.05	1.36	48	
29	0.50	0.83	0.83	0.50	0.83	0.83	0.43	0.79	0.79	-0.83	-0.99	-0.44	-0.56	-0.60	-0.63	0.63	0.69	0.95	49	
30	0.53	0.95	1.00	0.53	0.95	1.00	0.40	0.91	1.00	-0.30	-0.30	-1.00	-1.00	-0.70	-0.67	0.60	0.95	1.05	50	

TABLE VI

Results of Correlation of Round 4 Degree  
of Success and Amount of Movement

Correlation run on		Pearson's correlation coefficient	coefficient of determination	standard error of the estimate
Round 4 degree of success	amount of movement			
R4 (non-standardized) (Factually-based Delphi)	R4-R1	0.12200	0.01488	0.20513
	AD-R1	-0.48485	0.23508	0.18076
R4 (error) (Factually-based Delphi)	R4-R1	0.51994	0.27033	0.17372
	AD-R1	0.43908	0.19279	0.18272
R4 (index) (Value-laden Delphi)	R4-R1	0.78194	0.61143	0.14892
	AD-R1	-0.18526	0.03432	0.23477

TABLE VII

Results of Analysis of Variances on the Change of Each Manipulated Participant by the Change of Each Non-Manipulated Participant

Factually-based Delphi	sum of squares	df	mean square	F	sign. of F
actual change (R4-R1)- manipulated verses non-manipulated	44.402	1	44.402	44.711	0.001
actual change (R4-R1) for non-manipulated verses desired change (AD-R1) for manipulated	105.430	1	105.400	113.906	0.001

Value-laden Delphi	sum of squares	df	mean square	F	sign. of F
actual change (R4-R1)- manipulated verses non-manipulated	33.076	1	33.076	67.540	0.001
actual change (R4-R1) for non-manipulated verses desired change (AD-R1) for manipulated	117.518	1	117.518	226.746	0.001

statements were moved to a significantly different place than the non-manipulated statements. (Hypothesis H4)

Table VII also shows the results of running an analysis of variance on the desired change of the manipulated statements by the actual change of the corresponding non-manipulated statements for each participant. The results show the desired change for a manipulated statement was significantly different from the actual change that occurred for that statement when it was not manipulated. Thus, the desired change was significantly different from the change that would have normally occurred. (Hypothesis H5)

#### Comparison of Factually-Based and Value-Laden Delphis

The third research hypothesis (R3) to be tested (Hypothesis H6) concerns itself with whether it was easier to manipulate factually-based Delphi statements or value-laden Delphi statements or whether there was no significant difference. If one considers the cumulative percentage of statements that were manipulated to a certain degree of success as being a measure of success in manipulation, one can use a Z-test to compare two population proportions to test if there was a significant difference between the two percentages. Table VIII contains the results of such a statistical test for degrees of success ranging from fifty to one hundred percent.

The overall results strongly suggest that one cannot reject research hypothesis R3. That is, the results strongly indicate there was no significant difference between factually-based and value-laden Delphi statements, with respect to manipulation via statistical feedback. The one notable exception was at the 100% degree of success.

TABLE VIII

Results of Comparing the Success of the Factually-based  
Delphi with the Success of the Value-laden Delphi

<u>Cummulative %</u>					<u>Z Value</u>				<u>Significant at</u>			
<u>% Success</u>	<u>Std.</u>	<u>Error</u>	<u>Index-1</u>	<u>Index-2</u>	<u>STD, Index-1</u>	<u>STD. Index-2</u>	<u>Error Index-1</u>	<u>Error Index-2</u>	<u>STD. Index-1</u>	<u>STD. Index-2</u>	<u>Error Index-1</u>	<u>Error Index-2</u>
100	0.13	0.13	0.10	0.43	0.36	-2.59	0.36	-2.59		0.01		0.01
95	0.27	0.33	0.27	0.50	0.00	-1.83	0.51	-1.34		0.1		
90	0.43	0.50	0.43	0.60	0.00	-1.32	0.54	-0.78				
85	0.60	0.67	0.43	0.60	1.32	0.00	1.87	0.56			0.1	
80	0.73	0.67	0.53	0.70	1.60	0.26	1.11	-0.25				
75	0.73	0.73	0.73	0.80	0.00	-0.64	0.00	-0.64				
70	0.77	0.83	0.80	0.87	-0.28	-1.01	-0.73	-0.43				
65	0.83	0.87	0.87	0.93	-0.73	-1.19	0.00	-0.77				
60	0.90	0.87	0.97	0.97	-1.10	-1.10	-1.43	-1.43				
55	0.90	0.90	0.97	0.97	-1.10	-1.10	-1.10	-1.10				
50	0.90	0.90	0.97	0.97	-1.10	-1.10	-1.10	-1.10				

$$\bar{P} = \frac{n_1 P_1 + n_2 P_2}{n_1 + n_2}$$

$$\sigma_{\Delta p} = \sqrt{\bar{P}(1-\bar{P}) \frac{n_1 + n_2}{n_1 n_2}}$$

$$Z = \frac{P_1 + P_2}{\sigma_{\Delta p}}$$

When one uses Index-2 as the measure of success for value-laden Delphis (i.e., anything over 100% successful is considered 100% successful), the value-laden Delphi statements were significantly ( $\alpha = 0.01$ ) more successfully manipulated. This significance, however, quickly fades away as one accepts lower levels of success as indicating successful manipulation (i.e., if one considered moving the final round answer ninety percent of the distance between the first round answer and the desired answer, there would be no significant difference as to whether it was a factually-based or a value-laden Delphi statement).

The acceptance of these results must be cautioned by two considerations. First, the above tests were only indirectly testing the true relationship since the measures of success in both cases were different. The second consideration is the choice of the desired answers was somewhat subjective. Therefore, there was no guarantee that the values chosen for the value-laden Delphi statements were more easily obtainable than those for the factually-based Delphi statements or vice versa.

#### Summary of Success Results

The above results indicate that statistical manipulation did cause a highly significant shift in the answers of the participants and that a high degree of success of obtaining a desired value existed and that this success was enhanced by running additional rounds. It was also determined there was no significant difference between the manipulability of factually-based Delphi statements and of value-laden Delphi statements.

## STATISTICAL MANIPULATION AND CONVERGENCE OF DELPHI STATEMENTS

It was hypothesized that statistical manipulation could affect the convergence of Delphi statements. With this in mind the following research hypotheses were developed:

- R4 - manipulation of statistical feedback will not result in a lesser degree of convergence for factually-based Delphi statements,
- R5 - manipulation of statistical feedback will not result in a lesser degree of convergence for value-laden Delphi statements, and
- R6 - there will be no difference between factually-based and value-laden Delphi statements with respect to the effects manipulation of statistical feedback has upon the degree of convergence.

Factually-based Delphi Results

Convergence of factually-based Delphi statements is usually measured by changes in the quartile range. There are some people, however, who would argue that the standard deviation is a better answer. Both measures are considered in this analysis.

T-tests and analysis of variances were run on the statistically manipulated and non-manipulated quartiles and standardized standard deviations for each round of the Delphi.  $F_{\max}$  tests were also run on the variances for each question to see if the variances of each individual question were equal (Hypothesis H7).

The t-tests and analysis of variances on the standardized standard deviations showed no significant difference between the statistically manipulated and the non-manipulated Delphi statements (see Table IX). The  $F_{\max}$  tests on the variances of each question for



TABLE IX

Results of Statistical Tests on Convergence -  
Factually-based Delphi

Round	Quartile Values				Standardized Standard Deviations			
	t-test (df=58)		anal. of var. (df=1,58)		t-test (df=58)		anal. of var. (df=1,58)	
	t value	t sign. at	F value	F sign. at	t value	t sign. at	F value	F sign. at
1	0.338	-	0.114	0.999	0.072	-	0.005	0.999
2	-1.794	0.1	3.216	0.075	0.098	-	0.010	0.999
3	-1.946	0.1	3.788	0.053	0.240	-	0.058	0.999
4	-1.757	0.1	3.087	0.081	0.239	-	0.057	0.999

each round did not indicate that the statistically manipulated variances were greater than or less than the non-manipulated statements (see Table X).

The t-tests and analysis of variances of the quartile ranges, however, indicated a significant difference (at the  $\alpha = 0.1$  level) existed from the second round to the last round (see Table IX).

Thus one can say, while statistical manipulation did not have any effect on the standard deviation, it did have a significant effect on the convergence of the quartile range. That is, statistical manipulation tended to increase the convergence of the quartile range. One must treat this result carefully, however, for two reasons. First, the level of significance was rather low,  $\alpha = 0.1$ . Second the quartile ranges used in the manipulated statistical feedback tended to be rather close. It stands to reason that if people demonstrate a desire to be within the quartile range (even if just at the end of the range) a tighter range in the statistical feedback will force people to compromise to a tighter range for the next round. It was interesting to note, however, even if this is true, this movement was not uniform enough to reduce the standard deviation by a significant amount.

#### Value-laden Delphi Results

Convergence of value-laden Delphi statements is best measured by the changes in the standard deviation. One would expect the standard deviation of a statement to get smaller with each round. The question to be answered here is does statistical manipulation affect the convergence of the standard deviation?

TABLE X

## Results of Fmax Test for Equal Variances

Statement	Fmax Value For Round				Fmax Sign. at (For Round)				Which is Greater at Round 4
	R1	R2	R3	R4	R1	R2	R3	R4	M = Manip. NM = Non-Manip.
1	3.86	2.37	2.43	2.33	.01	.05	.05	.05	M
2	1.37	2.66	1.94	1.81		.05	.10		
3	1.47	4.18	1.10	1.01		.01			
4	2.71	1.85	1.18	1.17	.01	.10			
5	1.15	1.97	1.72	1.75		.10			
6	2.21	2.31	2.98	8.85	.05	.05	.01	.01	M
7	1.37	2.78	2.14	1.76		.01	.05		
8	1.75	1.87	1.95	1.80		.10	.10		
9	1.00	3.24	4.89	4.15		.01	.01	.01	NM
10	1.11	1.35	1.84	1.86				.10	NM
11	1.10	3.05	5.97	3.13		.01	.01	.01	M
12	17.74	1.89	12.59	16.09	.01	.10	.01	.01	NM
13	2.04	3.75	2.38	2.66	.10	.01	.05	.05	M
14	1.57	1.92	2.59	3.39		.10	.05	.01	M
15	5.94	1.45	1.65	1.37	.01				
16	1.90	2.03	1.44	1.56	.10	.10			
17	1.15	1.14	1.47	1.09					
18	8.27	1.17	1.08	2.27	.01			.05	M
19	2.13	1.70	1.77	2.97	.05			.01	NM
20	3.43	2.94	2.59	2.83	.01	.01	.05	.01	M
21	1.55	1.27	1.21	1.60					
22	1.03	1.10	1.72	1.61					
23	1.50	1.35	2.05	1.74			.10		
24	1.34	1.47	2.06	2.36			.10	.05	M
25	3.30	2.05	17.81	17.70	.01	.10	.01	.01	M
26	1.04	1.99	2.61	2.57		.10	.05	.05	NM
27	1.45	6.18	1.91	1.08		.01	.10		
28	2.25	1.18	1.18	1.14	.05				
29	1.28	2.30	1.15	1.03		.05			
30	1.93	4.95	7.45	7.89	.10	.01	.01	.01	M

Table XI shows the results of running t-tests and analysis of variances on the standard deviations of the manipulated and non-manipulated value-laden Delphi statements for each round of the Delphi. The results show a significant difference existed for each round except the first round.

The interpretation of the above indicates there was no significant difference in the standard deviations during the first round, which was as one would expect (i.e., no manipulation had yet taken place). Beginning with the second round, however, the standard deviation of the manipulated group was significantly different from the non-manipulated group. About two-thirds of the manipulated standard deviations were greater than the non-manipulated statements and about one-third were smaller. Thus, one cannot say which way statistical manipulation affected the standard deviations of the value-laden Delphi statements, only that it significantly affected them. The cautions indicated for the factually-based Delphi results also apply here.

#### Comparison of Factually-based and Value-laden Delphis

The outcome of the above results made it very difficult to compare the two types of Delphis. The results for the standard deviation of the two types of Delphis were in direct conflict with each other. The results of the quartile range (factually-based Delphi) and the standard deviation (value-laden Delphi) were, however, consistent with each other; but these two measures could not be directly compared. The best one could do was to compare the resulting t and Z-values and see if they were consistent with each other. Such a comparison

TABLE XI  
Results of Statistical Tests on Convergence-  
Value-laden Delphi

<u>Round</u>	<u>Standard Deviation</u>			
	<u>t-test (df = 58)</u>		<u>anal. of var. (df = 1,58)</u>	
	<u>t value</u>	<u>t sign. at</u>	<u>F value</u>	<u>F sign. at</u>
1	0.692	-	0.479	0.999
2	2.192	0.05	4.805	0.030
3	2.070	0.05	4.284	0.040
4	2.570	0.02	6.607	0.012

indicated they were reasonably close to each other with the standard deviation (value-laden Delphi) being slightly more significant. This difference did not appear to be significant enough to indicate there was a significant difference between the two types of Delphis.

#### Summary of Convergence Results

The above results indicate a cautious rejection of research hypotheses R4 and R5 and the acceptance of research hypothesis R6. While statistical manipulation did not have any significant effect on the standard deviation of factually-based Delphi statements, it did have a significant effect on the convergence of the quartile range. Statistical manipulation also had a significant effect on the convergence of value-laden Delphi statements, although nothing could be said as to whether it increased or decreased the convergence. It did not appear that convergence of factually-based Delphi statements were more or less affected by statistical manipulation than convergence of value-laden Delphi statements.

#### STATISTICAL MANIPULATION AND STABILITY OF DELPHI STATEMENTS

Stability as defined earlier, is a measure of the number of changes participants make between two consecutive rounds. It was hypothesized that the effects of statistical manipulation would increase the number of changes that occurred and thus reduce the stability of Delphi statements. To test the research hypotheses

- R7 - manipulation of statistical feedback will not reduce the stability (and therefore not require an extra round(s)) in factually-based Delphi statements,

R8 - manipulation of statistical feedback will not reduce the stability (and therefore not require an extra round(s)) in value-laden Delphi statements, and

R9 - there will be no difference between factually-based and value-laden Delphi statements with respect to the effect manipulation of statistical feedback has upon stability (and therefore the number of rounds necessary to obtain stability),

it was decided to test the following research subhypotheses separately for both the factually-based Delphi statements and the value-laden Delphi statements:

N1 - there is no difference between manipulated and non-manipulated statements with respect to the percent change between rounds 1 and 2,

N2 - same as N1 except percent change is for rounds 2 and 3,

N3 - same as N1 except percent change is for rounds 3 and 4, and

N4 - there is no difference between manipulated and non-manipulated statements with respect to the round where stability is first achieved.

A strong acceptance of N1 through N4 would indicate a strong acceptance of R7 (R8). A comparison of the mean round where stability occurred for manipulated and non-manipulated statements for the factually-based Delphi and the value-laden Delphi will allow for the acceptance or rejection of the following research subhypotheses:

N5 - there is no difference between factually-based and value-laden Delphi statements with respect to the number of rounds necessary to obtain stability and

N6 - manipulation of statistical feedback has no effect on the number of rounds necessary to obtain stability.

The acceptance or rejection of these subhypotheses (N5-N6) will throw additional light on the original set of research hypotheses (R7-R9).

(N1, N2, and N3 are tested by H8; N4 is tested by H9; and N5 and N6 are tested by H10 through H13.)

#### Factually-based Delphi Results

To test N1 through N4, t-tests and analysis of variance were run on the percent change between rounds 1 and 2, rounds 2 and 3, and rounds 3 and 4 and on the round where 20% stability was first achieved (reference Table XII for data). They were also run on the round where 15% stability was first achieved (for those who feel more comfortable with Scheibe, Skutsch, and Schofer's [85] estimate of where stability should occur). As Table XIV indicates, there was a highly significant difference between the statistically manipulated and non-manipulated Delphi statements in all cases. Thus null hypotheses N1 through N4 were rejected at the highly significant level. These results support a strong rejection of the research hypothesis R7. Since in all cases, the mean of the statistically manipulated Delphi statements was greater than the mean of the non-manipulated Delphi statements, one must accept the alternative hypothesis that statistical manipulation had a highly significant destabilizing effect on factually-based Delphi statements.

#### Value-laden Delphi Results

The procedure used to test research subhypotheses N1 through N4 for the value-laden Delphi statements was the same that was used for the factually-based Delphi statements. The results were also the same. Table XIII contains the data used in the analysis. Table XIV reports the results. Similar to the factually-based Delphi, there



TABLE XII

## Stability of Manipulation - Factually-based Delphi

Statement Number	% Change Between Rounds						20%		15%	
	Manipulated			Non-manipulated			Stability First		Stability First	
	1-2	2-3	3-4	1-2	2-3	3-4	Reached in Round Manip	Non-Manip	Reached in Round Manip	Non-Manip
1	0.70	0.40	0.17	0.47	0.17	0.07	4	3	5	4
2	0.57	0.20	0.20	0.47	0.30	0.17	3	4	5	5
3	0.60	0.27	0.20	0.47	0.37	0.20	4	4	5	5
4	0.67	0.33	0.23	0.47	0.20	0.13	5	3	5	4
5	0.53	0.27	0.23	0.43	0.33	0.17	5	4	5	5
6	0.40	0.23	0.10	0.53	0.23	0.23	4	5	4	5
7	0.67	0.33	0.20	0.60	0.20	0.17	4	3	5	5
8	0.67	0.40	0.33	0.33	0.23	0.13	5	4	5	4
9	0.40	0.30	0.13	0.50	0.37	0.23	4	5	4	5
10	0.57	0.50	0.20	0.23	0.13	0.20	4	3	5	3
11	0.60	0.50	0.27	0.53	0.40	0.10	5	4	5	4
12	0.70	0.47	0.33	0.43	0.30	0.07	5	4	5	4
13	0.73	0.43	0.20	0.37	0.13	0.17	4	3	5	3
14	0.33	0.20	0.30	0.20	0.10	0.13	3	2	5	3
15	0.50	0.20	0.23	0.60	0.30	0.23	3	5	5	5
16	0.57	0.23	0.20	0.47	0.30	0.17	4	4	5	5
17	0.57	0.37	0.27	0.30	0.27	0.20	5	4	5	5
18	0.50	0.37	0.20	0.47	0.23	0.23	4	5	5	5
19	0.60	0.27	0.17	0.50	0.33	0.20	4	4	5	5
20	0.53	0.37	0.33	0.27	0.17	0.20	5	3	5	5
21	0.67	0.27	0.30	0.47	0.30	0.37	5	5	5	5
22	0.67	0.23	0.30	0.37	0.23	0.13	5	4	5	4
23	0.67	0.30	0.30	0.43	0.20	0.10	5	3	5	4
24	0.33	0.33	0.07	0.03	0.17	0.07	4	2	4	2
25	0.77	0.50	0.20	0.50	0.43	0.10	4	4	5	4
26	0.43	0.47	0.23	0.33	0.23	0.17	5	4	5	5

TABLE XII--Continued

Statement Number	% Change Between Rounds						20%		15%	
	Manipulated			Non-manipulated			Stability First		Stability First	
	1-2	2-3	3-4	1-2	2-3	3-4	Reached in Round Manip	Non-Manip	Reached in Round Manip	Non-Manip
27	0.57	0.43	0.23	0.57	0.37	0.27	5	5	5	5
28	0.50	0.37	0.17	0.40	0.23	0.20	4	4	5	5
29	0.47	0.30	0.10	0.43	0.20	0.13	4	3	4	4
30	0.67	0.47	0.23	0.43	0.17	0.03	5	3	5	4
Averages	0.57	0.34	0.22	0.42	0.25	0.17	4.33	3.77	4.87	4.37

TABLE XIII

## Stability of Manipulation - Value-laden Delphi

Statement Number	% Change Between Rounds						20%		15%	
	Manipulated			Non-manipulated			Stability First		Stability First	
	1-2	2-3	3-4	1-2	2-3	3-4	Reached in Round Manip	Non-Manip	Reached in Round Manip	Non-Manip
1	0.37	0.17	0.20	0.17	0.10	0.07	3	2	5	3
2	0.47	0.30	0.13	0.30	0.03	0.10	4	3	4	3
4	0.67	0.27	0.10	0.37	0.10	0.20	4	3	4	3
5	0.30	0.30	0.23	0.40	0.20	0.10	5	3	5	4
6	0.37	0.13	0.10	0.33	0.07	0.10	3	3	3	3
8	0.47	0.20	0.07	0.23	0.07	0.10	3	3	4	3
9	0.57	0.33	0.20	0.27	0.10	0.10	4	3	5	3
11	0.20	0.17	0.17	0.30	0.10	0.03	2	3	5	3
12	0.53	0.33	0.30	0.27	0.20	0.13	5	3	5	4
13	0.27	0.27	0.23	0.37	0.27	0.20	5	4	5	5
15	0.47	0.33	0.27	0.27	0.30	0.23	5	5	5	5
16	0.37	0.23	0.27	0.33	0.23	0.17	5	4	5	5
18	0.33	0.27	0.13	0.17	0.20	0.10	4	2	4	4
22	0.37	0.13	0.17	0.33	0.13	0.13	3	3	3	3
23	0.13	0.30	0.27	0.27	0.23	0.17	2	4	2	5
24	0.40	0.37	0.23	0.33	0.20	0.10	5	3	5	4
27	0.43	0.43	0.13	0.20	0.20	0.13	4	2	4	4
31	0.23	0.23	0.07	0.30	0.17	0.20	4	3	4	5
32	0.43	0.03	0.13	0.30	0.13	0.23	3	3	3	3
33	0.40	0.20	0.17	0.40	0.07	0.07	3	3	5	3
34	0.53	0.23	0.17	0.30	0.13	0.17	4	3	5	3
36	0.37	0.27	0.17	0.20	0.17	0.10	4	2	5	4
38	0.50	0.20	0.13	0.27	0.23	0.07	3	4	4	4
41	0.33	0.20	0.03	0.17	0.27	0.17	3	2	4	5
42	0.53	0.20	0.10	0.43	0.20	0.10	3	3	4	4
44	0.37	0.17	0.10	0.33	0.23	0.13	3	4	4	4

TABLE XIII--Continued

Statement Number	% Change Between Rounds						20%		15%	
	Manipulated			Non-manipulated			Stability First		Stability First	
	1-2	2-3	3-4	1-2	2-3	3-4	Reached in Round Manip	Non-Manip	Reached in Round Manip	Non-Manip
46	0.40	0.07	0.13	0.27	0.17	0.17	3	3	3	5
48	0.37	0.23	0.17	0.33	0.03	0.03	4	3	5	3
49	0.40	0.23	0.20	0.43	0.23	0.13	4	4	5	4
50	0.50	0.27	0.07	0.30	0.13	0.23	4	3	4	3
Averages	0.40	0.24	0.16	0.30	0.16	0.13	3.70	3.10	4.27	3.80

TABLE XIV

## Results of Statistical Tests on Stability

Factually-based Delphi	t-test		Analysis of Variance	
	t value	t sign. at	F value	F sign. at
R1-R2 changes	4.902	0.001	24.038	0.001
R2-R3 changes	3.833	0.001	14.694	0.001
R3-R4 changes	3.071	0.01	9.429	0.004
When 20% stability occurred	2.865	0.01	8.209	0.006
When 15% stability occurred	3.114	0.01	9.695	0.003

Value-laden Delphi	t-test		Analysis of Variance	
	t value	t sign. at	F value	F sign. at
R1-R2 changes	4.267	0.001	18.209	0.001
R2-R3 changes	3.525	0.001	12.424	0.001
R3-R4 changes	1.810	0.1	3.277	0.072
When 20% stability occurred	2.909	0.01	8.465	0.005
When 15% stability occurred	2.214	0.05	4.900	0.029

was a significant difference between the statistically manipulated and non-manipulated Delphi statements in all cases. Thus, research sub-hypotheses N1 through N4 were rejected. These results support a strong rejection of the research hypothesis R8. Since in all cases, the mean of the statistically manipulated Delphi statements was greater than the mean of the non-manipulated Delphi statements, one must accept the alternative hypothesis that statistical manipulation had a highly significant destabilizing effect on value-laden Delphi statements.

#### Additional Results Using the Stability Data

It has been reported in numerous articles that the value of going more than two rounds is questionable and that to go beyond three rounds is almost surely unnecessary. The results of these Delphis, however, indicate there is still a considerable amount of changing of answers taking place.

The average round that 20% stability took place in the non-manipulated Delphi was 3.77 for the factually-based Delphi (see Table XII) and 3.10 for the value-laden Delphi (see Table XIII), which was considerably later than the second round. The average percent of changes between rounds for the factually-based non-manipulated Delphi statements was 25% between rounds 2 and 3 and 17% between rounds 3 and 4. This indicates that it would have been better to run at least three rounds. The average percent of change between rounds for the value-laden non-manipulated Delphi statements, however, was 16% between rounds 2 and 3 and 13% between rounds 3 and 4. This was somewhat contrary to the average round where 20% stability took place (3.10). This indicates that while some value statements achieved stability early (by round 2),

others (almost half in this case) required at least three rounds to reach the desired stability (20%).

If the above results are proven consistent in other studies, it will add credibility to the use of stability in determining when to eliminate a Delphi statement from further consideration or in determining the optimal number of rounds to run a Delphi.

An argument can be made that stability is irrelevant to factually-based Delphis, that the main concern is whether there are significant changes in the median and quartile ranges. Table XV shows a tally of the number of changes in the quartiles and means of both the manipulated and non-manipulated Delphis. As can be seen, there was significant movement in the quartiles of the non-manipulated Delphi between rounds 2 and 3 and a lesser but still significant change between rounds 3 and 4. The median, however, did not show a significant movement after round 2. This is somewhat typical of most Delphis (i.e. the median tends to stay stationary or only slight movement occurs after the second round while the quartiles converge). The question then becomes is it worth the additional costs (time, money, and other resources) to run another round to achieve a higher level of convergence?

Table XV also demonstrates some other interesting points when one compares the manipulated Delphi with the non-manipulated Delphi. From the results of the earlier t-tests and analysis of variances on stability, one would expect the number of changes that occur between rounds to be greater for manipulated Delphi statements than for non-manipulated. While there were more changes, the additional number

TABLE XV

Number of Factually-Based Delphi Statements  
that Changed Between Rounds

number of Delphi statements that		Lower Quartile			Median			Upper Quartile		
		R1-R2	R2-R3	R3-R4	R1-R2	R2-R3	R3-R4	R1-R2	R2-R3	R3-R4
Non- Manip.	changed	23	18	10	9	4	3	23	20	7
	no change	7	12	20	21	26	27	7	10	23
Manip.	changed	26	19	11	30	28	18	27	23	8
	no change	4	11	19	0	2	12	3	7	22



was not significantly greater. This was probably due to the large number of changes that occurred normally under the non-manipulated conditions. Therefore while the number of participants changing their answers were significantly larger for statistically manipulated Delphi statements, there was not a significantly larger number of changes in the quartiles between rounds. There was, however, as Table XV demonstrates, a highly significant difference between the number of changes that occurred in the median.

#### Comparison of Factually-based and Value-laden Delphis

The results of running a 2-way analysis of variance on the average round where 20% and 15% stability took place are shown in Tables XVI and XVII (Hypotheses H10 and H11). As can be seen from the results there was a significant difference in the degree of stability obtained between the types of Delphi as well as whether the Delphi was manipulated or not. This would indicate a rejection of research subhypotheses N5 and N6. Since the mean round where 20% stability (15% stability) occurred was greater for factually-based Delphi statements than for value-laden Delphi statements, one must accept the alternative hypothesis that the factually-based Delphi statements took longer to reach stability than the value-laden Delphi statements, regardless of whether they were manipulated or not. Since the mean round where 20% stability (15% stability) occurred was greater for statistically manipulated Delphi statements than for non-manipulated Delphi statements, one must also accept the alternative hypothesis that statistical manipulation had a significant destabilizing effect on the responses to the Delphi statements regardless of what type of

TABLE XVI

Analysis of Variance on Summarized 20% Stability Data

	<u>20% Stability</u>		<u>t<sub>i.</sub></u>	<u><math>\bar{y}_{i.}</math></u>
	<u>non-manip.</u>	<u>manip.</u>		
Factually-based	3.77	4.33	8.10	4.05
Value-based	3.10	3.70	6.80	3.40
<hr/>				
t <sub>.j</sub>	6.87	8.03	14.9	
$\bar{y}_{.j}$	3.435	4.015		3.725

<u>Source of Variation</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>sign. at</u>
Between factual & value	0.4225	1	0.4225	0.05
Between manip. & non-manip.	0.3364	1	0.3364	0.05
Error	<u>0.0004</u>	<u>1</u>	0.0004	
Total	0.7593	3		

$$F_{1,1} = \frac{0.4225}{0.0004} = 1056.25 \quad \text{sign. at } 0.05$$

$$F_{1,1} = \frac{0.3364}{0.0004} = 841.0 \quad \text{sign. at } 0.05$$

TABLE XVII

Analysis of Variance on Summarized 15% Stability Data

15% Stability				
	<u>non-manip.</u>	<u>manip.</u>	<u>t<sub>j.</sub></u>	<u><math>\bar{y}_{i.}</math></u>
Factually-based	4.37	4.87	9.24	4.62
Value-based	3.80	4.27	8.07	4.035
<hr/>				
t <sub>.j</sub>	8.17	9.14	17.31	
$\bar{y}_{.j}$	4.085	4.57		4.3275

<u>Source of Variation</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>sign. at</u>
Between factually & value	0.342225	1	0.342225	0.05
Between manip. & non-manip.	0.235225	1	0.235225	0.05
Error	<u>0.000225</u>	<u>1</u>	0.000225	
Total	0.577675	3		

$$F_{1,1} = \frac{0.342225}{0.000225} = 1521.0 \text{ sign. at } 0.05$$

$$F_{1,1} = \frac{0.235225}{0.000225} = 1045.444 \text{ sign. at } 0.05$$

statements they were.

Table XVIII shows the results of running t-tests on the above data (Hypotheses H10 through H13). The t-test results substantiate the results of the above analysis of variance. In addition one can also see that manipulated factually-based Delphi statements were the most unstable while the non-manipulated value-based Delphi statements were the most stable (even though their mean stability did not occur until round 3). One can also notice that the manipulated value-based Delphi statements had about the same stability as the non-manipulated factually-based Delphi statements (i.e., they were not significantly different).

The results of the above analysis suggest the rejection of research hypothesis R9. As demonstrated there was a significant difference between factually-based Delphi statements and value-laden Delphi statements with respect to the effect manipulation of statistical feedback had upon stability.

#### Summary of Stability Results

The above results call for the rejection of all three research hypotheses, R7, R8, and R9. Statistical manipulation did have a highly significant destabilizing effect on both types of Delphi statements. There also was a difference in the effects statistical manipulation had on the two types of Delphi statements. Manipulated factually-based Delphi statements were the most unstable, while non-manipulated value-laden Delphi statements were the most stable. Non-manipulated factually-based Delphi statements had about the same degree of stability as manipulated value-laden Delphi statements.

TABLE XVIII

t-tests on Summarized Stability Data

	20% Stability		15% Stability	
	non-manip.	manip.	non-manip.	manip.
factually-based	$\bar{X}_{11} = 3.77$ $\sigma_{11} = 0.844$	$\bar{X}_{12} = 4.33$ $\sigma_{12} = 0.795$	$\bar{X}_{13} = 4.37$ $\sigma_{13} = 0.795$	$\bar{X}_{14} = 4.87$ $\sigma_{14} = 0.340$
value-based	$\bar{X}_{21} = 3.10$ $\sigma_{21} = 0.700$	$\bar{X}_{22} = 3.70$ $\sigma_{22} = 0.862$	$\bar{X}_{23} = 3.80$ $\sigma_{23} = 0.792$	$\bar{X}_{24} = 4.27$ $\sigma_{24} = 0.814$

$$\hat{\sigma} = \sqrt{\frac{n_1 S_1^2 + n_2 S_2^2}{n_1 + n_2 - 2}} = \sqrt{\frac{15(S_1^2 + S_2^2)}{58}} \quad \text{since } n_1 = n_2 = 30$$

$$\hat{\sigma}_{\Delta\bar{x}} = \hat{\sigma} \sqrt{\frac{n_1 + n_2}{n_1 n_2}} = \sqrt{\frac{S_1^2 + S_2^2}{29}}$$

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\hat{\sigma}_{\Delta\bar{x}}} \quad df = n_1 + n_2 - 2 = 58$$

20% Stability				15% Stability			
$\bar{X}_1$	$\bar{X}_2$	t	sign. at	$\bar{X}_1$	$\bar{X}_2$	t	sign. at
$\bar{X}_{11}$	$\bar{X}_{12}$	-2.83	0.01	$\bar{X}_{13}$	$\bar{X}_{14}$	-3.11	0.01
$\bar{X}_{21}$	$\bar{X}_{22}$	-2.91	0.01	$\bar{X}_{23}$	$\bar{X}_{24}$	-2.23	0.05
$\bar{X}_{11}$	$\bar{X}_{21}$	3.29	0.01	$\bar{X}_{13}$	$\bar{X}_{23}$	2.75	0.01
$\bar{X}_{12}$	$\bar{X}_{22}$	3.14	0.01	$\bar{X}_{14}$	$\bar{X}_{24}$	3.66	0.001
$\bar{X}_{11}$	$\bar{X}_{22}$	0.31	-	$\bar{X}_{13}$	$\bar{X}_{24}$	0.47	-
$\bar{X}_{21}$	$\bar{X}_{12}$	-6.25	0.001	$\bar{X}_{23}$	$\bar{X}_{14}$	-6.69	0.001

Overall, value-laden Delphi statements were more stable than factually-based Delphi statements, regardless of whether they were manipulated or not. If one were to use stability as a criteria for determining the number of rounds to run a Delphi, the results of this experiment indicated running at least three rounds.

#### STATISTICAL MANIPULATION AND CONFIDENCE OF DELPHI PARTICIPANTS

It was hypothesized that statistical manipulation might have an effect on the confidence (as expressed by self-rating) of a participant. The following research hypothesis was thus created:

- R10 - manipulation of statistical feedback in factually-based Delphi statements has no relationship to the changes in the respondents' self-rating of their knowledge of the subject matter for those Delphi statements.

In order to gain better insights into the behavior of change in self-rating and to determine how manipulation of statistical feedback can affect this behavior, the following research subhypotheses were proposed:

- N8 - there is not a tendency for Delphi participants to shift their self-rating toward the middle after having participated in several rounds,
- N9 - there is not a tendency for participants to shift their self-rating less at the lower end of the self-rating scale and more at the higher end of the scale on statements that have been statistically manipulated than on statements that have not been statistically manipulated,
- N10 - those participants who originally self-rated themselves low but whose answers were closely supported by the reported median will not have a propensity to increase their self-rating more than those whose answers were not closely supported by the median, and

N11 - those participants who originally self-rated themselves high but whose answers were distant from the reported median will not have a propensity to decrease their self-ratings more than those whose answers were not as distant from the median.

It was also questioned if there was a relationship between an individual's round 1 self-rating and the amount he changed his answer. This was expressed as the following research subhypotheses:

N12 - the average shift in responses between round 1 and round 4 for those participants in each of the self-rating classifications will not decrease as the self-rating classification increases, and

N13 - the average shift in responses between round 1 and round 4 in each of the self-rating classifications for participants manipulated via statistical feedback will not be greater than those for non-manipulated participants.

(N8 and N9 are tested by H15; N10 and N11 are tested by H16; and N12 and N13 are tested by H17.)

#### Factually-based Delphi Results

The average difference between the round 4 self-rating and the round 1 self-rating of all the participants for several special cases can be found in Table XIX. The table also contains the standard deviation and the results of two significant tests for a single mean using the t-distribution. The purpose of the first single mean t-test was to determine if the mean change in the self-rating from round 1 to round 4 was significantly different from zero. Thus the test assumed that people would not or should not change their self-rating of all the non-manipulated Delphi statements (Hypothesis H14). The second test assumed that people changed their self-rating to reflect an increase in confidence that was gained from the greater familiarity

TABLE XIX

Results of Statistical Tests on the Average Differences Between Round 1 and Round 4  
Self-rating by Manipulated and Non-manipulated Participants

Explanation	Manip.							Non-Manip.						
	SR4-SR1 Mean	std dev	$\bar{x}-0/(\sigma/\sqrt{n-1})$ t-calc	sign at	$\bar{x}-0.47/(\sigma/\sqrt{n-1})$ t-calc	sign at	df	SR4-SR1 Mean	std dev	$\bar{x}-0/(\sigma/\sqrt{n-1})$ t-calc	sign at	$\bar{x}-0.47/(\sigma/\sqrt{n-1})$ t-calc	sign at	df
All data	0.20	0.94	6.525	.001	8.61	.001	899	0.47	0.93	15.123	.001	0		899
SR1 = 1	0.60	0.78	14.311	.001	3.12	.01	351	0.82	0.84	19.113	.001	8.17	.001	384
SR1 = 2	0.20	0.79	4.550	.001	6.10	.001	319	0.44	0.86	9.136	.001	-0.63	.6	322
SR1 = 3	-0.22	0.89	-3.060	.01	-9.68	.001	156	-0.09	0.78	-1.398	.2	-8.56	.001	142
SR1 = 4	-0.63	1.14	-4.021	.001	-6.89	.001	51	-0.45	0.93	-3.053	.01	-6.17	.001	39
SR1 = 5	-1.26	1.19	-4.609	.001	-6.16	.001	18	-0.56	1.01	-1.644	.2	-2.89	.02	8
Lower range 1	0.49	0.78	6.629	.001	0.27	.01	112	0.74	0.93	12.069	.001	4.39	.001	229
Lower range 2	0.60	0.79	6.030	.001	1.30	.2	62	0.73	0.90	10.096	.001	3.60	.001	155
Lower range 3	0.72	0.79	5.654	.001	1.95	.1	38	0.72	0.87	9.359	.001	3.24	.01	127
Upper range 1	-1.11	1.29	-4.554	.001	-6.37	.001	27	-1.17	1.11	-3.626	.01	-4.90	.001	11
Upper range 2	-1.39	1.20	-4.600	.001	-6.39	.001	17	-1.00	1.10	-2.236	.1	-2.99	.05	5
Upper range 3	-1.57	1.09	-5.397	.001	-6.76	.001	13	-1.00	1.10	-2.236	.1	-2.99	.05	5
Not lower range 1	0.39	0.81	11.387	.001	-2.33	.02	558	0.60	0.84	15.472	.001	3.36	.001	471
Not upper range 2	-0.60	1.12	-3.941	.001	-6.82	.001	52	-0.40	0.90	-2.870	.01	-6.26	.001	42

SR1 = self-rating during round 1

Lower range 1 SR1 = 1 or 2 and AD-R1\*  $\leq$  .25

Lower range 2 SR1 = 1 or 2 and AD-R1\*  $\leq$  .15

Lower range 3 SR1 = 1 or 2 and AD-R1\*  $\leq$  .10

\*for non-manipulated statements AD-R1 is  
replaced by R3-R1

Upper range 1 SR1 = 5 and AD-R1\*  $\geq$  0.4  
SR1 = 4 or 5 and AD-R1\*  $\geq$  0.8

Upper range 2 SR1 = 5 and AD-R1\*  $\geq$  0.5  
SR1 = 4 or 5 and AD-R1\*  $\geq$  1.0

Upper range 3 SR1 = 5 and AD-R1\*  $\geq$  0.75  
SR1 = 4 or 5 and AD-R1\*  $\geq$  1.25



and knowledge obtained from the thought and consideration given the statement through several rounds of the Delphi. The latter test also assumed that the mean of all the non-manipulated Delphi statements was representative of the overall increase in self-rating attributable to these statements. An analysis of this information will now be given.

As one might expect, the mean change in the self-ratings of the participants for the non-manipulated Delphi statements was greater than the mean change for the manipulated statements. Both cases were significantly different from zero. This indicates that as Delphi participants were forced to think about each statement and as they saw how others reacted to the statement, they increased both their base of knowledge relative to that statement and their familiarity with that statement. Thus when they were asked to self-rate themselves during a later round, they felt more confident in their ability to respond. This is supportive of the idea that the Delphi can be used as an information dissemination device as well as an information collection device.<sup>7</sup> The significantly lower mean change in the manipulated statements indicates that while the participants felt more confident in their ability to respond as a result of the above reasons, their confidence was undermined by the problem that the statistical feedback did not agree with what they anticipated.

While the above lends support to the rejection of research hypothesis R10, it presents a summary view. More can be learned if one subdivides the self-rating changes according to how the

<sup>7</sup>This directly supports the results of Ludlow's study [57] and is suggested by Linstone and Turoff in their definition of Delphi as a "communication" tool [56].

participants originally self-rated themselves. When one studies the means presented in the second through the sixth rows (SR1=1 through SR1=5) of Table XIX, one sees that those who originally self-rated themselves low increased their self-rating in later rounds and those who originally self-rated themselves high decreased their self-rating during later rounds. (In the case of the manipulated participants, the mean of the self-rating changes appears to be almost a linear function of the first round self-rating.) The results of the analysis of variance presented in Table XX verified there was a highly significant difference between the round 1 self-ratings with respect to how much change occurred. The results of the analysis of variance also showed the change depended upon whether the participant was manipulated or not. In this case the manipulated participants did not change their self-ratings as much at the lower end of the scale but changed them more at the higher end of the scale.

The above is strong evidence to reject research subhypotheses N8 and N9. This would indicate that there was a significant tendency for Delphi participants to shift their self-ratings during later rounds toward the middle. That is, those who originally self-rated themselves low increased their self-rating during later rounds; and those who originally self-rated themselves high decreased their self-rating during later rounds. The further a participant's original self-rating was from the middle, the greater was his tendency to move toward the middle. While statistically manipulated participants who originally self-rated themselves low significantly increased their self-rating during later rounds, they did not increase it as

TABLE XX

Analysis of Variance to Test the Significance of the Shift of  
Self-rating Towards the Middle in Later Rounds

	<u>SR4-SR1 Mean</u>		<u>t<sub>i.</sub></u>	<u><math>\bar{y}_i</math></u>
	<u>non-manip</u>	<u>manip</u>		
SR1 = 1	0.82	0.60	1.42	0.71
SR1 = 2	0.44	0.20	0.64	0.32
SR1 = 3	-0.09	-0.22	-0.31	-0.155
SR1 = 4	-0.45	-0.63	-1.08	-0.54
SR1 = 5	-0.56	-1.26	-1.82	-0.91
t <sub>.j</sub>	0.16	-1.31	-1.15	
$\bar{y}_{.j}$	0.032	-0.262		-0.115

<u>Source of Variation</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>sign at</u>
Between SR1 ratings	3.3682	4	0.84205	0.01
Between manip & non-manip	0.21609	1	0.21609	0.05
Error	<u>0.10656</u>	<u>4</u>	0.02664	
Total	3.69085	9		

$$F_{1,4} = \frac{0.21609}{0.02664} = 8.11 \text{ sign at } 0.05$$

$$F_{4,4} = \frac{0.84205}{0.02664} = 31.61 \text{ sign at } 0.01$$

	1.42	0.64	-0.31	-1.08	-1.82
1.42	-				
0.64	0.78	-			
-0.31	1.73	0.95	-		
-1.08	2.50	1.72	0.77	-	
-1.82	3.24	2.46	1.51	.74	-

all combinations of rows are significantly different from each other at 0.01 except SR1=4 and SR1=5 which are significantly different from each other at 0.05

$$* \text{LSD}_{.90} = \sqrt{\frac{2}{2} (0.02664)(4.54)} = .348$$

$$** \text{LSD}_{.95} = \sqrt{\frac{2}{2} (0.02664)(7.71)} = .453$$

$$*** \text{LSD}_{.99} = \sqrt{\frac{2}{2} (0.02664)(21.20)} = .752$$

much as non-manipulated participants. The opposite was true for those who originally self-rated themselves high. The statistically manipulated participants who originally self-rated themselves high decreased their self-rating during later rounds by a significantly greater amount than the non-manipulated participants. This signified an overall decrease in the confidence of the participants who were statistically manipulated regardless of their original self-rating. The rejection of research subhypotheses N8 and N9 gives more credence to and explanation behind, the rejection of research hypothesis R10.

The last eight rows of Table XIX and XXI address themselves to the changes that occurred in self-rating for those participants who originally self-rated themselves low (1 or 2) but whose initial response was quite close to the median reported during round 4 (low ranges 1, 2, and 3) and those participants who originally self-rated themselves high (4 or 5) but whose initial response was quite distant from the median reported during round 4 (upper ranges 1, 2, and 3). It was hypothesized that the former participants would increase their self-rating more than other participants who self-rated themselves low since the falsified median would act in a reinforcing manner, making them feel as though they knew more than they thought. It was also hypothesized the latter would show a tendency to reduce their self-rating more than other participants who self-rated themselves high, since the considerably different median would act to undercut their confidence in their ability to respond to the statement.

Table XXII shows there was a significant difference between the non-manipulated participants who originally self-rated themselves

TABLE XXI

Significance of Differences Between Means of Self-rating Between Round 1 and Round 4 for  
Manipulated and Non-manipulated Participants (reference Table XIX).

	SR4-SR1 mean		std. dev.		n		$\hat{\sigma}_{\Delta x}$	t	df	sign. at
	non-manip	manip	non-manip	manip	non-manip	manip				
All data	0.47	0.20	0.93	0.94	900	900	.0441	6.12	1798	0.001
SR1 = 1	0.82	0.60	0.84	0.78	385	352	.0600	3.67	735	0.001
SR1 = 2	0.44	0.20	0.86	0.79	323	320	.0652	3.68	641	0.001
SR1 = 3	-0.09	-0.22	0.78	0.89	143	157	.0974	1.34	298	0.2
SR1 = 4	-0.45	-0.63	0.93	1.14	40	52	.2241	.80	90	0.5
SR1 = 5	-0.56	-1.26	1.01	1.19	9	19	.477	1.47	26	0.2
Lower range 1	0.74	0.49	0.93	0.78	230	113	.1018	2.46	341	0.02
Lower range 2	0.73	0.60	0.90	0.79	156	63	.1304	1.00	217	0.4
Lower range 3	0.72	0.72	0.87	0.79	128	39	.1568	0	165	1.0
Upper range 1	-1.17	-1.11	1.11	1.29	12	28	.4385	-0.14	38	0.9
Upper range 2	-1.00	-1.39	1.10	1.20	6	18	.5789	0.67	22	0.6
Upper range 3	-1.00	-1.57	1.10	1.09	6	14	.5622	1.01	18	0.3
Not Lower range 1	0.60	0.39	0.84	0.81	472	559	.0516	4.07	1029	0.001
Not Upper range 2	-0.40	-0.60	0.90	1.12	43	53	.2131	0.94	94	0.4

$$\hat{\sigma}_{\Delta x} = \sqrt{\frac{(n_1 s_1^2 + n_2 s_2^2)}{(n_1 + n_2 - 2)}} \left( \frac{n_1 + n_2}{n_1 n_2} \right)$$

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\hat{\sigma}_{\Delta x}}$$

TABLE XXII

Significance of Differences Between Means of Self-rating Change for Those in Lower  
Range 1 and Those Not in Lower Range 1

	<u>SR4-SR1 mean</u>		<u>std. dev.</u>		<u>n</u>		<u><math>\hat{\sigma}_{\Delta x}</math></u>	<u>t</u>	<u>df</u>	<u>sign. at</u>
	<u>lower range 1</u>	<u>not lower range 1</u>	<u>lower range 1</u>	<u>not lower range 1</u>	<u>lower range 1</u>	<u>not lower range 1</u>				
non-manip	0.74	0.60	0.93	0.84	230	472	.0701	2.00	700	0.05
manip	0.49	0.39	0.78	0.81	113	559	.0832	1.20	670	0.3

low but whose responses were closely supported by the reported median and the non-manipulated participants who originally self-rated themselves low but whose responses were not closely supported by the reported median. This relationship was not significant for the manipulated participants. Table XXIII shows the opposite was true for the upper range figures. There was a significant difference between the manipulated participants who originally self-rated themselves high but whose responses were distant from the reported median and the manipulated participants who originally self-rated themselves high but whose responses were not distant from the reported median. This relationship was not significant for the non-manipulated participants. Had the sample size of the non-manipulated upper range 2 been larger, the results might have been different. This is illustrated by the comparison of the data for upper range 1 where a significant result was found for the non-manipulated participants. The interpretation of the results thus becomes difficult due to the inherent contradictions. Therefore, the results for research sub-hypotheses N10 and N11 are inclusive. The distance between a participant's original estimate and the median reported to him may or may not contribute significantly to the change in his self-rating.

Table XXIV presents the results of a two-way analysis of variance run on the mean change of the responses (round 4 answer minus round 1 answer) for each self-rating category, according to whether the participant was manipulated or not. The results indicate the self-rating category had a highly significant ( $\alpha = 0.01$ ) effect on the amount of change in the responses. With the exception of the

TABLE XXIII

Significance of Differences Between Means of Self-rating Change for Those in Upper  
Range 2 and Those Not in Upper Range 2

	<u>SR4-SR1 mean</u>		<u>std. dev.</u>		<u>n</u>		<u><math>\hat{\sigma}_{\Delta x}</math></u>	<u>t</u>	<u>df</u>	<u>sign. at</u>
	<u>upper range 2</u>	<u>not upper range 2</u>	<u>upper range 2</u>	<u>not upper range 2</u>	<u>upper range 2</u>	<u>not upper range 2</u>				
non-manip	-1.00	-0.40	1.10	0.90	6	43	.4124	-1.45	47	0.2
manip	-1.39	-0.60	1.20	1.12	18	53	.3157	2.50	69	0.02
non-manip (upper range 1)	-1.17	-0.32	1.11	0.86	12	40	.3115	-2.73	50	0.01



TABLE XXIV

Analysis of Variance to Test the Significance of the Mean Change in Answers

	R4-R1 mean		<u>t<sub>i.</sub></u>	<u>y<sub>i.</sub></u>
	<u>non-manip</u>	<u>manip</u>		
SR1 = 1	0.64	1.01	1.65	0.825
SR1 = 2	0.47	0.85	1.32	0.66
SR1 = 3	0.41	0.59	1.00	0.50
SR1 = 4	0.35	0.54	0.89	0.445
SR1 = 5	0.11	0.38	0.49	0.245
t. <sub>j</sub>	1.98	3.37	5.35	
y. <sub>j</sub>	0.396	0.674		.535

<u>Source of Variation</u>	<u>SS</u>	<u>df</u>	<u>MS</u>	<u>sign at</u>
Between SR1 ratings	0.3863	4	0.097	0.01
Between manip & non-manip	0.19321	1	0.193	0.01
Error	0.01814	4	0.005	
Total	0.59765	9		

$$F_{1,4} = \frac{0.193}{0.005} = 38.6 \quad \text{sign at } 0.01$$

$$F_{4,4} = \frac{0.097}{0.005} = 19.4 \quad \text{sign at } 0.01$$

	0.825	0.66	0.50	0.445	0.245	
0.825	-					all combinations of rows are significantly different from each other at least at the 0.1 significance level with the exception of rows 3 and 4
0.66	0.165*	-				
0.50	0.325***	0.16*	-			
0.445	0.38***	0.215**	0.055	-		
0.245	0.58***	0.415***	0.255**	0.200**	-	

$$*LSD_{.90} = \sqrt{\frac{2}{2}(.005)(4.54)} = 0.151 \quad ***LSD_{.99} = \sqrt{\frac{2}{2}(.005)(21.20)} = 0.326$$

$$**LSD_{.95} = \sqrt{\frac{2}{2}(.005)(7.71)} = 0.196$$

combinations of rows 3 and 4, all combinations of rows were significantly different from each other at least at the 0.1 significance level. The results also indicate there was a highly significant ( $\alpha = 0.01$ ) difference between whether the participant was manipulated or not. However, looking at Table XXV one notices this highly significant difference holds only for a low self-rating (SR=1 or 2). The middle self-rating (SR=3) was significant at the  $\alpha = 0.01$  level. There was not a significant difference for those who self-rated themselves high even though the relative difference between the manipulated and non-manipulated participants was as great or greater than the low self-raters. Had there been more participants in this category, the results might have been different.

The results of Tables XXIV and XXV indicate the rejection of research subhypothesis N12 and the qualified rejection of research subhypothesis N13. The higher a participant self-rated himself, the less likely he was to change his response. This was true for both non-manipulated and manipulated participants. In further support of the rejection of research hypothesis R10, manipulated participants changed their responses by a significantly greater amount than non-manipulated participants, although this was primarily true for those who did not self-rate themselves high.

#### Summary of Confidence Results

The results of the above statistical tests and the implications of the resulting acceptance or rejection of the research subhypotheses N8 through N13 strongly support the rejection of research

TABLE XXV

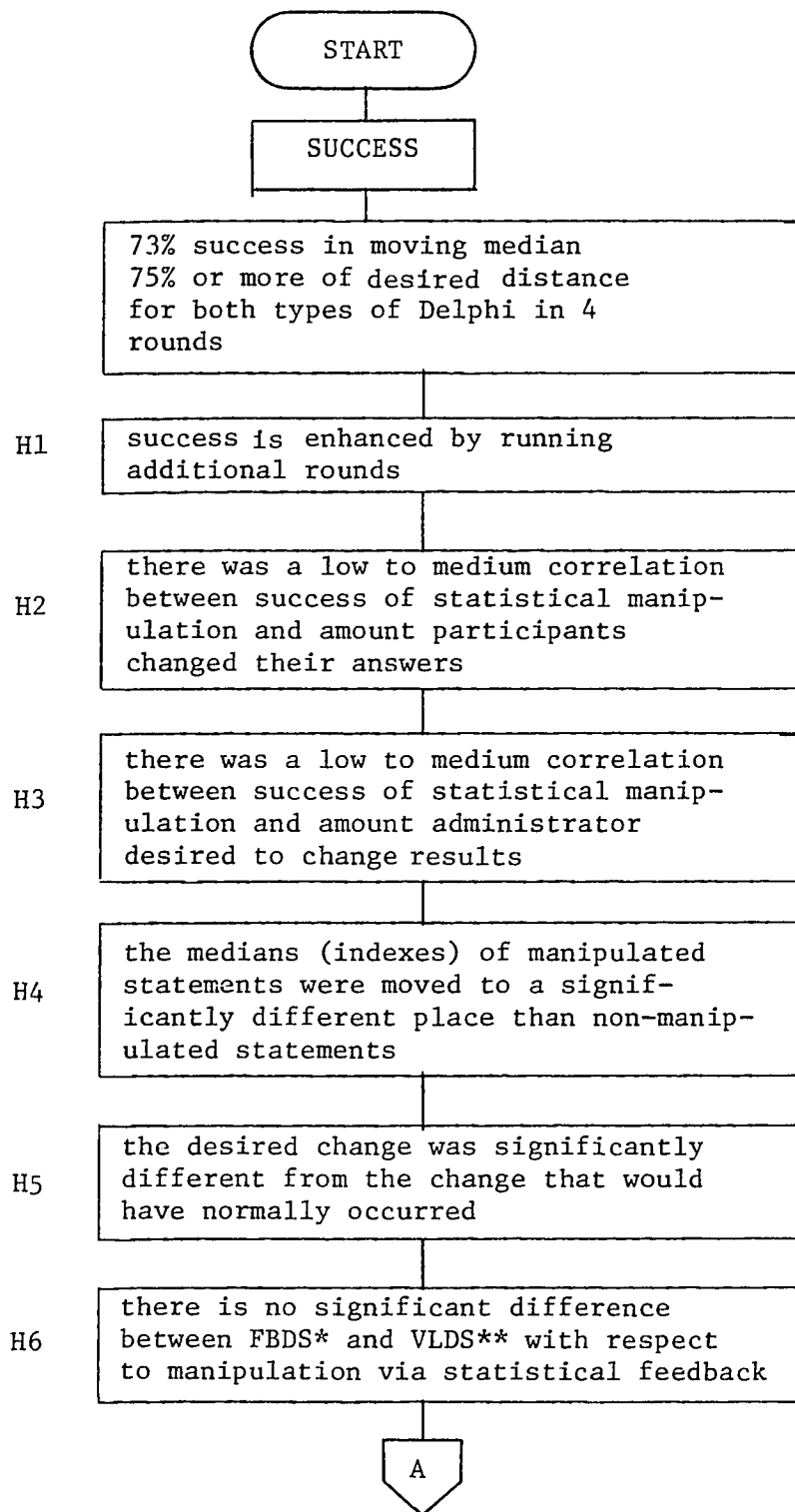
Significance of Differences Between Means of Change in Answers for Manipulated and Non-manipulated Participants Depending on Their Round 1 Self-rating

	<u>R4-R1 mean</u>		<u>std. dev.</u>		<u>n</u>		<u><math>\hat{\sigma}_{\Delta x}</math></u>	<u>t</u>	<u>df</u>	<u>sign. at</u>
	<u>non-manip</u>	<u>manip</u>	<u>non-manip</u>	<u>manip</u>	<u>non-manip</u>	<u>manip</u>				
SR1 = 1	.64	1.01	1.05	1.34	385	352	.0884	-4.18	735	.001
SR1 = 2	.47	.85	0.77	1.21	323	320	.0800	-4.75	641	.001
SR1 = 3	.41	.59	0.79	.82	143	157	.0935	-1.93	298	.1
SR1 = 4	.35	.54	0.64	.92	40	52	.1723	-1.10	90	.3
SR1 = 5	.11	.38	0.19	.93	9	19	.3249	-0.83	26	.5

hypothesis R10, indicating manipulation of statistical feedback does tend to affect the confidence and, as a result, the response of a participant.

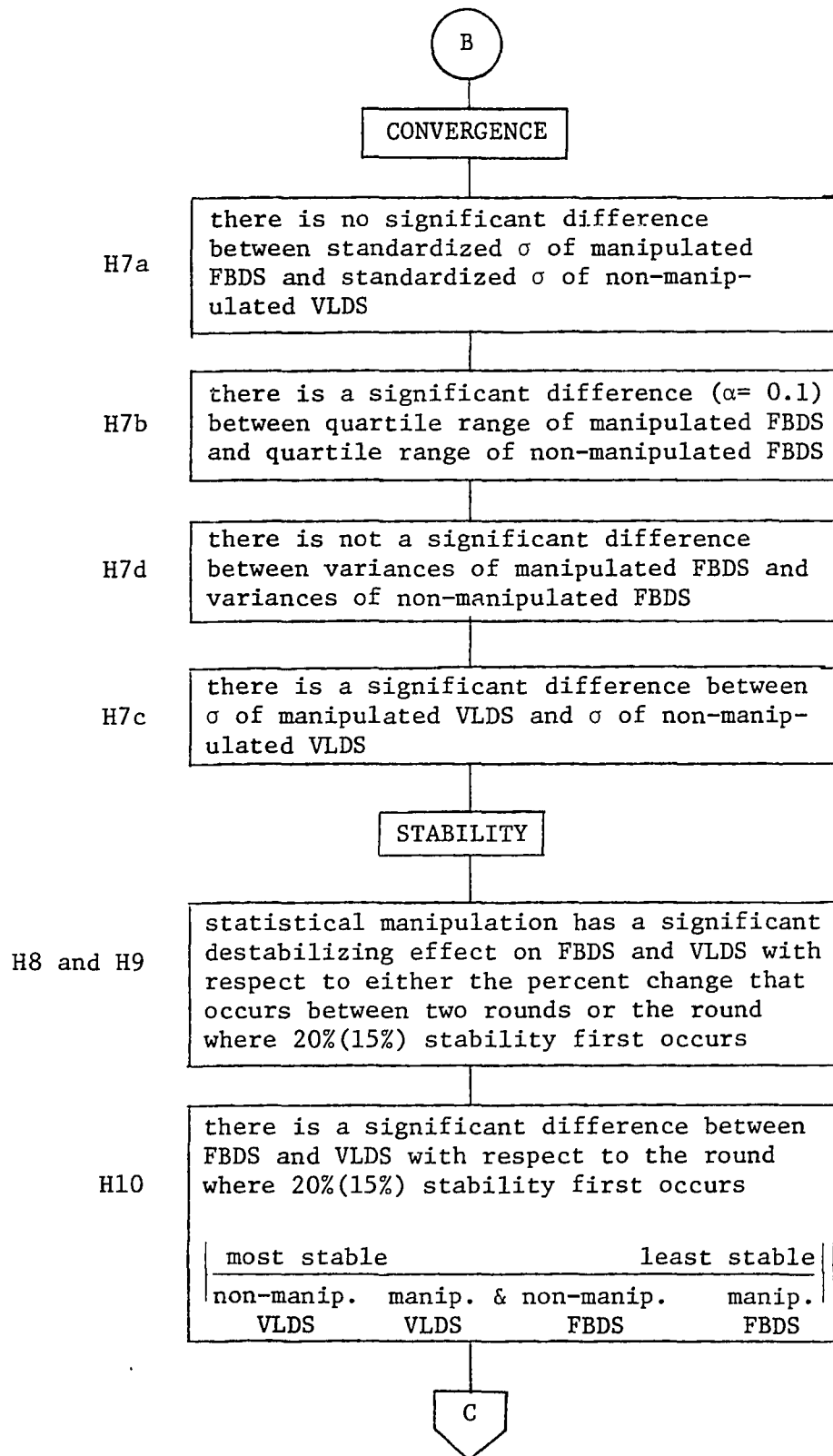
#### SUMMARY OF RESULTS

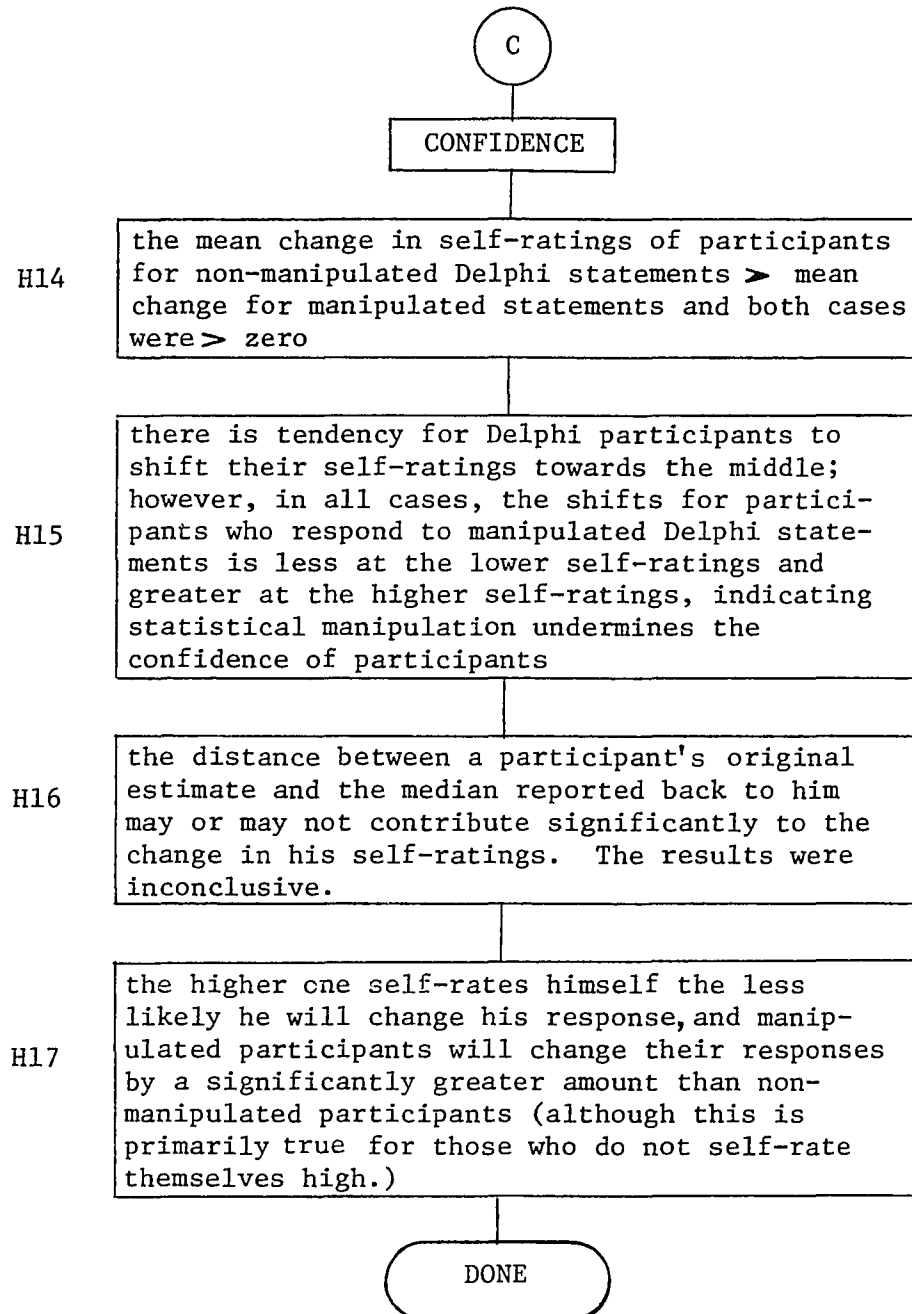
Figure 3 provides a brief synopsis of the results. It was written to closely follow the design of Figure 2 at the beginning of Chapter III.



\*FBDS = factually-based Delphi statement  
 \*\*VLDS = value-laden Delphi statement

Figure 3. Flowchart of the results of the statistical tests.





## CHAPTER V

### CONCLUSIONS AND EXTENSIONS

The purpose of this research was to investigate empirically the statistical manipulation of factually-based and value-laden Delphi statements to see if it was possible to achieve a particular desired point and to explore the effects such manipulation had upon the convergence and stability of the responses to Delphi statements. The effects of statistical manipulation upon the confidence of the Delphi participant (as measured by self-rating) was also explored.

The significance of the problem is evident in the increased use of the Delphi technique in providing input to policy decision making bodies in government, defense, business, education, etc. and the increased concern expressed in the literature about the possibilities of manipulation.

### CONCLUSIONS

The results of the research with respect to the original ten research hypotheses proposed can be summarized as follows:

Success: R1 and R2 were rejected while R3 was accepted. Statistical manipulation did cause a highly significant shift in the answers of participants and a high degree of success existed in obtaining a desired value. This success was enhanced by running additional rounds. The above was true for both factually-based



and value-laden Delphi statements. There was, however, no significant difference between the statistical manipulability of factually-based and value-laden Delphi statements.

Convergence: R4 and R5 were rejected and R6 was accepted. While statistical manipulation did not have any significant effect on the standard deviation of factually-based Delphi statements, it did have a significant effect on the convergence of the quartile range. Statistical manipulation also had a significant effect on the convergence of value-laden Delphi statements, although nothing can be said as to whether it increased or decreased the convergence. It did not appear that convergence of factually-based Delphi statements was more or less affected by statistical manipulation than convergence of value-laden Delphi statements.

Stability: All three research hypotheses (R7, R8, and R9) were rejected. Statistical manipulation did have a highly significant destabilizing effect on both types of Delphi statements. There also was a difference in the effects statistical manipulation had on the two types of Delphi statements. Manipulated factually-based Delphi statements were the most unstable, while non-manipulated value-laden Delphi statements were the most stable. Non-manipulated factually-based Delphi statements had about the same degree of stability as manipulated value-laden Delphi statements. Overall, value-laden Delphi statements were more stable than factually-based Delphi statements, regardless of whether they were manipulated or not. If one were to use stability as a criteria for determining the number of rounds to run a Delphi, the results of this experiment

indicated running at least three rounds.

Confidence: R10 was rejected. There was a significant tendency for Delphi participants to shift their self-rating during later rounds toward the middle. While statistically manipulated participants who originally self-rated themselves low significantly increased their self-rating during later rounds, they did not increase it as much as non-manipulated participants. The opposite was true for those who originally self-rated themselves high. The statistically manipulated participants who originally self-rated themselves high decreased their self-rating during later rounds by a significantly greater amount than the non-manipulated participants. This signified an overall decrease in the confidence of the participants who were statistically manipulated, regardless of their original self-rating. The distance between a participant's original estimate and the median reported back to him may or may not contribute significantly to the change in his self-rating. The results were inconsistent. The higher a participant self-rated himself the less likely he was to change his response. This was true for both non-manipulated and manipulated participants. Manipulated participants, however, changed their responses by a significantly greater amount than non-manipulated participants, although this was primarily true for those who did not self-rate themselves high.

#### RECOMMENDATIONS FOR AVOIDING STATISTICAL MANIPULATION

The probity of the results of a Delphi must ultimately rely upon the integrity of those who have administered the Delphi.

The more impervious a tool is to fraudulent misuse the less one has to worry about such actions. But because fraudulent misuse can occur does not lessen the value of the procedure, for the same is true for most tools. If one were to discard a tool because it could be misused through either fraudulent intent or ignorance, one would have to throw away such valuable tools as statistics, linear programming and other operations research tools, economics, engineering, and most of the tools of other disciplines. The fundamental problem of misuse of these techniques lies not in that it may happen but in why it may happen.

Perhaps the most fundamental recommendation in avoiding any form of manipulation of a Delphi is that the administrators of a Delphi should have no vested interest in the results of the Delphi. If an administrator has a vested interest, he belongs on the panel, not as an administrator. If one chooses a consultant whose livelihood depends upon developing and administering procedures such as Delphis, it is unlikely that he will risk his reputation and the reputation of one of his primary tools for the whim or desires of a client. It is, therefore, recommended that as an initial protection against manipulation one hire a reputable consultant who has experience in designing and administering Delphis.

When manipulating a Delphi statement via statistical feedback, the biggest adjustment of the statistical feedback usually is made to the first round statistics. It is like straightening out a clothes hanger. If one does not bend it to at least the straight position, it will not end up straight. If one bends it to exactly

the straight position and lets it go, it will spring back to a position somewhere between its original position and the straight position. What one must do is bend it just enough beyond the straight position so that when it springs back it will be straight. The key is knowing just how much to bend it beyond where one wants it. While this large adjustment at the beginning is necessary to accomplish the desired manipulation, it can also result in some early warning signals.

Discrepancies in factually-based Delphi statements are not easily detectable due to the form of statistical feedback (quartiles and medians). However, if the frequency distribution of the previous round is used as the statistical feedback for a value-laden Delphi, the corrupt administrator may run into several problems unless he is careful. These problems in turn can warn the alert participant that there may be discrepancies in the statistical feedback he is receiving. In trying to force answers to the desired results, he may leave blank a category where some participants have voted. The absence of a tally of their vote should quickly warn the participants. During the first round, he may also leave just a few people (1, 2, or 3) in an extreme category where there originally were several people (e.g. 8 or 9). The administrator will then experience trouble during later rounds when there is movement out of this extreme category. If he does not reduce the tally in the category in the next round of feedback, the people who moved might become suspicious. If he does reduce the tally he may run out of people or end up with only one person left in that category at the end of the Delphi. If there was more than one person left and the tally showed only one person,

the administrator exposes himself to a high risk situation of being exposed if the respondents begin discussing the Delphi with each other. Radical changes in later rounds (in particular the final results) may be a telltale sign of manipulation (i.e. an attempt to report the final tally to avoid the above problem).

The above naturally leads us to another measure that could expose manipulation if it took place. An administrator would be considerably more reluctant to use statistical manipulation if he knew the participants would be actively discussing the results with each other (either formally or informally). Such a meeting(s) could also have other useful benefits, but it may destroy some of the anonymity desired.

The success of statistical manipulation tends to be enhanced by additional rounds. Limiting the rounds where statistical feedback is returned to two or three rounds would thus reduce some of the success that could be achieved; however, the desired stability and/or convergence may not be achieved.

As will be discussed in the next section, inclusion of narrative feedback may or may not enhance the ability of the administrator to manipulate Delphi statements.

One last method one could use to try to determine if manipulation has taken place is to audit the results. One possible way to do this would be to have a disinterested third party request the participants to recast their final votes on several statements (a small percent of the total statements) that appear to be in question. This recasted vote distribution could then be compared with the

reported distribution. The candidate statements for investigation could be chosen by selecting those statements whose results are counter-intuitive and/or whose stability is low. Running such an audit, however, may have the effect of compromising anonymity and/or destroying the creditability of the results and must be handled very delicately.

#### EXTENSIONS

As stated in the very beginning of this report, this research is not the final word on the topic of manipulation of the Delphi technique or, for that matter, the broader topic of the misuse of the Delphi technique. To try to test all the ramifications of manipulation would have been over ambitious for anyone. It has been shown, however, that a group of individuals participating in a Delphi have been manipulated to produce significant changes in their responses. This in itself is reason enough to point to the need for further research in this area. Suggestions pertaining to the direction this research can take will now be discussed.

One obvious change in the normal Delphi procedure in the experiment was the elimination of narrative feedback. The major reason for this was to eliminate any possible influence from another primary form of manipulation, the language used in narrative feedback. That is, it is possible to add certain levels of bias and ambiguity when synthesizing the individual dissenting opinion into the generic dissenting statements that make up narrative feedback. (The same form of manipulation can also be applied to the original wording of the

of the statement itself.) Murray Turoff in personal correspondence agrees that while such a form of manipulation may be successful, the risk of discovery or of dissension of the participants increases greatly. This results from the fact that it would be obvious to a participant if his argument was not included or was worded in such a manner as not to convey the intent desired. However, while manipulation of narrative feedback increases the risk of discovery or of dissension of the participants, this risk does not preclude the possibility of manipulation of narrative feedback being a successful form of manipulation.

The implications of narrative feedback on this research and on the question of manipulability suggests three possible extensions of this work. First it would be interesting to see how the inclusion of non-manipulated narrative feedback would affect the success of statistical manipulation. To do this one could replicate the above experiments but include the provision for, and encourage the use of, narrative feedback.

A second possible extension would be to test the success of manipulating Delphi statements only through the use of manipulated narrative feedback (i.e. the statistical feedback would not be manipulated). One can explore this extension with three experiments. The first experiment would test to see if arguments representing the desired viewpoint could be presented well enough to overcome arguments supplied by the participants that are counter to the desired viewpoint. This would involve allowing the unsupportive arguments to appear in the narrative feedback in a form that would be

commensurate to a valid Delphi. However, it would also permit one to interject additional carefully worded narrative feedback statements which express arguments for the desired position. This technique of manipulation tends to be a little more subtle and has the least risk associated with it. The question being investigated here is can the administrator through the interjection of additional narrative feedback significantly influence the results of a Delphi statement?

The second experiment would involve only allowing arguments that are supportive of the desired viewpoint to appear in the narrative feedback. This means that feedback supplied by the participants that are counter to the desired viewpoint would not be allowed in the narrative feedback. As in the first experiment, the administrator could interject fabricated arguments supporting his point of view. This form of manipulation would have a high degree of risk associated with it since it should be clearly visible to the participants that their arguments are being ignored and only arguments counter to their opinion are being registered. Thus the question being asked in this case is will the participants rebel when they experience such discrepancies occurring in a Delphi or will they submit to the pressures and allow themselves to be manipulated? If they do rebel, how far can they be pushed before they rebel and what forms will their rebellion take?

While the first experiment tested the one extreme of allowing unsupportive arguments from the participants to appear in a valid form and the second experiment tested the other extreme of not



allowing them to appear at all, the third experiment tests the gray area in between the two extremes. This experiment would involve fabricating and interjecting many arguments in favor of the desired viewpoint and combining all the unsupportive arguments from the participants into a few statements that are carefully worded to include the ideas expressed but to express them in a somewhat bland or unforceful manner. To accomplish this, one would have to have a command of the English language and to be aware of the feelings expressed by each word. A background in linguistics, psychology, and sociology would be useful. The risk in this experiment is somewhat compromised. All of the arguments expressed are included, but the unsupportive ones are combined into a few watered down statements. Thus the participants may be upset that their arguments do not contain the strength they meant them to have, but they can at least see their arguments are included in the narrative feedback.

To run only one of the three experiments in the second extension would be to only answer part of the questions posed. To be able to synergistically view the problem of manipulation through the use of manipulated narrative feedback, one should run all three experiments and investigate the difference in their results.

The third extension involving narrative feedback would be to use a combination of both statistical and narrative feedback to manipulate to the desired answer. The suggested way to approach this extension would be to replicate the three experiments discussed for the second extension but include the use of manipulated statistical feedback. Thus one would not only be able to compare the

results amongst the three experiments but also between the two extensions. One would expect the success to be greater when the two forms of manipulation are used in combination. If this is true, by using the strength of both one could reduce the risk of discovery by not having to use one procedure as extensively as one would if he only used one method. It is conceivable, however, that one could get into trouble if one is not careful of avoiding conflicting situations between the narrative and statistical feedback.

The above three extensions, if written in the form of research hypotheses, would take on the following form:

- E<sub>1</sub> - the inclusion of non-manipulated narrative feedback would not significantly reduce the success achieved through manipulated statistical feedback,
- E<sub>2</sub> - the administrator through interjection of additional fabricated narrative feedback cannot significantly influence the results of a Delphi statement,
- E<sub>3</sub> - the administrator cannot significantly manipulate Delphi statements by including only supportive arguments in the narrative feedback (i.e. not include any arguments supplied by the participants that do not support the desired viewpoint and allowing the interjection of fabricated arguments by the administrator),
- E<sub>4</sub> - Corollary to E<sub>3</sub> - the Delphi participants will not rebel when they experience the discrepancies occurring as a result of E<sub>3</sub> (i.e. they will submit to the pressures and allow themselves to be manipulated),
- E<sub>5</sub> - the administrator cannot significantly manipulate Delphi statements by including additional fabricated supportive arguments in the narrative feedback and by combining the unsupportive statements of the participants into a few somewhat bland and unforceful arguments in the narrative feedback,
- E<sub>6</sub> - the administrator through the use of statistical manipulation and the interjection of additional fabricated

narrative feedback cannot significantly influence the results of a Delphi statement (this assumes the proper inclusion of unsupportive narrative feedback),

- E<sub>7</sub> - the administrator cannot significantly manipulate Delphi statements by the use of statistical manipulation and by the inclusion of only supportive arguments in the narrative feedback (i.e. not include any arguments supplied the the participants that do not support the desired viewpoint and allowing the interjection of fabricated arguments by the administrator),
- E<sub>8</sub> - Corollary to E<sub>7</sub> - the Delphi participants will not rebel when they experience the discrepancies occurring as a result of E<sub>7</sub> (i.e. they will submit to the pressures and allow themselves to be manipulated), and
- E<sub>9</sub> - the administrator cannot significantly manipulate Delphi statements by using statistical manipulation, by including additional fabricated supportive arguments in the narrative feedback, and by combining the unsupportive arguments of the participants into a few somewhat bland and unforceful arguments in the narrative feedback.

Each of the above hypotheses can be further specified to investigate factually-based Delphi statements and value-laden Delphi statements separately and then into investigating the differences between the two types of Delphi statements. Specifying the hypotheses in this manner would follow the same procedure used in this research.

There are many other factors that may or may not influence the manipulation of a Delphi. Many of these were discussed in the review of the literature (Chapter II) and are presented in a summarized form in Figures 4 through 6. Each of these factors represent a potential extension of this research, although some are more important than others. This taxonomy does not exhaust the universe of potential factors. As time progresses and more people view the subject, many additional parameters will be added. This initial set of factors, however, will be a useful and necessary tool in the analysis of the subject.

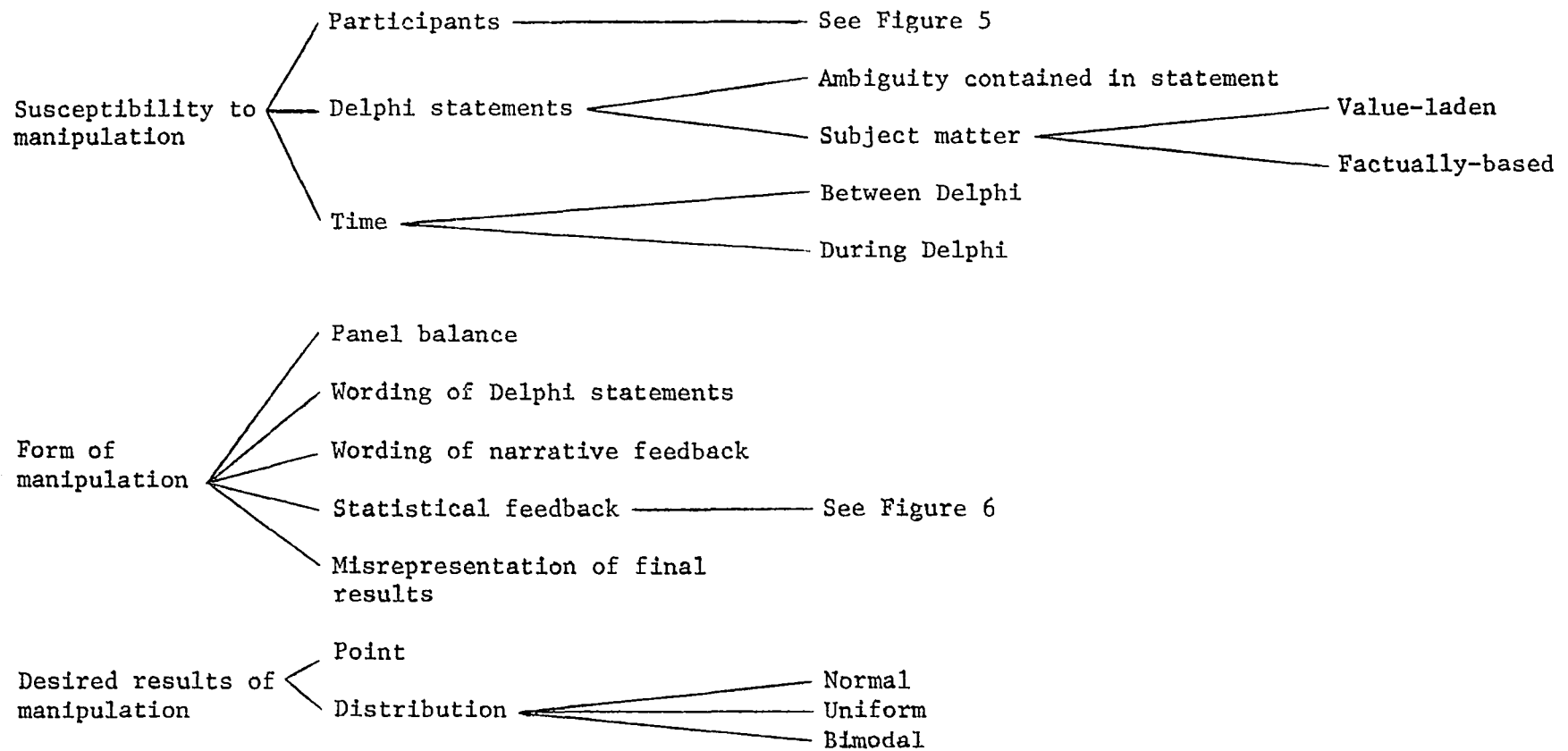


Figure 4. Factors that may determine the degree of manipulability of Delphi statements.

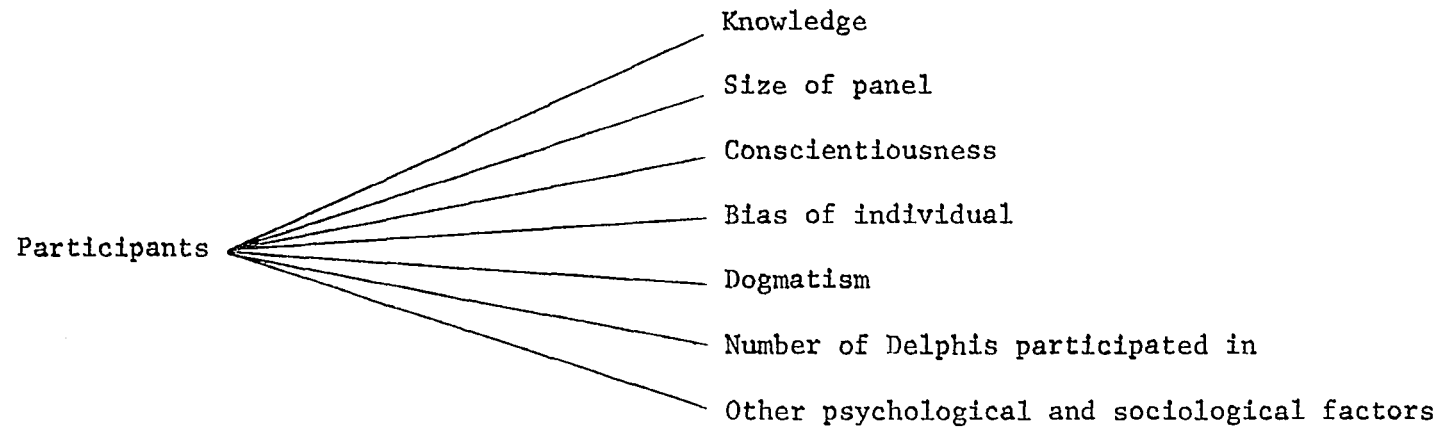


Figure 5. Factors that may determine the susceptibility of participants to be manipulated.

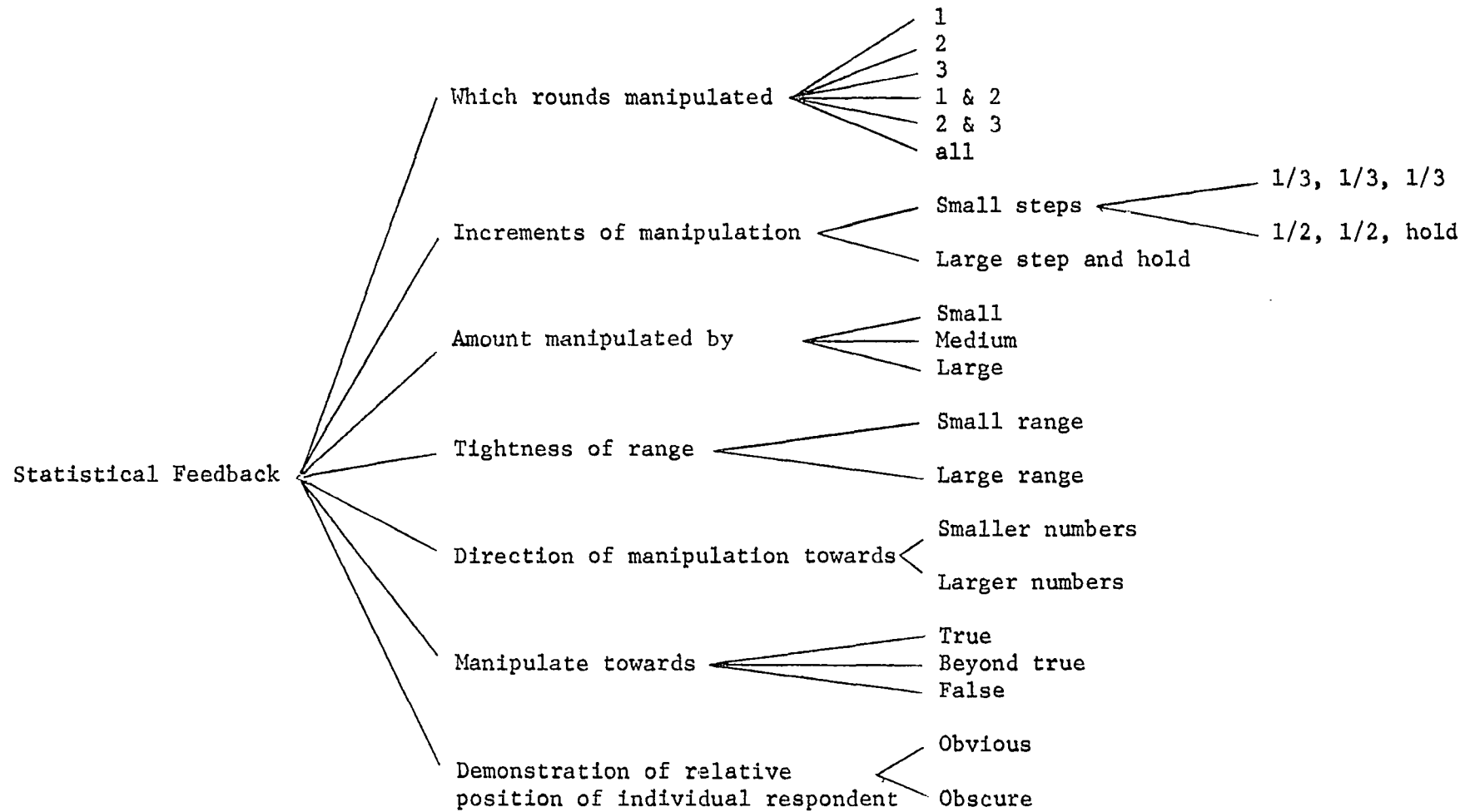


Figure 6. Factors that may determine the effectiveness of statistical feedback in manipulation.

## GLOSSARY

The following is a limited glossary. It is intended to define some of the terms used in this thesis that may be unfamiliar to the reader. Where a term is adequately defined or elaborated in the text, a reference to the appropriate page is made in lieu of a definition.

administrator: one who administers a Delphi

almanac Delphi: see page 49

anonymous response: see page 4

confidence: how assured a person is that his response is correct, see page 70

convergence: see page 64

Delphi: see page 3

desired value - the value (median or index) one is attempting to achieve through manipulation of statistical feedback

dogmatism: how authoritative, positive, or arrogant one is in his assertion of opinions

factually-based Delphi: see page 49

iterative and controlled feedback: see page 4

participant: one who participates in a Delphi as a panel member

policy Delphi: see page 50

pull of the median: see page 30

pull of the true: see page 30

response: an individual participant's reply for a particular round of Delphi

round: an iteration of a Delphi (what is involved in a particular round of a Delphi depends on the Delphi in question)

stability: see page 66

statistical group response: see page 4

value-laden Delphi: see page 49



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## APPENDIX A

### FACTUALLY-BASED DELPHI USED IN THIS EXPERIMENT

## ALMANAC DELPHI

Self-Rating		last 4 digits of Soc. Sec.#	STATISTICAL FEEDBACK		
			Lower Quartile	Median	Upper Quartile
<input type="text"/>	1. There were _____ primary USAF training centers in 1974.		<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	2. The total amount spent for book reimbursements for this program (GFAFB AFIT program) from July 1, 1975 to April 1, 1976 was _____ (dollars).		<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	3. The 1970 U.S. Census reported East Grand Forks as having population of _____.		<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	4. There were _____ students enrolled in the schools located on GFAFB on Sept. 30, 1974. (Public Schools)		<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	5. The total number of GFAFB AFIT students who registered for courses in Term 76-1 (last-term) was _____.		<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	6. The altitude of Grand Forks is _____ (feet).		<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	7. The launch weight of a Titan II (official configuration) is _____ (pounds).		<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	8. There were _____ bomber and tanker squadrons in the USAF in February 1974.		<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	9. There were _____ telephone numbers in Grand Forks in March, 1976 (this does not include extensions, Centrex phone systems (e.g., University of North Dakota and GFAFB), East Grand Forks, or GFAFB).		<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	10. The average wind velocity (in knots) at at GFAFB in January 1976 was _____.		<input type="text"/>	<input type="text"/>	<input type="text"/>
<input type="text"/>	11. On December 31, 1974, there were _____ Captains in the USAF.		<input type="text"/>	<input type="text"/>	<input type="text"/>

Self-  
Rating☐

12. The total number of deaths of USAF personnel in the Vietnam war between June 1, 1961 and Jan 25, 1973 was \_\_\_\_\_.

☐

13. A Captain with 6-8 years in the USAF received a \_\_\_\_\_ percent increase in military basic pay from 1963 to 1973.

☐

14. The average age of a USAF officer on Dec. 31, 1974 was \_\_\_\_\_.

☐

15. There were \_\_\_\_\_ military personnel (officers and enlisted) in the USAF on June 30, 1972.

☐

16. On December 31, 1974, \_\_\_\_\_ percent of USAF officers were women (use fraction of a percent if desired).

☐

17. The 25 year average annual precipitation (includes rain and rain equivalent of snow) in Grand Forks is \_\_\_\_\_ (inches).

☐

18. On December 29, 1973, there were \_\_\_\_\_ USAF personnel missing in action in southeast Asia.

☐

19. According to the 1970 census, there were \_\_\_\_\_ blacks (including dependents) living at GFAFB.

☐

20. The ratio of military personnel to civilian personnel working at GFAFB on December 31, 1974 was \_\_\_\_\_ (you may use fractions if desired).

☐

21. The USAF outlays (expenditures) for 1972 (in millions of dollars) was \_\_\_\_\_.

☐

22. The estimated nonagricultural wage and salary employment in Grand Forks on July 1, 1975, was \_\_\_\_\_ (i.e. the number of jobs)

☐

23. The total active aircraft in the USAF in June 1973 was \_\_\_\_\_.

STATISTICAL FEEDBACK  
Lower Upper  
Quartile Median Quartile

Self-  
Rating☐

24. The highest temperature ever recorded in North Dakota was \_\_\_\_\_ (°F).

☐

25. There are \_\_\_\_\_ acres of city parks in Grand Forks.

☐

26. The total number of semester hours completed by GFAFB AFIT students in the MMEP between July 1, 1975 and Dec. 31, 1975 was \_\_\_\_\_.

☐

27. The F15 Eagle's time to climb for 0-12,000 meters set in Jan. 1975 at GFAFB was \_\_\_\_\_ (seconds).

☐

28. There were \_\_\_\_\_ Air Force Academy Cadets in 1970.

☐

29. In July 1973, there were \_\_\_\_\_ Minuteman II missiles deployed.

☐

30. The USAF accepted or scheduled acceptance for \_\_\_\_\_ fixed wing aircraft in 1974 (not the number that was budgeted for, but the number that money was actually expended for).

STATISTICAL FEEDBACK  
Lower                      Upper  
Quartile   Median   Quartile

## INSTRUCTION SHEET FOR ALMANAC DELPHI

## Round 1

The experiment in which you are taking part is an effort to investigate human information processing. Your primary task will be to answer thirty questions of a general information type. The questionnaire is not a quiz or examination, nor is it a test of social influence. It will not be graded. Since it is done with total anonymity, no one will know how you answer a question nor how you may change it during later rounds. I am interested in the way groups use incomplete information to arrive at factual conclusions.

The experimental session will consist of four rounds. In the first, you will answer the thirty questions relying on what background information you may have. In the second round, you will be furnished a summary of the answers for this group. The summary will consist of the median answers of the group, and the two quartiles, that is, the range in which fifty percent of the group's answers are found. This summary is a form of "pooling" of the information of all the members of your group and will serve as a basis for revising your answers if it seems appropriate. The third and fourth rounds will contain the same type of information supplied in round two.

It is not expected that you will know the exact answer to any of the questions. However, for most of them, you will have some general knowledge that will enable you to make an estimate of the answer. You are to make as good an estimate as you can; but in any case, answer every question as best as you can. Captain Porter has verified that the answers to all the questions are publicly available (i.e., there is no classified information requested). You are not required to give the answers in whole numbers (numbers with decimal fractions are acceptable).

In addition to answering the questions, you are requested to rate each question with respect to the amount of knowledge you feel you have concerning the answers. Please use the following scale and record the appropriate self-rating number in the self-rating box for each question:

<u>Self-rating</u>	<u>Explanation</u>
1	possess little or no knowledge on the subject, answer would basically be a guess
2	possess a limited amount of knowledge on the subject, answer would basically be an educated guess
3	possess enough knowledge to make a reasonable estimate of the answer
4	know some pertinent details about the subject or have more than an average amount of experience in the subject that would make my estimate better than most people

Instructions Round 1  
Page 2

- 5        considerable knowledge, either know the answer or have available knowledge that directly pretains to the statement and can make a reasonably close estimate of the actual true value.

During the second, third, and forth rounds you may request to see your previous round answers to help you recall how you answered a question.

It is imperative that you do not discuss the questions or the experiment with anyone (especially other participants) and that you do not look up the answers.



## INSTRUCTION SHEET FOR ALMANAC DELPHI

## Rounds 2 and 3

Your task for this round will be to reconsider your answers to the thirty questions, and make any revisions which, on second thought, you feel are called for. Do not hurry, but rethink each question, considering whether there were factors you might have overlooked, or computations which might have contained numerical mistakes. However, keep in mind that you are still being asked only for your best estimate, based on what you know.

Following each statement is a summary of the answers of all the other participants from the preceding round. This summary is given in terms of the Median and the Quartile interval. The median is the middle response for that question; that is, 50 percent of the responses were greater than this number and 50 percent were less than this number. The quartile interval is comprised of the lower quartile and the upper quartile; that is, 25 percent of the responses were less than the lower quartile and 25 percent of the responses were greater than the upper quartile. The quartile interval thus gives you some indication of how widely the answers differ from one another. Taking this information into account, you may revise your answers where you think it appropriate.

Instead of self-rating yourself on each question as you did in round one, you are requested to indicate the reason why you did or did not change your estimate. Choose the number for the entry that best corresponds to your new estimate and enter it into the self-rating box. Thus, if you changed your answer because you realized you had made an error in computation, you would enter a 2 in the self-rating box. If you did not change your answer because you believed it to be correct whatever the group opinion, you would enter a 6 in the self-rating box.

## BASIS FOR ESTIMATE

I  
If You  
Changed Your Answer

1. I had misread the question.
2. I made a mistake in computation
3. I remembered some additional facts.
4. My estimate was too far from the group median.
5. The other members of the group are likely to know more about the question than I do.

II  
If You Did Not  
Change your Answer

6. I believe my original estimate.
7. The other members of the group are not likely to know more about the question than I do.
8. No good reason to change.
9. My estimate was close to the group median.
10. It would be more effort than it's worth to rethink the answer.

Instructions Rounds 2-3  
Page 2

If you would like to see your previous round of the Delphi to see how you answered some questions, I will provide them.

Again, please do not discuss the questions or the experiment with anyone (especially other participants) and do not look up any answers.

## INSTRUCTION SHEET FOR ALMANAC DELPHI

## Round 4

Your task for this round will be to reconsider your answers to the thirty questions, and make any revisions which, on second thought, you feel are called for. Do not hurry, but rethink each question, considering whether there were factors you might have overlooked, or computations which might have contained numerical mistakes. However, keep in mind that you are still being asked only for your best estimate, based on what you know.

Following each statement is a summary of the answers of all the other participants from the preceding round. This summary is given in terms of the Median and the Quartile interval. The median is the middle response for that question; that is, 50 percent of the responses were greater than this number and 50 percent were less than this number. The quartile interval is comprised of the lower quartile and the upper quartile; that is, 25 percent of the responses were less than the lower quartile and 25 percent of the responses were greater than the upper quartile. The quartile interval thus gives you some indication of how widely the answers differ from one another. Taking this information into account, you may revise your answers where you think it appropriate.

This is the last round and you are requested to use the same self-rating scale that you used in round 1. As the scale indicates, you are requested to rate each question with respect to the amount of knowledge you feel you have concerning the answers. Record the appropriate self-rating number in the self-rating box for each question.

<u>Self-rating</u>	<u>Explanation</u>
1	possess little or no knowledge on the subject, answer would basically be a guess
2	possess a limited amount of knowledge on the subject, answer would basically be an educated guess
3	possess enough knowledge to make a reasonable estimate of the answer
4	know some pertinent details about the subject or have more than an average amount of experience in the subject that would make my estimate better than most people
5	considerable knowledge, either know the answer or have available knowledge that directly pertains to the statement and can make a reasonably close estimate of the actual true value.

If you would like to see your previous round of the Delphi to see how you answered some questions, I will provide them.

## APPENDIX B

### VALUE-LADEN DELPHI USED IN THIS EXPERIMENT

Policy Delphi to Establish Objectives of MBA  
Program at UND

ROUND

Last 4 digits of Soc. Sec. Num. _____	Current Rating	Statistical Feedback of Previous Round				
1. To provide a supportive environment for highly creative individuals.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				
2. To prepare an environment conducive to informal, comfortable, human relationships.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				
3. To help students develop social skills, poise, and confidence.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				
4. To reward excellence in research and scholarly inquiry through promotions and salary increases.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				
5. To prepare students for service in the community.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				
6. To help students develop the ability to synthesize knowledge from different sources.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				
7. To respond to internal needs and goals of the institution, rather than to external pressure.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				
8. To select faculty who have diverse backgrounds and attitudes.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				
9. To encourage applied research (attempt to find solutions to actual problems) for government, business, or industry by the faculty to enhance their intellectual growth and experience.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				
10. To promote concern in students for the well-being of others.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				
11. To model the new MBA program in the established patterns of the more successful MBA programs.	_____	<table border="1" style="width: 100%;"> <tr> <td style="width: 25%; height: 20px;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> <td style="width: 25%;"></td> </tr> </table>				

	Current Rating	Statistical Feedback of Previous Round
12. To be receptive to and to encourage experimentation with new ideas for educational practices at all levels.	_____	_____
13. To help students acquire the ability to adapt to new occupational requirements as technology and society change.	_____	_____
14. To apply resources of the program to the solution of major national problems.	_____	_____
15. To establish a long-range plan for the institution.	_____	_____
16. To provide critical evaluations of prevailing practices and values of the business community.	_____	_____
17. To insure faculty participation in the program's decision making.	_____	_____
18. To help students develop the ability to speak and write effectively.	_____	_____
19. To provide the student with the skills, attitudes, and experiences which maximize the likelihood of his occupying a high status in life and a position of leadership in society.	_____	_____
20. To establish and clearly define the purposes the institution will serve.	_____	_____
21. To provide advisory assistance to the USAF (GFAF in particular).	_____	_____
22. To help students develop the capacity to assume leadership.	_____	_____
23. To provide a continuing plan of curricular and institutional evaluation and change for all programs.	_____	_____

	Current Rating	Statistical Feedback of Previous Round					
24. To assure academic freedom for faculty.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
25. To maintain an atmosphere of intellectual excitement among faculty, students, and administrators.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
26. To provide technical assistance to agencies of the national government.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
27. To provide students with an opportunity to acquire a broad understanding of the variety of occupational possibilities.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
28. To permit a student wide latitude in selecting the courses he will take towards his degree.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
29. To encourage open and honest communication among faculty, students and administrators.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
30. To instill in students a respect for knowledge for its own sake.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
31. To encourage involvement of students in research and/or community involvement (e.g. consulting, volunteer work, etc.) with the faculty.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
32. To provide for freedom of student expression and to clarify and protect student's rights.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
33. To enable students to develop a set of principles to guide their business behavior.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
34. To apply the technical expertise available in the program to the solution of state and regional problems.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					
35. To encourage a concern for the welfare of the institution among faculty members, students, and administrators.	<div></div>	<table><tr><td></td><td></td><td></td><td></td><td></td></tr></table>					

	Current Rating	Statistical Feedback of Previous Round
36. To involve students in curricular and instructional evaluation.	<hr/>	<hr/>
37. To base faculty promotions more on an estimate of teaching effectiveness than on the value of scholarly research and publications.	<hr/>	<hr/>
38. To help students develop a respect for their own abilities and an understanding of their limitations.	<hr/>	<hr/>
39. To insure that students have the opportunity to hear all points of view.	<hr/>	<hr/>
40. To help students to lead satisfying personal and social lives.	<hr/>	<hr/>
41. To help students develop the ability to apply critical thought to all areas of life.	<hr/>	<hr/>
42. To help students develop a sense of responsible membership in the world community.	<hr/>	<hr/>
43. To encourage pure research (research for the sake of knowledge) for government, business, or industry by the faculty to enhance their intellectual growth and experience.	<hr/>	<hr/>
44. To maintain a distinctiveness that sets the institution apart from other institutions.	<hr/>	<hr/>
45. To increase the desire and ability of students to undertake self-directed study.	<hr/>	<hr/>
46. To help solve business community problems in the immediate geographical area.	<hr/>	<hr/>



	Current Rating	Statistical Feedback of Previous Round				
47. To assure that work experience or specially assessed performances may be substituted for specific course requirements.	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
48. To avoid having the reputation of the institution damaged by the action of a few students or faculty.	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
49. To encourage community involvement (e.g. consulting, volunteer work, etc.) by the faculty to enhance their background and experience.	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>
50. To help students in the choice of a personally satisfying vocation.	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>	<hr/>

ATTENTION ALL AFIT STUDENTSANNOUNCEMENTANNOUNCEMENT

In discussing the status of my thesis with Dean Rowe, he requested that I run a special Delphi for him. As many of you know, the downtown campus will be offering an MBA program, beginning this fall. They are also in the process of trying to acquire accreditation for the new program. Part of the accreditation procedures require a discussion of the orientation and goals of the MBA program. Since a later part of the accreditation procedure will test the attainment of these goals, it is best to establish goals that are desired by a consortium of administrators, faculty and students. Since the new program does not yet have students and the summer is an inconvenient time to use undergraduate students, Dean Rowe has asked me to run a Delphi using AFIT students. He has supplied me with fifty (50) statements which he has selected from a number of similar studies and has asked that you rate their importance. Since this is in addition to my normal teaching load and writing my thesis, he has consented to allow me to set it up using the same procedures as the one I used on the previous Almanac Delphi. This does have an additional advantage for me, since it will enable me to see if the Delphi characteristics I was looking for in the Almanac Delphi will also exist in a Policy Delphi. If they do, it will add some additional strength to my original hypotheses and allow me to generalize the results more.

Because of the above decision there will be two Delphis run (one in Section A and the other in Section B). Each Delphi will have thirty (30) participants. (This allows me to use the same computer programs to do the analysis.) As before, there will be four rounds one each day of the next two AFIT sessions.

Section A	July 23, 24 & August 1, 2
Section B	July 26, 27 & August 4, 5

There will be fifty (50) statements of the following nature:

	of extremely high importance	of high importance	of medium importance	of low importance	of no importance
To decentralize decision-making to the greatest extent feasible.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
To provide an architectural climate conducive to learning.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Since there will be no self-rating, it is anticipated it will take about the same time to complete as the Almanac Delphi (around 45 minutes the first round and less than 30 minutes on succeeding rounds).

Those interested in participating in the study should contact Brad Nelson as soon as possible.

Instruction Sheet for Policy Delphi to Establish  
Objectives for UND's New MBA Program  
ROUND I

As you already are aware, the objective of this Delphi study is to provide viable input to Dean Rowe and those who have the authority to establish the objectives of the new MBA program that is now being created on campus at UND. It is necessary to establish these objectives for two reasons. First and most important, they will give direction and guidance to the new program. Secondly, they are a necessary part of the accreditation procedures for establishing accreditation for the new program.

This Delphi will consist of four rounds. In the first round, you will individually rate the importance of fifty objectives. During the second, third and fourth rounds you will be given back a frequency distribution of how people responded in the previous round. You in turn will be requested to rethink the objective in light of the statistical feedback (the frequency distribution) given you and any new thoughts that may have occurred to you since the previous rounds. Since the objectives established may have some impact on you as a student in this program, it is important that you give each statement some deep consideration.

The procedure you will be using to rate the importance of each Delphi statement is as follows:

- 5 - of extremely high importance
- 4 - of high importance
- 3 - of medium importance

2 - of low importance

1 - of no importance

Please use only these five values since the computer will only accept the values 1, 2, 3, 4, or 5 (i.e., it will not accept fractional values). An example will help illustrate the procedure. Assume the following objective:

To provide an architectural climate conducive to learning.	(current rating) _____
---	---------------------------

If you decide this is "of high importance," you would put a "4" in the space under "current rating." If you feel it has "no importance" you would put a "1" in the space under "current rating."

As with all Delphis, the results of each individual participant are completely confidential and total anonymity will exist throughout the study. If you deem if necessary, you may request to see your previous round answers to help you recall how you rated a statement.

As it is with all Delphis, it is imperative that you do not discuss the statements or the experiment with anyone (especially other participants). If there is enough interest shown, a special session will be held at the end of the study for those who wish to discuss the results. The next round will be tomorrow.

APPENDIX C

BERGER'S REVISION OF ROKEACH'S DOGMATISM SCALE

## Anonymous Identification

## OPINION INVENTORY

The following is a study of what the general public thinks and feels about a number of important social and personal questions. The best answer to each statement below is your personal opinion. We have tried to cover many different and opposing points of view; you may find yourself agreeing strongly with some of the statements, disagreeing just as strongly with others, and perhaps uncertain about others; whether you agree or disagree with any statement, you can be sure that many people feel the same as you do.

Mark each statement in the left margin according to how much you agree or disagree with it. Please mark every one. Write +1, +2, +3, or -1, -2, -3, depending on how you feel in each case.

- +3: I agree a great deal more with A than B.
- +2: I agree somewhat more with A than B.
- +1: I agree slightly more with A than B.
- 1: I agree slightly more with B than A.
- 2: I agree somewhat more with B than A.
- 3: I agree a great deal more with B than A.

- +3: I agree a great deal more with A than B.
- +2: I agree somewhat more with A than B.
- +1: I agree slightly more with A than B.
- 1: I agree slightly more with B than A.
- 2: I agree somewhat more with B than A.
- 3: I agree a great deal more with B than A.

- \_\_\_ 1. A. There may be crucial differences between the United States and Russia, but there are also many important features they have in common.  
B. The United States and Russia have just about nothing in common.
- \_\_\_ 2. A. To really believe in democracy means that the less intelligent will have an equal share in the government.  
B. The highest form of government is a democracy and the highest form of democracy is a government run by those who are most intelligent.
- \_\_\_ 3. A. Even though freedom of speech for all groups is a worthwhile goal, it is unfortunately necessary to restrict the freedom of certain political groups.  
B. To believe seriously in freedom of speech means that freedom of even those political groups we disagree with cannot be restricted.
- \_\_\_ 4. A. It is only natural that a person would have a much better acquaintance with ideas he believes in than with ideas he opposes.  
B. It is natural for a person to be nearly as well acquainted with ideas he opposes as with ideas he believes in.
- \_\_\_ 5. A. Man on his own is a helpless and miserable creature.  
B. Man on his own has many resources within himself, and is neither helpless nor miserable.
- \_\_\_ 6. A. The world is fundamentally more a place full of friendly people than a lonesome place.  
B. Fundamentally, the world we live in is a pretty lonesome place.
- \_\_\_ 7. A. Most people generally care about others.  
B. Most people just don't give a "dam" for others.



- +3: I agree a great deal more with A than B.
- +2: I agree somewhat more with A than B.
- +1: I agree slightly more with A than B.
- 1: I agree slightly more with B than A.
- 2: I agree somewhat more with B than A.
- 3: I agree a great deal more with B than A.

- \_\_\_ 8. A. I'd like it if I could find someone who would  
tell me how to solve my personal problems.  
B. If I have personal problems I'd rather try to  
work them out by myself than find someone  
who would tell me how to solve them.
- \_\_\_ 9. A. There's no need to be afraid of the future.  
B. It is only natural for a person to be rather  
fearful of the future.
- \_\_\_ 10. A. What I really hope to accomplish is limited  
enough so that I don't feel rushed about  
it.  
B. There is so much to be done and so little time  
to do it in.
- \_\_\_ 11. A. Once I get wound up in a heated discussion I  
just can't stop.  
B. I'm able to stop even if I get wound up in a  
heated discussion.
- \_\_\_ 12. A. I do not find it necessary to repeat myself  
several times in a discussion to make sure  
I'm being understood.  
B. In a discussion I often find it necessary to  
repeat myself several times to make sure I  
am being understood.
- \_\_\_ 13. A. In a heated discussion I generally become so  
absorbed in what I am going to say that  
I forget to listen to what the others  
are saying.  
B. I generally listen to what others are saying in  
a heated discussion rather than becoming  
absorbed in what I am going to say.
- \_\_\_ 14. A. It is better to be alive and not at all a hero,  
than to be a dead hero.  
B. It is better to be a dead hero than to be a live  
coward.

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- 1: I agree slightly more with B than A.
- 2: I agree somewhat more with B than A.
- 3: I agree a great deal more with B than A.

- \_\_\_15. A. While like most people I would like to make some small accomplishment in life, I have no secret ambition to become a great man; if I had I would certainly admit it to myself.  
B. While I don't like to admit this even to myself, my secret ambition is to become a great man, like Einstein, or Beethoven, or Shakespeare.
- \_\_\_16. A. The main thing in life is for a person to want to do something important.  
B. There are things in life that matter at least as much as for a person to want to do something important.
- \_\_\_17. A. If given the chance I would do something of great benefit to the world.  
B. While most people would probably want to do something of great benefit to the world if given a chance, I wouldn't care if it were done by someone else rather than myself.
- \_\_\_18. A. In the history of mankind there have probably been just a handful of really great thinkers.  
B. There have been many really great thinkers in the history of mankind who have had different ideas.
- \_\_\_19. A. There are a number of people I have come to hate because of the things they stand for.  
B. I do not hate anyone because he stands for things different from me.
- \_\_\_20. A. A man who does not believe in some great cause has not really lived.  
B. Whether a man has really lived or not is not determined by whether or not he believes in some great cause.
- \_\_\_21. A. Whether or not a person devotes himself to an ideal or cause, life can be meaningful.  
B. It is only when a person devotes himself to an ideal or cause that life becomes meaningful.

- +3: I agree a great deal more with A than B.
- +2: I agree somewhat more with A than B.
- +1: I agree slightly more with A than B.
- 1: I agree slightly more with B than A.
- 2: I agree somewhat more with B than A.
- 3: I agree a great deal more with B than A.

- \_\_\_ 22. A. Many of the different philosophies in this world are partly true, probably none of them is entirely correct.  
B. Of all the different philosophies which exist in this world there is probably only one which is correct.
- \_\_\_ 23. A. A person who gets enthusiastic about too many causes is likely to be a pretty "wishy-washy" sort of person.  
B. A person who gets enthusiastic about many causes is as likely to be a person of integrity as one who gets enthusiastic about a single cause.
- \_\_\_ 24. A. In order to achieve anything we often have to compromise with our political opponents; this isn't likely to lead to the betrayal of our own side.  
B. To compromise with our political opponents is dangerous because it usually leads to the betrayal of our own side.
- \_\_\_ 25. A. When it comes to differences of opinion in religion we must be careful not to compromise with those who believe differently from the way we do.  
B. We should be willing to compromise with those who believe differently from the way we do as regards differences of opinion and religion.
- \_\_\_ 26. A. In times like these, a person must be pretty selfish if he considers primarily his own happiness.  
B. It is not necessarily selfish for a person to consider primarily his own happiness.
- \_\_\_ 27. A. If a person feels that those who believe in the same thing he does are going wrong he should say so, publicly if necessary.  
B. The worst crime a person could commit is to attack publicly the people who believe in the same thing he does.

- +3: I agree a great deal more with A than B.
- +2: I agree somewhat more with A than B.
- +1: I agree slightly more with A than B.
- 1: I agree slightly more with B than A.
- 2: I agree somewhat more with B than A.
- 3: I agree a great deal more with B than A.

- \_\_\_28. A. Nowadays one should try to come to terms with different ideas of people or groups in our own camp, rather than being on guard against them as we might with ideas from the opposing camp.  
B. In times like these it is often necessary to be more on guard against ideas put out by people or groups in one's own camp than by those in the opposing camp.
- \_\_\_29. A. The best chance for a group to exist in the long run is to tolerate as much difference of opinion as there may be among its members.  
B. A group which tolerates too much differences of opinion among its own members cannot exist for long.
- \_\_\_30. A. There are two kinds of people in this world: those who are for the truth and those who are against the truth.  
B. It doesn't make sense to divide people into two distinct kinds, like those for the truth and those against the truth since almost everyone tries to be for the truth as he sees it.
- \_\_\_31. A. My blood boils whenever a person stubbornly refuses to admit he's wrong.  
B. I'm not likely to feel intense anger when a person refuses to admit he's wrong, even if he seems stubborn.
- \_\_\_32. A. One should be tolerant of a person who thinks primarily of his own happiness, not consider him to be beneath contempt.  
B. A person who thinks primarily of his own happiness is beneath contempt.
- \_\_\_33. A. Most of the ideas which get printed nowadays aren't worth the paper they are printed on.  
B. It's a good thing that many different ideas get printed nowadays since there may be something of value in many of them and this is the only way we can find out.

- +3: I agree a great deal more with A than B.
- +2: I agree somewhat more with A than B.
- +1: I agree slightly more with A than B.
- 1: I agree slightly more with B than A.
- 2: I agree somewhat more with B than A.
- 3: I agree a great deal more with B than A.

- \_\_\_34. A. In this complicated world of ours the only way we can know what's going on is to rely on leaders or experts who can be trusted.  
B. In trying to know what's going on in our complex world there are matters where we can not avoid relying on leaders or experts, but there are many issues that we should try to decide ourselves on their own merits.
- \_\_\_35. A. It is often desirable to reserve judgment about what's going on until one has had a chance to hear the opinions of those one respects.  
B. Before hearing the opinions of those one respects, one should try to have an opinion of one's own about what's going on.
- \_\_\_36. A. In the long run rather than have only friends and associates whose tastes and beliefs are the same as ones own, it is better to include some friends and associates with different tastes and beliefs.  
B. In the long run the best way to live is to pick friends and associates whose tastes and beliefs are the same as one's own.
- \_\_\_37. A. It's important to live life in the present; one can never be sure what the future may bring.  
B. The present is all too often full of unhappiness. It is only the future that counts.
- \_\_\_38. A. If a man is to accomplish his mission in life it is sometimes necessary to gamble "all or nothing at all".  
B. Since a man cannot know how it will turn out, he should not risk everything in a single gamble if he wants to accomplish his mission in life.
- \_\_\_39. A. People with whom I have discussed important social and moral problems tend to understand what's going on as much as I do.  
B. Unfortunately, a good many people with whom I have discussed important social and moral problems don't really understand what's going on.

- +3: I agree a great deal more with A than B.
- +2: I agree somewhat more with A than B.
- +1: I agree slightly more with A than B.
- 1: I agree slightly more with B than A.
- 2: I agree somewhat more with B than A.
- 3: I agree a great deal more with B than A.

40. A. Most people know what's good for them as well as  
anyone else does.  
B. Most people just don't know what's good for them.

## APPENDIX D

COMPUTER PROGRAM TO CALCULATE INTERMEDIATE STATISTICS

```

$JOB      (11646316), 'BRADLEY NELSON', LINES=60, PAGES=80, TIME=200
1  DIMENSION ANS(40,31), SUMA(30), SUMA2(30), WS(40), NORM(62), STDDEV(62)
   , TANS(30), ISSN(40), ICUMDS(62), CUMPRO(62), FEEDBK(4,30,24)
2  ICD=5
3  IPR=6
4  50 ISW=1
5  YLOW=0.0
6  NWST=0
7  DO 60 I=1,30
8      SUMA(I)=0.0
9      SUMA2(I)=0.0
10     NORM(I)=0
11  60 CONTINUE
12  DO 70 I=31,62
13     NORM(I)=0
14  70 CONTINUE
15  READ(ICD,9000)N,M,ISEC,IROUND
16  IF (IROUND.EQ.9) GO TO 2000
17  READ(ICD,9010) (TANS(I),I=1,M)
18  DO 100 I=1,N
19     DO 100 K=1,M,7
20     K6=K+6
21     IF (K6.GT.M) K6=M
22     READ (ICD,9020) ISSN(I), (ANS(I,J),J=K,K6)
23  100 CONTINUE
24  WRITE (IPR,9700) ISEC,IROUND,(J,J=1,15)
25  WRITE (IPR,9720) (ISSN(I), (ANS(I,J),J=1,15),I=1,N)
26  WRITE (IPR,9700) ISEC,IROUND,(J,J=16,M)
27  DO 150 I=1,N
28     WRITE (IPR,9720) ISSN(I), (ANS(I,J),J=16,M)
29  150 CONTINUE
30  9700 FORMAT('1:SECTION ',A1,' ROUND ',I1/
   1  '0PARTICIPANTS ANSWERS TO QUESTIONS'/
   2  ' PART ',1X,I2,8X,5(I2,6X),1X,8(I2,6X),2X,I2/)
31  9720 FORMAT(15,F7.1,F10.1,4F8.1,F9.1,7F8.1,F10.1)
32  WRITE (IPR,9140) ISEC,IROUND
33  200 WRITE (IPR,9100)
34  DO 1000 J=1,M
35     NWS=N
36     K=0
37     DO 300 I=1,N
38     IF (ANS(I,J).NE.999999.0) GO TO 250
39     NWS=NWS+1
40     GO TO 300
41  250 K=K+1
42     WS(K)=ANS(I,J)
43     IF (ISW.EQ.2) GO TO 300
44     SUMA(J)=SUMA(J)+WS(K)
45     SUMA2(J)=SUMA2(J)+WS(K)*WS(K)
46  300 CONTINUE
47     AMEAN=SUMA(J)/NWS
48     STD=(SUMA2(J)-NWS*AMEAN*AMEAN)/(NWS-1)
49     STD=SQR(STD)
50     IF (ISW.EQ.2) GO TO 650
C  BUBBLE SORT OF ANSWERS TO A QUESTION
51     DO 500 K=2,NWS
52     L=K-1
53     DO 400 I=K,NWS
54     IF (WS(I).LT.WS(L)) L=I
55  400 CONTINUE
56     TEMP=WS(K-1)
57     WS(K-1)=WS(L)
58     WS(L)=TEMP
59  500 CONTINUE
C  CALC WHICH INDEX WILL BE USED FOR LQ, MED, UQ
60     X=NWS/4.0
61     IX=NWS/4
62     R=X-IX
63     LQ=IX+1
64     MED=2*IX
65     IUQ=3*IX
66     IF (R.LT.0.1) GO TO 560

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67      IF (R.LT.0.3) GO TO 550
68      MED=MED+2
69      IUQ=IUQ+2
70      IF (R.LT.0.6) GO TO 560
71      LQ=LQ+1
72      GO TO 560
73      550 MED=MED+1
74      IUQ=IUQ+1
75      560 CONTINUE
76      ERR=ALOG(WS(MED)/TANS(J))
77      WRITE (IPR,9110) J,WS(LQ),WS(MED),WS(IUQ),TANS(J),ERR
78      FEEDBK(ROUND,J,1)=WS(LQ)
79      FEEDBK(ROUND,J,2)=WS(MED)
80      FEEDBK(ROUND,J,3)=WS(IUQ)
81      FEEDBK(ROUND,J,7)=TANS(J)
82      FEEDBK(ROUND,J,8)=ERR
83      FEEDBK(ROUND,J,14)=AMEAN
84      FEEDBK(ROUND,J,15)=STD
C      CALC CUMHULATIVE DISTRIBUTION TO PLOT AGAINST LOGNORMAL DIST.
85      DO 600 I=1,NWS
86      Y=(WS(I)-AMEAN)/STD+1
87      IF (Y.LT.YLOW) YLOW=Y
88      600 CONTINUE
89      GO TO 1000
90      650 DO 700 I=1,NWS
91      Y=(WS(I)-AMEAN)/STD-YLOW+1
92      IY=Y*10.0+0.01
93      IF (IY.GT.60) IY=61
94      IF (IY.EQ.0) IY=62
95      NORM(IY)=NORM(IY)+1
96      700 CONTINUE
97      NWST=NWST+NWS
98      1000 CONTINUE
99      IF (ISW.EQ.2) GO TO 1050
100     ISW=2
101     GO TO 220
102     1050 ICUMDS(1)=NORM(62)
103     ICUMD=NORM(62)
104     CUMPRO(1)=100.0*ICUMD/NWST
105     DO 1100 I=1,61
106     STDDEV(I)=1/10.0
107     IF (NORM(I).EQ.0) GO TO 1060
108     ICUMD=ICUMD+NORM(I)
109     ICUMDS(I+1)=ICUMD
110     CUMPRO(I+1)=100.0*ICUMD/NWST
111     GO TO 1100
112     1060 ICUMDS(I+1)=0
113     CUMPRO(I+1)=0.0
114     1100 CONTINUE
115     WRITE (IPR,9120) YLOW,(STDDEV(I),I=1,21)
116     WRITE (IPR,9130) NORM(62),(NORM(I),I=1,21)
117     WRITE (IPR,9130) (ICUMDS(I),I=1,22)
118     WRITE (IPR,9135) (CUMPRO(I),I=1,22)
119     WRITE (IPR,9136) (STDDEV(I),I=22,43)
120     WRITE (IPR,9130) (NORM(I),I=22,43)
121     WRITE (IPR,9130) (ICUMDS(I),I=23,44)
122     WRITE (IPR,9135) (CUMPRO(I),I=23,44)
123     WRITE (IPR,9125) (STDDEV(I),I=44,60)
124     WRITE (IPR,9130) (NORM(I),I=44,61)
125     WRITE (IPR,9130) (ICUMDS(I),I=45,62)
126     WRITE (IPR,9135) (CUMPRO(I),I=45,62)
127     GO TO 50
128     2000 CONTINUE
129     READ (ICD,9200) MANSW
130     IF (MANSW.EQ.1) GO TO 2500
131     DO 2400 IR=1,4
132     WRITE (IPR,9140) ISEC,IR
133     WRITE (IPR,9220)
134     DO 2200 IQ=1,30
135     READ (ICD,9210) (FEEDBK(IR,IQ,I),I=4,6)
136     FEEDBK(IR,IQ,11)=FEEDBK(IR,IQ,3)-FEEDBK(IR,IQ,1)
137     IF (FEEDBK(IR,IQ,5).EQ.0.0) GO TO 2100

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```

138      FEEDBK(IR,IQ,9) =ALOG(FEEDBK(IR,IQ,5)/FEEDBK(IR,IQ,7))
139      FEEDBK(IR,IQ,10)=FEEDBK(IR,IQ,9) -FEEDBK(IR,IQ,8)
140      FEEDBK(IR,IQ,12)=FEEDBK(IR,IQ,6) -FEEDBK(IR,IQ,4)
141      FEEDBK(IR,IQ,13)=FEEDBK(IR,IQ,12)-FEEDBK(IR,IQ,11)
142      WRITE (IPR,9230) IQ,(FEEDBK(IR,IQ,I),I=1,13)
143      GO TO 2200
144      2100      WRITE (IPR,9240) IQ,FEEDBK(IR,IQ,1),FEEDBK(IR,IQ,2),
145              1      FEEDBK(IR,IQ,3),FEEDBK(IR,IQ,7),
146              2      FEEDBK(IR,IQ,8),FEEDBK(IR,IQ,11)
147      2200 CONTINUE
148      WRITE (IPR,9140) ISEC,IR
149      WRITE (IPR,9400)
150      DO 2300 IQ=1,30
151      FEEDBK(IR,IQ,17)=FEEDBK(IR,IQ,2)-FEEDBK(1,IQ,14)
152      IF (FEEDBK(IR,IQ,17).NE.0.0)
153      1      FEEDBK(IR,IQ,17)=FEEDBK(IR,IQ,17)/FEEDBK(1,IQ,15)
154      FEEDBK(IR,IQ,16)=FEEDBK(1,IQ,17)
155      FEEDBK(IR,IQ,19)=FEEDBK(IR,IQ,7)-FEEDBK(1,IQ,14)
156      IF (FEEDBK(IR,IQ,19).NE.0.0)
157      1      FEEDBK(IR,IQ,19)=FEEDBK(IR,IQ,19)/FEEDBK(1,IQ,15)
158      IF (FEEDBK(IR,IQ,5).EQ.0.0) GO TO 2250
159      FEEDBK(IR,IQ,18)=FEEDBK(IR,IQ,5)-FEEDBK(1,IQ,14)
160      IF (FEEDBK(IR,IQ,18).NE.0.0)
161      1      FEEDBK(IR,IQ,18)=FEEDBK(IR,IQ,18)/FEEDBK(1,IQ,15)
162      FEEDBK(IR,IQ,20)=FEEDBK(IR,IQ,17)-FEEDBK(IR,IQ,16)
163      FEEDBK(IR,IQ,21)=FEEDBK(IR,IQ,18)-FEEDBK(IR,IQ,16)
164      FEEDBK(IR,IQ,22)=FEEDBK(IR,IQ,20)/FEEDBK(IR,IQ,21)*100.0
165      FEEDBK(IR,IQ,23)=(FEEDBK(IR,IQ,2)-FEEDBK(1,IQ,2))/
166      (FEEDBK(IR,IQ,5)-FEEDBK(1,IQ,2))*100.0
167      FEEDBK(IR,IQ,24)=(FEEDBK(IR,IQ,8)-FEEDBK(1,IQ,8))/
168      (FEEDBK(IR,IQ,9)-FEEDBK(1,IQ,8))*100.0
169      WRITE (IPR,9410) IQ,FEEDBK(1,IQ,2),FEEDBK(IR,IQ,2),
170      1      FEEDBK(IR,IQ,5),FEEDBK(IR,IQ,7),
171      2      (FEEDBK(IR,IQ,I),I=14,24)
172      GO TO 2300
173      2250      WRITE (IPR,9420) IQ,FEEDBK(1,IQ,2),FEEDBK(IR,IQ,2),
174      1      FEEDBK(IR,IQ,7),(FEEDBK(IR,IQ,I),I=14,17),FEEDBK(IR,IQ,19)
175      2360 CONTINUE
176      2400 CONTINUE
177      GO TO 2600
178      2500 CONTINUE
179      IR=1
180      2600 CONTINUE
181      WRITE (IPR,9140) ISEC,IR
182      WRITE (IPR,9220)
183      DO 2700 IQ=1,30
184      FEEDBK(IR,IQ,11)=FEEDBK(IR,IQ,3) -FEEDBK(IR,IQ,1)
185      WRITE (IPR,9240) IQ,FEEDBK(IR,IQ,1),FEEDBK(IR,IQ,2),
186      1      FEEDBK(IR,IQ,3),FEEDBK(IR,IQ,7),
187      2      FEEDBK(IR,IQ,8),FEEDBK(IR,IQ,11)
188      2700 CONTINUE
189      2800 CONTINUE
190      IR=IR+1
191      IF (IR.LE.4) GO TO 2600
192      IR1=1
193      IR2=2
194      IR3=3
195      IR4=4
196      DO 3900 J=1,3
197      WRITE (IPR,9300) ISEC
198      WRITE (IPR,9310)
199      K2=10*J
200      K1=K2-9
201      DO 3500 IQ=K1,K2
202      WRITE (IPR,9340) IQ,IR1,FEEDBK(1,IQ,1),FEEDBK(1,IQ,2),
203      1      FEEDBK(1,IQ,3),FEEDBK(1,IQ,7),
204      2      FEEDBK(1,IQ,8),FEEDBK(1,IQ,11)
205      IF (MANSW.EQ.1) GO TO 3300
206      IF (FEEDBK(2,IQ,5).EQ.0.0) GO TO 3300
207      WRITE (IPR,9330) IR2,(FEEDBK(2,IQ,I),I=1,13)
208      WRITE (IPR,9330) IR3,(FEEDBK(3,IQ,I),I=1,13)
209      WRITE (IPR,9330) IR4,(FEEDBK(4,IQ,I),I=1,13)

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196          GO TO 3500
197 3300 CONTINUE
198          WRITE (IPR,9350)   IR2,FEEDBK(2,IQ,1),FEEDBK(2,IQ,2),
1          FEEDBK(2,IQ,3),FEEDBK(2,IQ,7),
2          FEEDBK(2,IQ,8),FEEDBK(2,IQ,11)
199          WRITE (IPR,9350)   IR3,FEEDBK(3,IQ,1),FEEDBK(3,IQ,2),
1          FEEDBK(3,IQ,3),FEEDBK(3,IQ,7),
2          FEEDBK(3,IQ,8),FEEDBK(3,IQ,11)
200          WRITE (IPR,9350)   IR4,FEEDBK(4,IQ,1),FEEDBK(4,IQ,2),
1          FEEDBK(4,IQ,3),FEEDBK(4,IQ,7),
2          FEEDBK(4,IQ,8),FEEDBK(4,IQ,11)
201 3500 CONTINUE
202          WRITE (IPR,9300) ISEC
203          WRITE (IPR,9430)
204          DO 3800 IQ=K1,K2
205             IR=1
206             WRITE (IPR,9460) IQ,IR,FEEDBK(1,IQ,2),FEEDBK(1,IQ,2),
1             FEEDBK(1,IQ,7),(FEEDBK(1,IQ,I),I=14,17),FEEDBK(1,IQ,19)
207             IF (MANSW.EQ.1) GO TO 3600
208             IF (FEEDBK(2,IQ,5).EQ.0.0) GO TO 3600
209             WRITE (IPR,9450)   (IR,FEEDBK(1,IQ,2),FEEDBK(1,IQ,2),
1             FEEDBK(1,IQ,5),FEEDBK(1,IQ,7),
2             (FEEDBK(1,IQ,I),I=14,24),IR=2,4)
210          GO TO 3800
211 3600 CONTINUE
212          WRITE (IPR,9470)   (IR,FEEDBK(1,IQ,2),FEEDBK(1,IQ,2),
1          FEEDBK(1,IQ,7),(FEEDBK(1,IQ,I),I=14,17),FEEDBK(1,IQ,19),
2          IR=2,4)
213 3800 CONTINUE
214 3900 CONTINUE
215 8999 CONTINUE
216          WRITE (IPR,9999)
217          STOP
218 9000 FORMAT(2I4,3X,A1,3X,I1)
219 9010 FORMAT(8F10.0)
220 9020 FORMAT(14,6X,7F10.0)
221 9100 FORMAT('0QUESTION',8X,'*** STATISTICAL FEEDBACK ***      TRUE'/
1          'NUMBER ',8X,' LQ          MED          UQ          VALUE',7X,
2          'ERROR'/' ')
222 9110 FORMAT(3X,I3,3X,4F12.2,F12.4)
223 9120 FORMAT('0'/'0CUMULATIVE DISTRIBUTION FOR LOGNORMAL DISTRIBUTION',
1          ' - ALL VALUES ADJUSTED BY ',F10.3/'0 0.0',21F6.1)
224 9125 FORMAT('0',17F6.1,' 6.1AUP')
225 9130 FORMAT(' ',22I6)
226 9135 FORMAT(' ',22F6.2)
227 9136 FORMAT('0',22F6.1)
228 9140 FORMAT('1SECTION ',A1,'      ROUND ',I1)
229 9200 FORMAT(I1)
230 9210 FORMAT(10X,3F10.0)
231 9220 FORMAT('0QUEST          STATISTICAL FEEDBACK          MANIPULATED',
1          ' FEEDBACK          TRUE          TRUE MANIP      ERROR      TRUE      ',
2          ' MANIP          RANGE'/'
3          ' NO.          LQ          MED          UQ          LQ          MED',
4          '          UQ          VALUE          ERROR          ERROR DIFFER      RANGE      ',
5          ' RANGE          DIFFER'/' )
232 9230 FORMAT(' ',13,3X,7F10.2,3F7.2,3F10.2)
233 9240 FORMAT(' ',13,3X,3F10.2,30X,F10.2,F7.2,14X,F10.2)
234 9300 FORMAT('1QUESTIONS BY ROUND          SECTION ',A1)
235 9310 FORMAT('0QUEST',15X, 'STATISTICAL FEEDBACK          MANIPULATED',
1          ' FEEDBACK          TRUE          TRUE MANIP      ERROR      TRUE      ',
2          ' MANIP          RANGE'/'
3          ' NO.  ROUND',8X,'LQ',7X,'MED',8X,'UQ',8X,'LQ          MED',
4          '          UQ          VALUE          ERROR          ERROR DIFFER      RANGE      ',
5          ' RANGE          DIFFER'/' )
236 9330 FORMAT(' ', 8X,I1,2X,7F10.2,3F7.2,3F10.2)
237 9340 FORMAT('0',I3,5X,I1,2X,3F10.2,30X,F10.2,F7.2,14X,F10.2)
238 9350 FORMAT(' ', 8X,I1,2X,3F10.2,30X,F10.2,F7.2,14X,F10.2)
239 9400 FORMAT('0          * * * * * ACTUAL VALUE OF * * * * *
1          '          RI          ** STANDARDIZED VALUE OF **      A      B',
2          '          % SUCCESS'/'
3          ' QUEST          RI          MANIP.          TRUE      ',
4          ' RI          STANDARD          RI          MANIP.          TRUE      STD. DIFF',

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5      'ER (RI-R1)/(MI-R1)*100'/
6      ' NO.      MEDIAN      MEDIAN      MEDIAN      ANSWER      M',
7      'EAN      DEVIATION      MEDIAN      MEDIAN      MEDIAN      ANSWER      RI-R1      MI-',
8      'R1      STD NON-STD ERROR'//)
240    9410 FORMAT(2X,I2,2X,6F11.2,5F7.2,F6.2,3F6.1)
241    9420 FORMAT(2X,I2,2X,2F11.2,11X,3F11.2,2F7.2,7X,F7.2)
242    9430 FORMAT('OQUEST      * * * * * ACTUAL VALUE OF * * * * *',
1      '      RI      ** STANDARDIZED VALUE OF **      A      B',
2      '      % SUCCESS'//
3      ' NO.      R1      RI      MANIP.      TRUE      ',
4      'R1      STANDARD      R1      RI      MANIP.      TRUE      STD. DIFF',
5      'ER (RI-R1)/(MI-R1)*100'/
6      ' ROUND MEDIAN      MEDIAN      MEDIAN      ANSWER      M',
7      'EAN      DEVIATION      MEDIAN      MEDIAN      MEDIAN      ANSWER      RI-R1      MI-',
8      'R1      STD NON-STD ERROR'//)
243    9450 FORMAT(4X,I1,1X,6F11.2,5F7.2,F6.2,3F6.1)
244    9460 FORMAT('O',I2,I2,1X,2F11.2,11X,3F11.2,2F7.2,7X,F7.2)
245    9470 FORMAT(4X,I1,1X,2F11.2,11X,3F11.2,2F7.2,7X,F7.2)
246    9999 FORMAT('1')
247    END

```

## SECTION A      ROUND 1

## PARTICIPANTS ANSWERS TO QUESTIONS

PART	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
684	45.0	3500.0	36000.0	1700.0	280.0	1500.0	550000.0	60.09999999.0	20.0	7000.0	20000.0	75.0	27.0	104000.0	
706	10.0	2500.0	8000.0	700.0	110.0	1100.0	80000.0	30.0 10000.0	15.0	15000.0	8000.0	60.0	38.0	120000.0	
1489	1.0	2000.0	7500.0	1000.0	100.0	911.0	3000.0	36.0 20000.0	15.0	30000.0	55000.0	40.0	29.0	650000.0	
1720	10.0	9000.0	20000.0	370.0	240.0	900.0	450000.0	30.0 25000.0	20.0	6000.0	5000.0	42.0	31.0	100000.0	
1854	30.0	999999.0	43500.0	2000.0	210.0	1000.0	100000.0	108.0 42100.0	15.0	80000.0	60000.0	40.09999999.0	500000.0		
2008	10.0	3000.0	42000.0	600.0	218.0	840.0	30000.0	32.0 20000.0	18.0	48000.0	0600000.0	100.0	28.0	610000.0	
2225	15.0	100.0	10000.0	1000.0	120.0	63.0	700000.0	28.0 35000.0	30.0	65000.0	20000.0	110.0	28.0	70000.0	
2376	1.0	5000.0	2900.0	500.0	265.0	1200.0	10000.0	35.0 39600.0	23.0	45000.0	0500000.0	50.0	31.0	750000.0	
2451	1.0	2000.0	10000.0	750.0	180.0	400.0	90000.0	32.0 8500.0	13.0	29000.0	1500.0	110.0	32.0	790000.0	
2639	30.0	2500.0	9000.0	1500.0	125.0	600.0	225000.0	96.0 13000.0	18.0	38000.0	8500.0	60.0	35.0	785000.0	
2685	8.0	2500.0	25000.0	2000.0	80.0	600.0	200000.0	20.0 10000.0	18.0	12000.0	54000.0	100.0	32.0	750000.0	
2947	1.0	500.0	12000.0	4000.0	53.0	10.0	25000.0	50.0 10000.0	20.0	8000.0	25000.0	40.0	26.0	200000.0	
3217	5.0	5000.0	15000.0	1600.0	130.0	520.0	6000.0	14.0 20000.0	28.0	11000.0	4000.0	45.0	31.0	500000.0	
3497	150.0	1500.0	14000.0	1500.0	155.0	775.0	250000.0	125.0 23000.0	14.0	33000.0	9500.0	150.0	33.0	900000.0	
4015	15.0	500.0	50000.0	300.0	125.0	275.0	235000.0	45.0 75000.0	20.0	5000.0	400.0	50.0	34.0	100000.0	
4080	10.0	2000.0	35000.0	650.0	125.0	1100.0	450000.0	20.0 38000.0	12.0	20000.0	15000.0	6.2	35.0	375000.0	
5371	10.0	2000.0	7500.0	1500.0	120.0	750.0	250000.0	28.0 25000.0	4.0	5000.0	3500.0	125.0	40.0	250000.0	
5578	1.0	750.0	15000.0	10000.0	210.0	800.0	40000.0	30.0 15000.0	25.0	20000.0	0500000.0	6.0	35.0	150000.0	
5823	10.0	1500.0	20000.0	6500.0	300.0	1000.0	80000.0	200.0 60000.0	15.0	8000.0	15000.0	7.5	27.0	170000.0	
6436	1.0	2000.0	7500.0	1100.0	200.0	290.0	120000.0	28.0 11500.0	12.0	7000.0	2800.0	28.0	31.0	650000.0	
6493	10.0	2000.0	10000.0	800.0	200.0	97.0	20000.0	60.0 10000.0	15.0	30000.0	5000.0	75.0	32.0	1500000.0	
6520	25.0	3000.0	20000.0	10000.0	500.0	911.0	8000.0	20.0 15000.0	18.0	50000.0	15000.0	50.0	31.0	500000.0	
6966	15.0	1500.0	5000.0	180.0	150.0	100.0	25000.0	30.0 10000.0	15.0	7500.0	55000.0	20.0	28.0	250000.0	
7244	1.0	350.0	6450.0	1800.0	325.0	275.0	6000.0	45.0 61000.0	22.0	40000.0	2500.0	25.0	28.0	90000.0	
7366	1.0	700.0	8000.0	3000.0	120.0	845.0	200000.0	35.0 9500.0	12.0	15000.0	18000.0	35.0	28.0	700000.0	
7536	50.0	15000.0	15000.0	1500.0	63.0	1250.0	540000.0	15.0 40000.0	18.09999999.0	2500.0	20.0	25.0	800000.0		
8150	6.0	8500.0	13000.0	840.0	260.0	911.0	160000.0	28.0 64000.0	26.0	14000.0	4000.0	24.0	29.0	890000.0	
8224	20.0	1000.0	8000.0	2000.0	160.0	150.0	25000.0	30.0 12000.0	18.0	5000.0	50000.0	30.0	28.0	500000.0	
8806	1.0	5000.0	7500.0	8000.0	200.0	890.0	320000.0	20.0 10000.0	14.0	40000.0	53000.0	50.0	28.0	1200000.0	
9091*****		1000.0	18000.0	4000.0	200.0	5000.0	8000.0	110.0 1000.0	30.0	25000.0	0150000.0	70.0	34.0	200000.0	

## SECTION A ROUND 1

QUESTION NUMBER	*** STATISTICAL FEEDBACK ***			TRUE VALUE	ERROR
	LQ	MED	UQ		
1	1.00	10.00	15.00	18.00	-0.5878
2	1000.00	2000.00	3000.00	2750.00	-0.3185
3	8000.00	13000.00	20000.00	7607.00	0.5359
4	750.00	1500.00	2000.00	1549.00	-0.0321
5	120.00	180.00	218.00	151.00	0.1757
6	290.00	840.00	1000.00	834.00	0.0072
7	25000.00	100000.00	250000.00	330000.00	-1.1939
8	28.00	32.00	50.00	66.00	-0.7239
9	10000.00	20000.00	38000.00	16701.00	0.1003
10	15.00	18.00	20.00	10.00	0.5878
11	8000.00	20000.00	38000.00	39914.00	-0.6910
12	4000.00	15000.00	55000.00	984.00	2.7242
13	28.00	50.00	75.00	150.00	-1.0986
14	28.00	31.00	33.00	33.20	-0.0606
15	170000.00	500000.00	750000.00	721449.00	-0.3667
16	1.50	4.00	8.00	4.60	-0.1398
17	20.00	28.00	35.00	19.40	0.3669
18	200.00	500.00	1000.00	586.00	-0.1587
19	500.00	1000.00	1500.00	879.00	0.1290
20	3.00	4.00	6.00	7.80	-0.6678
21	500.00	780.00	7000.00	24845.00	-3.4611
22	8500.00	10000.00	28000.00	18890.00	-0.6340
23	3500.00	6000.00	8000.00	12846.00	-0.7613
24	102.00	115.00	120.00	121.00	-0.0509
25	35.00	80.00	200.00	254.00	-1.1553
26	900.00	1290.00	2000.00	1157.00	0.1038
27	12.00	25.00	40.00	59.40	-0.8654
28	1000.00	3000.00	4500.00	4144.00	-0.3230
29	400.00	700.00	1000.00	510.00	0.3167
30	75.00	200.00	300.00	117.00	0.5361

## CUMMULATIVE DISTRIBUTION FOR LOGNORMAL DISTRIBUTION - ALL VALUES ADJUSTED BY -1.435

0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1
1	0	0	0	0	2	1	1	1	3	3	12	12	15	26	32	53	52	46	97	56	64
1	0	0	0	0	3	4	5	6	9	12	24	36	51	77	109	162	214	260	357	413	477
0.11	0.00	0.00	0.00	0.00	0.34	0.45	0.56	0.67	1.01	1.35	2.70	4.05	5.74	8.66	12.26	18.22	24.07	29.25	40.16	46.46	53.66
2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3
28	43	46	23	30	27	16	14	17	13	11	22	6	14	10	5	8	13	3	5	4	7
505	548	594	617	647	674	690	704	721	734	745	767	773	787	797	802	810	823	826	831	835	842
56.81	61.64	66.82	69.40	72.78	75.82	77.62	79.19	81.10	82.56	83.80	86.28	86.95	88.53	89.65	90.21	91.11	92.58	92.91	93.48	93.93	94.71
4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5
10	2	1	3	2	3	4	5	3	0	0	0	2	2	2	0	1	1	1	1	1	1
852	854	855	858	860	863	867	872	875	0	0	0	877	879	881	0	882	889				
95.84	96.06	96.18	96.51	96.74	97.08	97.53	98.09	98.43	0.00	0.00	0.00	98.65	98.88	99.10	0.00	99.21	100.00				

## SECTION A ROUND 2

QUEST NO.	STATISTICAL FEEDBACK			MANIPULATED FEEDBACK			TRUE VALUE	TRUE ERROR	MANIP ERROR	ERROR DIFFER	TRUE RANGE	MANIP RANGE	RANGE DIFFER
	LQ	MED	UQ	LQ	MED	UQ							
1	15.00	20.00	25.00	10.00	26.00	34.00	18.00	0.11	0.37	0.26	10.00	24.00	14.00
2	2600.00	2500.00	3000.00	1900.00	3600.00	4000.00	2750.00	-0.10	0.27	0.36	1000.00	2100.00	1100.00
3	8500.00	12000.00	15000.00				7607.00	0.46			6500.00		
4	1000.00	1500.00	1700.00				1549.00	-0.03			700.00		
5	120.00	126.00	160.00	80.00	110.00	145.00	151.00	-0.18	-0.32	-0.14	40.00	65.00	25.00
6	600.00	850.00	911.00				834.00	0.02			311.00		
7	200000.00	280000.00	320000.00	100000.00	300000.00	420000.00	330000.00	-0.16	-0.10	0.07	120000.00	320000.00	200000.00
8	30.00	32.00	45.00				66.00	-0.72			15.00		
9	10000.00	13000.00	20000.00	10000.00	11000.00	15000.00	16701.00	-0.25	-0.42	-0.17	10000.00	5000.00	-5000.00
10	11.00	15.00	18.00	7.00	8.00	18.00	10.00	0.41	-0.22	-0.63	7.00	11.00	4.00
11	24000.00	30000.00	36000.00	20000.00	42000.00	50000.00	39914.00	-0.29	0.05	0.34	12000.00	30000.00	18000.00
12	4000.00	8000.00	18000.00				984.00	2.10			14000.00		
13	45.00	50.00	65.00				150.00	-1.10			20.00		
14	31.00	32.00	35.00	31.00	39.00	41.00	33.20	-0.04	0.16	0.20	4.00	10.00	6.00
15	650000.00	750000.00	800000.00	600000.00	900000.00	950000.00	721449.00	0.04	0.22	0.18	150000.00	350000.00	200000.00
16	2.00	4.00	5.00				4.60	-0.14			3.00		
17	30.00	33.00	40.00	28.00	40.00	52.00	19.40	0.53	0.72	0.19	10.00	24.00	14.00
18	300.00	400.00	600.00				586.00	-0.38			300.00		
19	500.00	750.00	1000.00	400.00	500.00	800.00	879.00	-0.16	-0.56	-0.41	500.00	400.00	-100.00
20	3.00	4.00	6.00				7.80	-0.67			3.00		
21	10000.00	15000.00	18000.00	10000.00	18000.00	20000.00	24845.00	-0.50	-0.32	0.18	8000.00	10000.00	2000.00
22	15000.00	16000.00	20000.00	16000.00	20000.00	28000.00	18090.00	-0.05	0.06	0.11	5000.00	12000.00	7000.00
23	5000.00	7000.00	8000.00				12846.00	-0.61			3000.00		
24	112.00	118.00	122.00	120.00	130.00	133.00	121.00	-0.03	0.07	0.10	10.00	13.00	3.00
25	65.00	100.00	170.00				254.00	-0.93			105.00		
26	720.00	1000.00	1290.00	600.00	700.00	1200.00	1157.00	-0.15	-0.50	-0.36	570.00	600.00	30.00
27	15.00	22.00	30.00				59.40	-0.99			15.00		
28	3500.00	4000.00	4800.00	3000.00	4800.00	5200.00	4144.00	-0.04	0.15	0.18	1300.00	2200.00	900.00
29	500.00	700.00	900.00				510.00	0.32			400.00		
30	100.00	200.00	250.00				117.00	0.54			150.00		

## SECTION A ROUND 2

QUEST NO.	***** ACTUAL VALUE OF *****				RI		** STANDARDIZED VALUE OF **				A		B		% SUCCESS		
	RI MEDIAN	RI MEDIAN	MANIP. MEDIAN	TRUE ANSWER	RI MEAN	STANDARD DEVIATION	RI MEDIAN	RI MEDIAN	MANIP. MEDIAN	TRUE ANSWER	STD. RI-RI	DIFFER MI-RI	STD. RI-RI	DIFFER MI-RI	(RI-RI)/(MI-RI)*100	STD	NON-STD ERROR
1	10.00	20.00	26.00	18.00	19.93	9.26	-0.24	0.10	0.31	0.03	0.35	0.56	62.5	62.5	72.5		
2	2000.00	2500.00	3600.00	2750.00	2405.00	884.19	-0.30	-0.15	0.20	-0.07	0.16	0.50	31.3	31.3	38.0		
3	13000.00	12000.00		7607.00	13093.33	7378.10	-0.30	-0.38		-0.73							
4	1500.00	1500.00		1549.00	1398.33	698.21	-0.32	-0.32		-0.31							
5	180.00	126.00	110.00	151.00	142.57	46.09	-0.04	-0.63	-0.81	-0.36	-0.59	-0.76	77.1	77.1	72.4		
6	840.00	850.00		834.00	807.50	284.62	0.01	0.02		-0.00							
7	100000.00	280000.00	300000.00	330000.00	272516.60	104311.40	-0.38	0.55	0.66	0.81	0.93	1.04	90.0	90.0	93.7		
8	32.00	32.00		66.00	35.47	13.29	-0.39	-0.39		0.44							
9	20000.00	13000.00	11000.00	16701.00	15672.41	7242.27	-0.27	-0.63	-0.73	-0.44	-0.36	-0.46	77.8	77.8	72.1		
10	18.00	15.00	8.00	10.00	14.87	4.36	-0.02	-0.54	-1.74	-1.40	-0.52	-1.73	30.0	30.0	22.5		
11	20000.00	30000.00	42000.00	39914.00	29827.59	12845.30	-0.24	0.27	0.88	0.77	0.51	1.12	45.5	45.5	54.6		
12	15000.00	8000.00		984.00	15210.00	16505.19	-0.38	-0.42		-0.47							
13	50.00	50.00		150.00	56.70	22.79	-0.13	-0.13		2.59							
14	31.00	32.00	39.00	33.20	32.27	3.42	0.05	0.32	2.26	0.66	0.28	2.21	12.5	12.5	13.8		
15	500000.00	750000.00	900000.00	721449.00	710633.00	190367.80	-0.02	0.67	1.08	0.59	0.69	1.10	62.5	62.5	69.0		
16	4.00	4.00		4.60	3.86	2.52	-0.09	-0.09		0.07							
17	28.00	33.00	40.00	19.40	35.70	10.66	-0.12	0.18	0.60	-0.64	0.30	0.72	41.7	41.7	46.1		
18	500.00	400.00		586.00	469.43	302.82	-0.29	-0.35		-0.24							
19	1000.00	750.00	500.00	879.00	898.83	638.23	-0.29	-0.50	-0.71	-0.39	-0.21	-0.42	50.0	50.0	41.5		
20	4.00	4.00		7.80	4.92	2.25	-0.25	-0.25		0.05							
21	780.00	15000.00	18000.00	24845.00	16344.53	15606.57	-0.46	0.31	0.48	0.85	0.78	0.94	82.6	82.6	94.2		
22	10000.00	18000.00	20000.00	18890.00	18950.00	7243.61	-0.50	-0.06	0.05	-0.01	0.44	0.55	80.0	80.0	84.8		
23	6000.00	7000.00		12846.00	6736.66	3426.32	-0.20	0.00		1.18							
24	115.00	118.00	130.00	121.00	116.63	7.00	0.21	0.65	2.40	1.09	0.44	2.19	20.0	20.0	21.0		
25	80.00	100.00		254.00	215.00	397.81	-0.40	-0.36		-0.07							
26	1290.00	1000.00	700.00	1157.00	1140.37	540.87	-0.26	-0.53	-0.82	-0.38	-0.28	-0.56	49.2	49.2	41.7		
27	25.00	22.00		59.40	24.61	12.53	-0.30	-0.38		0.52							
28	3000.00	4000.00	4800.00	4144.00	3873.33	1331.10	-0.02	0.43	0.80	0.50	0.46	0.83	55.6	55.6	61.2		
29	700.00	700.00		510.00	698.33	226.85	0.09	0.09		-0.47							
30	260.00	200.00		117.00	195.67	117.39	-0.13	-0.13		-0.49							



QUESTIONS BY ROUND

SECTION A

QUEST NO.	ROUND	STATISTICAL FEEDBACK			MANIPULATED FEEDBACK			TRUE VALUE	TRUE ERROR	MANIP ERROR	ERROR DIFFER	TRUE RANGE	MANIP RANGE	RANGE DIFFER
		LQ	MED	UQ	LQ	MED	UQ							
1	1	1.00	10.00	15.00				18.00	-0.59			14.00		
	2	15.00	20.00	25.00	10.00	26.00	34.00	18.00	0.11	0.37	0.26	10.00	24.00	14.00
	3	18.00	22.00	26.00	21.00	26.00	32.00	18.00	0.20	0.37	0.17	8.00	11.00	3.00
	4	20.00	24.00	26.00	23.00	24.00	31.00	18.00	0.29	0.29	0.00	6.00	8.00	2.00
2	1	1000.00	2000.00	3000.00				2750.00	-0.32			2000.00		
	2	2000.00	2500.00	3000.00	1900.00	3600.00	4000.00	2750.00	-0.10	0.27	0.36	1000.00	2100.00	1100.00
	3	2000.00	2500.00	3500.00	3500.00	3600.00	3800.00	2750.00	-0.10	0.27	0.36	1500.00	300.00	-1200.00
	4	2000.00	2500.00	3500.00	3500.00	3600.00	3800.00	2750.00	0.09	0.27	0.18	1500.00	300.00	-1200.00
3	1	8000.00	13000.00	20000.00				7607.00	0.54			12000.00		
	2	8500.00	12000.00	15000.00				7607.00	0.46			6500.00		
	3	9000.00	12000.00	14000.00				7607.00	0.46			5000.00		
	4	9000.00	12000.00	13000.00				7607.00	0.46			4000.00		
4	1	750.00	1500.00	2000.00				1549.00	-0.03			1250.00		
	2	1000.00	1500.00	1700.00				1549.00	-0.03			700.00		
	3	1000.00	1500.00	1500.00				1549.00	-0.03			500.00		
	4	1000.00	1500.00	1500.00				1549.00	-0.03			500.00		
5	1	120.00	180.00	210.00				151.00	0.18			98.00		
	2	120.00	126.00	160.00	80.00	110.00	145.00	151.00	-0.18	-0.32	-0.14	40.00	65.00	25.00
	3	115.00	125.00	130.00	100.00	115.00	130.00	151.00	-0.19	-0.27	-0.08	15.00	30.00	15.00
	4	115.00	120.00	130.00	100.00	115.00	120.00	151.00	-0.23	-0.27	-0.04	15.00	20.00	5.00
6	1	290.00	640.00	1000.00				834.00	0.01			710.00		
	2	600.00	850.00	911.00				834.00	0.02			311.00		
	3	760.00	850.00	911.00				834.00	0.02			151.00		
	4	800.00	850.00	911.00				834.00	0.02			111.00		
7	1	25000.00	100000.00	250000.00				330000.00	-1.19			225000.00		
	2	200000.00	280000.00	320000.00	100000.00	300000.00	420000.00	330000.00	-0.16	-0.10	0.07	120000.00	320000.00	200000.00
	3	280000.00	300000.00	330000.00	280000.00	330000.00	400000.00	330000.00	-0.10	0.00	0.10	50000.00	120000.00	70000.00
	4	300000.00	310000.00	330000.00	310000.00	330000.00	380000.00	330000.00	-0.06	0.00	0.06	30000.00	70000.00	40000.00
8	1	28.00	32.00	50.00				66.00	-0.72			22.00		
	2	30.00	32.00	45.00				66.00	-0.72			15.00		
	3	30.00	32.00	40.00				66.00	-0.72			10.00		
	4	30.00	32.00	35.00				66.00	-0.72			8.00		
9	1	10000.00	20000.00	38000.00				16701.00	0.18			28000.00		
	2	10000.00	13000.00	20000.00	10000.00	11000.00	15000.00	16701.00	-0.25	-0.42	-0.17	10000.00	5000.00	-5000.00
	3	10000.00	12500.00	15000.00	10000.00	11500.00	13000.00	16701.00	-0.29	-0.37	-0.08	5000.00	3000.00	-2000.00
	4	10000.00	12000.00	15000.00	10000.00	11500.00	12500.00	16701.00	-0.33	-0.37	-0.04	5000.00	2500.00	-2500.00
10	1	15.00	18.00	20.00				10.00	0.59			5.00		
	2	11.00	15.00	18.00	7.00	8.00	18.00	10.00	0.41	-0.22	-0.63	7.00	11.00	4.00
	3	10.00	12.00	15.00	7.00	8.00	10.00	10.00	0.18	-0.22	-0.41	5.00	3.00	-2.00
	4	10.00	12.00	15.00	7.00	9.00	9.00	10.00	0.18	-0.11	-0.29	5.00	2.00	-3.00

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$JOB      (11646316), 'BRADLEY NELSON      ', LINES=60, PAGES=80, TIME=200
1      INTEGER A(30,70), W(5)
2      DIMENSION IPART(30), IFREQ(4,70,5), XNDEX(4,70),
1      STD(4,70), MFREQ(4,70,5), YNDEX(4,70), RIR1(4,70),
2      YIR1(4,70), SUC(4,70), DI(70), DIR1(4,70)
3      DATA IFREQ/1400*0/, YNDEX/280*0.0/, MFREQ/1400*0/
4      ICD=5
5      IPR=6
C      ** READ DESIRED INDEX **
6      READ (ICD,9030) (DI(IQ), IQ=1,50)
C      ** READ START CARD **
7      100 READ(ICD,9000) NP,NQ,IM,IR,IEND
C      ** READ DETAIL INPUT **
8      DO 150 IF=1,NP
9      READ(ICD,9010) IPART(IP), (A(IP,IQ), IQ=1,NQ)
10     150 CONTINUE
C      ** WRITE DETAIL REPORT **
11     JQ=1
12     KQ=40
13     200 CONTINUE
14     IF (KQ.GT.NQ) KQ=NQ
15     WRITE(IPR,9100) IM,IR
16     WRITE(IPR,9110) (I,I=JQ,KQ)
17     DO 300 II=1,NP
18     WRITE(IPR,9120) IPART(IP), (A(IP,IQ), IQ=JQ,KQ)
19     300 CONTINUE
20     IF (KQ.EQ.NQ) GO TO 1000
21     JQ=JQ+40
22     KQ=KQ+40
23     GO TO 200
24     1000 CONTINUE
25     WRITE(IPR,9200) IM,IR
C      ** CALC. FREQ DIST, INDEX, & STD DEV **
26     DO 1500 IQ=1,NQ
27     DO 1100 IP=1,NP
28     IFREQ(IR,IQ,A(IP,IQ))=IFREQ(IR,IQ,A(IP,IQ))+1
29     1100 CONTINUE
30     XNDEX(IR,IQ)=(1*IFREQ(IR,IQ,1)+2*IFREQ(IR,IQ,2)+
1     3*IFREQ(IR,IQ,3)+4*IFREQ(IR,IQ,4)+
2     5*IFREQ(IR,IQ,5))*1.0/NP
31     SUM=0.0
32     I=5
33     DO 1200 IF=1,5
34     X=IF-XNDEX(IR,IQ)
35     SUM=X*X*IFREQ(IR,IQ,IF)+SUM
36     1200 CONTINUE
37     STD(IR,IQ)=SQRT(SUM/NP)
C      ** WRITE INDIVIDUAL ROUND REPORT **
38     1 WRITE(IPR,9220) IQ,(IFREQ(IR,IQ,IF), IF=1,5), STD(IR,IQ),
XNDEX(IR,IQ)
39     1500 CONTINUE
40     IF (IEND.EQ.0) GO TO 100
41     2000 CONTINUE
42     READ(ICD,9000) NP,NQ,IM,IR,IEND,NM
43     IF (IEND.EQ.8) GO TO 8999
C      ** READ MANIPULATED FREQUENCIES **
44     DO 2050 I=1,NM
45     READ(ICD,9020) IQ,(W(IF), IF=1,5)
46     DO 2040 IF=1,5
47     MFREQ(IR,IQ,IF)=W(IF)

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48 2040 CONTINUE
C      ** CALC INDEX FOR MANIP FREQ **
49      YNDEX(IR,IQ)=(1*W(1)+2*W(2)+3*W(3)+4*W(4)+5*W(5))*1.0/NP
50 2050 CONTINUE
C      ** WRITE VALUE STATEMENT STATISTICS RPT **
51      WRITE(IPR,9300) IM,IR
52      DO 2300 IQ=1,NQ
53          RIR1(IR,IQ)=XNDEX(IR,IQ)-XNDEX(1,IQ)
54          IF (YNDEX(IR,IQ).EQ.0.0) GO TO 2200
55          YIR1(IR,IQ)=YNDEX(IR,IQ)-XNDEX(1,IQ)
56          DIR1(IR,IQ)=DI(IQ)-XNDEX(1,IQ)
57          SUC(IR,IQ)=RIR1(IR,IQ)/DIR1(IR,IQ)*100.0
58          WRITE(IPR,9320) IQ,(IFREQ(1,IQ,IF),IF=1,5),
1              (IFREQ(IR,IQ,IF),IF=1,5),(MFREQ(IR,IQ,IF),IF=1,5),
2              STD(IR,IQ),XNDEX(1,IQ),XNDEX(IR,IQ),YNDEX(IR,IQ),
3              DI(IQ),RIR1(IR,IQ),YIR1(IR,IQ),DIR1(IR,IQ),
4              SUC(IR,IQ)
59      GO TO 2300
60 2200 CONTINUE
61      WRITE(IPR,9330) IQ,(IFREQ(1,IQ,IF),IF=1,5),
1          (IFREQ(IR,IQ,IF),IF=1,5),STD(IR,IQ),XNDEX(1,IQ),
2          XNDEX(IR,IQ),RIR1(IR,IQ)
62 2300 CONTINUE
63      IF (IEND.NE.9) GO TO 2000
C      ** WRITE VALUE STATEMENT STATISTICS BY ROUND RPT **
64      NR=IR
65      ICTR=60
66      DO 3300 IQ=1,NQ
67          ICTR=ICTR+NR+1
68          IF (ICTR.LE.60) GO TO 3000
69          WRITE(IPR,9400) IM
70          ICTR=5+NR
71 3000      WRITE(IPR,9420) IQ,(IFREQ(1,IQ,IF),IF=1,5),STD(1,IQ),
1          XNDEX(1,IQ)
72      DO 3200 IR=2,NR
73          IF (YNDEX(IR,IQ).EQ.0.0) GO TO 3100
74          WRITE (IPR,9430) IR,(IFREQ(IR,IQ,IF),IF=1,5),
1              (MFREQ(IR,IQ,IF),IF=1,5),STD(IR,IQ),XNDEX(IR,IQ),
2              YNDEX(IR,IQ),DI(IQ),RIR1(IR,IQ),YIR1(IR,IQ),
3              DIR1(IR,IQ),SUC(IR,IQ)
75      GO TO 3200
76 3100      CONTINUE
77      WRITE (IPR,9440) IR,(IFREQ(IR,IQ,IF),IF=1,5),STD(IR,IQ),
1          XNDEX(IR,IQ),RIR1(IR,IQ)
78 3200      CONTINUE
79 3300 CONTINUE
80 8999 CONTINUE
81      WRITE (IPR,9900)
82      STOP
83 9000 FORMAT(2I3,2X,A1,3I3)
84 9010 FORMAT(I4,6X,70I1)
85 9020 FORMAT(6I3)
86 9030 FORMAT(BF10.2)
87 9100 FORMAT('1PARTICIPANTS ANSWERS TO VALUE DELPHI STATEMENTS - ',
1          'SECTION ',A1,3X,'ROUND ',I1)
88 9110 FORMAT('OPART. ',40I3/)
89 9120 FORMAT(1X,I4,2X,40I3)
90 9200 FORMAT('1FREQUENCY DISTRIBUTIONS OF VALUE DELPHI STATEMENTS - ',
1          'SECTION ',A1,3X,'ROUND ',I1/
2          'STATE. - FREQUENCY - STD.'/
3          ' NO. 1 2 3 4 5 DEV. INDEX'/)
91 9220 FORMAT(2X,I2,3X,5I3,2X,F6.2,F7.2)
92 9300 FORMAT('1VALUE STATEMENT STATISTICS - SECTION ',A1,3X,'ROUND ',I1/
1          'STATE. -- ROUND 1 -- -- ROUND I -- MANIPULATED ',
2          ' RI RI RI MANIP DESIRED ',
3          ' %'/
4          ' NO. 1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 ',
5          'STD DEV INDEX INDEX INDEX INDEX RI-R1 MI-R1 DI-R1 SUC',
6          'CESS'/)
93 9320 FORMAT(2X,I2,3X,3(SI3,1X),F7.2,1X,3F6.2,1X,F6.2,1X,3F6.2,F7.1)
94 9330 FORMAT(2X,I2,3X,2(SI3,1X),14X,F7.2,1X,2F6.2,14X,F6.2)
95 9400 FORMAT('1VALUE STATEMENT STATISTICS BY ROUND - SECTION ',A1/
1          'STATE. -- ROUND I -- MANIPULATED RI R',
2          ' I MANIP DESIRED %'/
3          ' NO. ROUND 1 2 3 4 5 1 2 3 4 5 STD DEV IND',
4          ' EX INDEX INDEX INDEX INDEX RI-R1 MI-R1 DI-R1 SUCCESS')
96 9420 FORMAT('0 ',I2,5X,'1 ',5I3,18X,F6.2,1X,F6.2)
97 9430 FORMAT(9X,I1,2X,2(SI3,1X),2F7.2,F6.2,1X,F6.2,1X,3F6.2,F7.1)
98 9440 FORMAT(9X,I1,2X,5I3,18X,F6.2,1X,F6.2,14X,F6.2)
99 9900 FORMAT('1')
100      END

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PARTICIPANTS ANSWERS TO VALUE DELPHI STATEMENTS - SECTION A ROUND 1

PART.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
411	3	3	4	1	2	4	3	4	2	2	3	4	5	3	2	5	4	4	3	1	1	5	3	4	3	2	4	3	5	3	2	2	2	2	1	3	3	3	4	4	1
723	4	4	3	3	4	4	2	3	4	3	3	4	4	4	4	5	4	3	3	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	
807	3	4	4	3	4	4	2	4	4	3	3	2	4	3	4	3	3	5	3	3	3	3	2	3	2	3	4	4	3	3	2	1	4	3	4	5	4	3	4	4	
859	4	5	3	4	3	5	2	4	2	4	4	5	5	3	4	4	4	2	3	5	3	4	5	3	4	1	5	5	5	4	5	4	5	1	3	3	5	5	5	2	
1078	4	2	3	1	5	4	1	3	4	3	1	4	3	2	1	4	2	3	1	1	1	5	3	4	3	2	2	2	5	1	4	5	5	3	1	1	2	5	5	1	
1489	3	2	2	2	4	4	2	3	4	3	3	3	3	3	3	3	4	4	4	3	2	4	3	4	4	2	3	3	4	1	3	4	3	2	2	3	3	4	4	2	
1720	3	3	2	3	2	3	3	3	4	3	4	3	4	4	3	3	3	2	5	3	2	3	3	3	3	3	3	3	4	3	4	3	2	3	3	3	3	4	4	3	
1928	4	3	4	3	4	4	5	3	4	3	3	4	5	5	4	4	3	3	2	4	4	4	5	3	4	4	5	4	5	4	5	4	4	5	4	3	4	4	5	4	
2008	3	3	4	5	4	5	3	5	1	3	3	4	5	4	5	5	5	5	5	5	5	5	4	4	5	2	5	3	5	4	5	4	4	5	4	3	4	4	5	4	
2376	3	4	4	4	3	5	2	3	2	1	5	3	4	4	3	4	5	3	5	5	1	3	4	1	4	2	1	3	3	4	2	4	4	2	2	3	5	5	4	1	
2451	3	4	4	3	5	5	2	4	5	4	4	3	5	3	2	5	4	5	2	2	2	5	4	3	3	3	5	5	5	3	5	3	5	3	5	3	5	5	4	1	
2639	3	4	2	3	4	4	3	5	4	2	3	3	5	2	4	3	3	4	4	4	3	4	5	4	5	3	3	4	4	4	4	4	4	4	3	3	4	4	4	3	
2685	2	3	2	1	1	4	3	4	2	2	3	2	3	3	3	4	3	4	4	3	2	5	3	3	4	2	4	3	4	2	3	2	5	2	2	3	4	4	3	3	
3497	4	3	3	3	5	5	1	4	2	3	4	4	5	4	3	4	2	3	4	4	3	4	3	5	5	3	4	4	4	2	3	2	5	2	2	3	4	4	3	3	
3507	4	3	5	3	5	4	2	3	4	3	5	4	5	5	5	5	4	4	4	5	4	3	5	5	3	4	4	4	5	5	4	4	5	4	3	3	3	5	2	4	
3874	4	3	2	3	3	5	3	2	4	2	4	4	3	3	4	3	4	3	3	3	3	4	2	2	3	2	4	4	4	4	3	2	3	4	4	4	3	3	4	4	
5371	3	4	4	2	3	5	2	5	3	2	2	5	5	2	2	3	3	2	3	2	3	2	3	3	3	2	4	4	5	4	4	5	4	3	3	3	3	4	4	3	
5533	1	1	2	1	4	3	1	4	4	3	3	2	4	4	2	5	4	1	4	2	2	2	4	4	4	3	2	1	5	1	2	1	4	4	2	2	4	1	5	1	
6493	4	5	3	4	5	3	2	5	5	2	3	3	2	2	2	2	3	2	2	5	4	1	4	4	4	3	2	1	5	1	2	1	4	4	2	2	4	1	5	1	
6520	4	3	4	5	4	4	4	4	4	4	5	5	5	4	5	5	5	5	5	4	4	4	4	4	4	4	5	5	4	4	3	4	4	4	4	4	3	3	4	5	
6548	4	5	5	4	5	5	5	4	4	5	5	4	4	3	3	4	4	5	3	4	3	5	5	3	5	4	5	4	5	5	5	4	5	4	3	4	5	5	4	5	
6604	5	4	4	3	5	4	4	5	4	4	3	5	5	3	5	4	5	5	3	5	4	4	5	4	4	2	3	2	4	2	3	4	5	3	4	4	4	4	5	4	
7366	2	4	5	3	5	4	1	3	5	3	1	2	4	2	2	4	1	5	5	2	1	4	3	2	4	2	3	4	5	1	5	4	2	5	3	4	4	4	3	2	
8224	1	3	3	2	2	3	2	3	2	2	3	2	3	2	4	3	4	3	5	2	3	4	4	2	3	1	4	4	3	4	3	3	4	2	4	3	4	4	4	3	
8783	3	4	3	3	4	5	1	4	4	2	5	4	4	3	2	4	5	5	5	2	1	5	4	5	5	2	5	4	5	5	4	4	5	3	2	3	4	4	5	3	
8985	4	5	4	3	4	5	3	5	4	3	3	3	4	2	2	3	4	4	3	4	3	5	4	4	5	3	4	5	5	3	4	3	3	3	4	4	4	5	3		
9091	4	4	4	3	5	5	3	4	4	3	4	4	4	3	4	3	3	4	4	5	4	4	4	4	4	3	4	3	5	4	4	5	4	3	3	4	4	4	5		
9164	3	4	4	3	5	4	5	5	3	3	3	3	5	4	4	3	3	5	4	4	4	4	5	3	5	3	5	3	5	2	4	3	5	4	3	3	5	4	4		
9481	3	4	4	3	3	4	4	4	3	4	3	4	3	5	3	3	2	3	5	4	3	4	5	3	4	3	4	4	4	4	3	4	4	3	3	3	4	5	4		
9710	2	4	3	2	3	4	3	4	3	3	2	2	5	3	3	4	2	2	4	4	2	4	4	3	4	3	4	4	4	4	2	2	2	3	3	3	2	3	5	3	

## FREQUENCY DISTRIBUTIONS OF VALUE DELPHI STATEMENTS - SECTION A ROUND 1

STATE. NO.	- FREQUENCY -					STD. DEV.	INDEX
1	2	3	12	12	1	0.92	3.23
2	1	2	10	13	4	0.92	3.57
3	0	6	8	13	3	0.92	3.43
4	4	4	16	4	2	1.02	2.87
5	1	3	6	10	10	1.10	3.83
6	0	0	4	15	11	0.67	4.23
7	5	10	9	3	3	1.17	2.63
8	0	1	9	13	7	0.81	3.87
9	1	6	4	16	3	1.02	3.47
10	1	8	14	6	1	0.85	2.93
11	2	2	15	6	5	1.04	3.33
12	0	6	9	11	4	0.96	3.43
13	0	1	5	10	14	0.84	4.23
14	0	7	13	8	2	0.86	3.17
15	1	8	8	9	4	1.09	3.23
16	0	2	10	11	7	0.88	3.77
17	1	3	10	11	5	0.99	3.53
18	1	5	7	7	10	1.19	3.67
19	1	3	9	10	7	1.05	3.63
20	2	5	6	9	8	1.23	3.53
21	5	7	9	8	1	1.12	2.77
22	0	3	4	13	10	0.93	4.00
23	0	1	10	12	7	0.82	3.83
24	1	4	12	11	2	0.90	3.30
25	0	0	9	13	8	0.75	3.97
26	2	11	12	5	0	0.83	2.67
27	1	3	4	13	9	1.06	3.87
28	1	3	9	11	6	1.02	3.60
29	0	0	2	12	16	0.62	4.47
30	4	5	7	9	5	1.28	3.20
31	0	5	9	9	7	1.02	3.60
32	1	4	9	13	3	0.96	3.43
33	0	3	5	11	11	0.97	4.00
34	1	5	12	9	3	0.96	3.27
35	2	7	13	8	0	0.87	2.90
36	1	2	19	6	2	0.79	3.20
37	0	1	9	12	8	0.83	3.90
38	1	2	1	14	12	0.99	4.13
39	0	0	6	13	11	0.73	4.17
40	4	8	10	6	2	1.11	2.80
41	0	3	6	14	7	0.90	3.83
42	0	4	11	10	5	0.92	3.53
43	3	6	14	7	0	0.90	2.83
44	9	6	8	6	1	1.20	2.47
45	0	2	5	18	5	0.76	3.87
46	0	7	10	9	4	0.98	3.33
47	1	3	16	9	1	0.79	3.20
48	5	6	10	5	4	1.25	2.90
49	1	10	1	17	1	1.05	3.23
50	1	2	12	5	10	1.10	3.70

VALUE STATEMENT STATISTICS - SECTION A ROUND 2

STATE. NO.	-- ROUND 1 --					-- ROUND 1 --					MANIPULATED					RI STD DEV	R1 INDEX	RI INDEX	MANIP INDEX	DESIRED INDEX	RI-R1	MI-R1	DI-R1	% SUCCESS
1	2	3	12	12	1	3	8	12	6	1	5	15	7	2	1	0.98	3.23	2.80	2.30	2.70	-0.43	-0.93	-0.53	81.3
2	1	2	10	13	4	0	0	14	15	1						0.56	3.57	3.57			0.00			
3	0	6	8	13	3	0	6	11	13	0						0.76	3.43	3.23			-0.20			
4	4	4	16	4	2	3	7	17	2	1						0.86	2.87	2.70			-0.17			
5	1	3	6	10	10	0	4	11	9	6	3	8	14	2	3	0.96	3.83	3.57	2.80	3.00	-0.27	-1.03	-0.83	32.0
6	0	0	4	15	11	0	0	2	19	9						0.56	4.23	4.23			0.00			
7	5	10	9	3	3	5	14	6	4	1						1.02	2.63	2.40			-0.23			
8	0	1	9	13	7	0	3	12	15	0	3	9	15	2	1	0.66	3.87	3.40	2.63	3.20	-0.47	-1.23	-0.67	70.0
9	1	6	4	16	3	0	6	7	15	2						0.88	3.47	3.43			-0.03			
10	1	8	14	6	1	0	9	16	5	0						0.67	2.93	2.87			-0.07			
11	2	2	15	6	5	2	3	10	11	4	1	1	5	12	11	1.05	3.33	3.40	4.03	3.70	0.07	0.70	0.37	18.2
12	0	6	9	11	4	0	1	9	17	3	0	2	6	9	13	0.68	3.45	3.73	4.10	4.10	0.30	0.67	0.67	45.0
13	0	1	5	10	14	0	0	4	16	10						0.65	4.23	4.20			-0.03			
14	0	7	13	8	2	0	7	14	9	0						0.73	3.17	3.07			-0.10			
15	1	8	8	9	4	1	8	7	12	2						1.01	3.25	3.20			-0.03			
16	0	2	10	11	7	0	3	15	10	2	2	10	12	4	2	0.75	3.77	3.37	2.80	3.00	-0.40	-0.97	-0.77	52.2
17	1	3	10	11	5	1	5	9	11	4						1.02	3.53	3.40			-0.13			
18	1	5	7	7	10	1	4	7	7	11						1.17	3.67	3.77			0.10			
19	1	3	9	10	7	1	2	9	14	4						0.92	3.63	3.60			-0.03			
20	2	5	6	9	8	1	3	7	13	6						1.01	3.53	3.67			0.13			
21	5	7	9	8	1	4	8	13	5	0						0.91	2.77	2.63			-0.13			
22	0	3	4	13	10	0	1	2	16	11						0.72	4.00	4.23			0.23			
23	0	1	10	12	7	1	2	10	11	6	2	8	12	5	3	0.98	3.83	3.63	2.97	3.10	-0.20	-0.87	-0.73	27.3
24	1	4	12	11	2	0	4	12	14	0						0.70	3.30	3.33			0.03			
25	0	0	9	13	8	0	0	6	19	5						0.60	3.97	3.97			0.00			
26	2	11	12	5	0	2	12	15	1	0						0.67	2.67	2.50			-0.17			
27	1	3	4	13	9	0	4	7	16	3	4	9	10	5	2	0.84	3.87	3.60	2.73	3.10	-0.27	-1.13	-0.77	34.8
28	1	3	9	11	6	0	3	11	12	4						0.84	3.60	3.57			-0.03			
29	0	0	2	12	16	0	0	0	15	15						0.50	4.47	4.50			0.03			
30	4	5	7	9	5	4	2	10	13	1						1.07	3.20	3.17			-0.03			
31	0	5	9	9	7	0	6	12	8	4	3	11	9	5	2	0.94	3.60	3.33	2.73	3.00	-0.27	-0.87	-0.60	44.4
32	1	4	9	13	3	1	1	13	14	1						0.76	3.43	3.43			0.00			
33	0	3	5	11	11	0	2	12	10	6	0	11	12	4	3	0.87	4.00	3.67	2.97	3.20	-0.33	-1.03	-0.80	41.7
34	1	5	12	9	3	0	7	17	5	1						0.73	3.27	3.00			-0.27			
35	2	7	13	8	0	2	7	16	5	0						0.79	2.90	2.80			-0.10			
36	1	2	19	6	2	1	1	21	6	1						0.69	3.20	3.17			-0.03			
37	0	1	9	12	8	0	2	7	15	6						0.82	3.90	3.83			-0.07			
38	1	2	1	14	12	1	6	6	11	6	5	12	8	3	2	1.12	4.13	3.50	2.50	3.40	-0.63	-1.63	-0.73	86.4
39	0	0	6	13	11	0	0	2	17	11						0.59	4.17	4.30			0.13			
40	4	8	10	6	2	4	9	14	2	1						0.92	2.80	2.57			-0.23			
41	0	3	6	14	7	0	2	10	13	5	3	9	11	4	3	0.82	3.63	3.70	2.83	3.20	-0.13	-1.00	-0.63	21.1
42	0	4	11	10	5	0	3	15	10	2						0.75	3.53	3.37			-0.17			
43	3	6	14	7	0	2	7	18	2	1						0.80	2.63	2.77			-0.07			
44	9	6	8	6	1	7	6	7	10	0	2	5	8	11	4	1.16	2.47	2.67	3.33	3.10	0.20	0.87	0.63	31.6
45	0	2	5	18	5	0	0	6	19	5						0.60	3.67	3.97			0.10			
46	0	7	10	9	4	0	9	16	4	1	4	11	10	4	1	0.75	3.33	2.90	2.57	2.80	-0.43	-0.77	-0.53	81.3
47	1	3	16	9	1	1	2	16	10	1						0.77	3.20	3.27			0.07			
48	5	6	10	5	4	6	5	16	3	0						0.92	2.90	2.53			-0.37			
49	1	10	1	17	1	0	13	9	8	0	2	17	5	5	1	0.82	3.23	2.83	2.53	2.60	-0.40	-0.70	-0.63	63.2
50	1	2	12	5	10	1	0	15	7	7						0.95	3.70	3.63			-0.07			

## VALUE STATEMENT STATISTICS BY ROUND - SECTION A

STATE. NO.	ROUND	-- ROUND I --					MANIPULATED					RI STD DEV	RI INDEX	MANIP INDEX	DESIRED INDEX	RI-R1	MI-R1	DI-R1	% SUCCESS
1	1	2	3	12	12	1						0.92	3.23						
	2	3	8	12	6	1	5	15	7	2	1	0.98	2.80	2.30	2.70	-0.43	-0.93	-0.53	81.3
	3	3	9	13	4	1	6	16	5	2	1	0.94	2.70	2.20	2.70	-0.53	-1.03	-0.53	100.0
	4	2	13	11	4	0	3	20	4	2	1	0.80	2.57	2.27	2.70	-0.67	-0.97	-0.53	125.0
2	1	1	2	10	13	4						0.92	3.57						
	2	0	0	14	15	1						0.56	3.57			0.00			
	3	0	0	15	14	1						0.56	3.53			-0.03			
	4	0	0	13	17	0						0.50	3.57			0.00			
3	1	0	6	8	13	3						0.92	3.43						
	2	0	6	11	13	0						0.76	3.23			-0.20			
	3	0	6	13	11	0						0.73	3.17			-0.27			
	4	0	5	16	9	0						0.67	3.13			-0.30			
4	1	4	4	16	4	2						1.02	2.87						
	2	3	7	17	2	1						0.86	2.70			-0.17			
	3	2	8	17	2	1						0.81	2.73			-0.13			
	4	2	2	23	2	1						0.73	2.93			0.07			
5	1	1	3	6	10	10						1.10	3.83						
	2	0	4	11	9	6	3	8	14	2	3	0.96	3.57	2.80	3.00	-0.27	-1.03	-0.83	32.0
	3	0	6	13	7	4	2	10	13	3	2	0.94	3.30	2.77	3.00	-0.53	-1.07	-0.83	64.0
	4	0	6	13	10	1	0	14	12	2	2	0.79	3.20	2.73	3.00	-0.63	-1.10	-0.83	76.0
6	1	0	0	4	15	11						0.67	4.23						
	2	0	0	2	19	9						0.56	4.23			0.00			
	3	0	0	1	21	8						0.50	4.23			0.00			
	4	0	0	1	22	7						0.48	4.20			-0.03			
7	1	5	10	9	3	3						1.17	2.63						
	2	5	14	6	4	1						1.02	2.40			-0.23			
	3	4	15	9	2	0						0.78	2.30			-0.33			
	4	4	15	11	0	0						0.67	2.23			-0.40			
8	1	0	1	9	13	7						0.81	3.87						
	2	0	3	12	15	0	3	9	15	2	1	0.66	3.40	2.63	3.20	-0.47	-1.23	-0.67	70.0
	3	0	3	16	11	0	2	10	15	3	0	0.63	3.27	2.63	3.20	-0.60	-1.23	-0.67	90.0
	4	0	3	16	11	0	0	10	18	2	0	0.63	3.27	2.73	3.20	-0.60	-1.13	-0.67	90.0
9	1	1	6	4	16	3						1.02	3.47						
	2	0	6	7	15	2						0.88	3.43			-0.03			
	3	0	5	6	17	2						0.85	3.53			0.07			
	4	0	3	8	18	1						0.72	3.57			0.10			
10	1	1	8	14	6	1						0.85	2.93						
	2	0	9	16	5	0						0.67	2.87			-0.07			
	3	1	8	16	5	0						0.73	2.83			-0.10			
	4	0	6	20	4	0						0.57	2.93			0.00			
11	1	2	2	15	6	5						1.04	3.33						
	2	2	3	10	11	4	1	1	5	12	11	1.05	3.40	4.03	3.70	0.07	0.70	0.37	18.2
	3	2	2	6	16	4	1	2	4	10	13	1.02	3.60	4.07	3.70	0.27	0.73	0.37	72.7
	4	2	2	5	17	4	1	2	3	11	13	1.02	3.63	4.10	3.70	0.30	0.77	0.37	81.8

## APPENDIX E

### COMPUTER PROGRAMS TO ANALYZE FINAL RESULTS



FORTRAN IV G LEVEL 21

MAIN

DATE = 76227

10/50/29

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0001      INTEGER SR(2,4,30,30),AP(4,30),VA(2,4,30,50),VP(4,30),PART
0002      INTEGER RPT1,RPT2,RPT3,RPT4,RPT5,RPT6,RPT7
0003      DIMENSION A(2,4,30,30),AT(30),AD(30),IAM(30),IANM(30),VID(50),
1          IVM(50),IVNM(50),IVSFR2(4,21)
0004      DIMENSION AMED(2,4,30),AUC(2,4,30),ALQ(2,4,30),VI(2,4,50),
1          VSTD(2,4,50),SA(4,30),SV(4,50),IASFRE(4,21),
2          IVSFR(4,21),WS(30),LF(5),IASSTR(4,21),AMEAN(2,4,30),
3          STD(2,4,30),IANSSF(4,21),SSA(4,30),SNSA(4,30)
0005      DIMENSION R4R1S(30),ADR1S(30),R4R1E(30),ADR1E(30),
1          R4R1U(50),ADR1U(50)
0006      DATA IASFRE/0.4*0/,IVSFR1/0.4*0/,VSTD/400*0.0/,IASSTR/0.4*0/,
1          IANSSF/0.4*0/,IVSFR2/0.4*0/
0007      JCD=13
0008      ICD=13
0009      IPR=6
0010      READ(5,9020) RPT1,RPT2,RPT3,RPT4,RPT5,RPT6,RPT7
C          ** READ ALMANAC INPUT **
0011      READ (ICD,9000) NR,NQ,NP1,NF2,NVR,NVQ,NVP1,NVP2,NVQH
0012      READ (ICD,9010) (AT(IQ),IQ=1,NQ)
0013      READ (ICD,9010) (AD(IQ),IQ=1,NQ)
0014      READ (ICD,9020) (IAM(IQ),IQ=1,NQ)
0015      READ (ICD,9020) (IANM(IQ),IQ=1,NQ)
0016      NP=NP1
0017      DO 400 IM=1,2
0018          DO 300 IR=1,NR
0019              DO 50 IP=1,NP
0020                  READ (ICD,9030) AP(IM,IP),(SR(IM,IR,IP,IQ),IQ=1,NQ)
0021          50 CONTINUE
0022              DO 200 IP=1,NP
0023                  DO 100 KQ=1,NQ,7
0024                      KQ6=KQ+6
0025                      IF (KQ6.GT.NQ) KQ6=NQ
0026                      READ (ICD,9040) PART,(A(IM,IR,IP,IQ),IQ=KQ,KQ6)
0027          100 CONTINUE
0028                      IF (PART.NE.AP(IM,IP)) GO TO 3000
0029          200 CONTINUE
0030          300 CONTINUE
0031              NP=NP2
0032          400 CONTINUE
C          ** READ VALUE INPUT **
0033      READ (ICD,9010) (VID(IQ),IQ=1,NVQ)
0034      READ (ICD,9020) (IVM(IQ),IQ=1,NVQ)
0035      READ (ICD,9020) (IVNM(IQ),IQ=1,NVQ)
0036      NVP=NVP1
0037      DO 600 IM=1,2
0038          DO 500 IR=1,NVR
0039              READ (ICD,9030) (VP(IM,IP),(VA(IM,IR,IP,IQ),IQ=1,NVQ),
1                  IP=1,NVP)
0040          500 CONTINUE
0041              NVP=NVP2
0042          600 CONTINUE
C          DETERMINE UQ,MED,LQ FOR EACH ALMANAC STATEMENT
0043      NP=NP1
0044      DO 1000 IM=1,2
0045          DO 1700 IR=1,NR
0046          1000 DO 1700 IQ=1,NQ
0047              NWS=NP
0048              K=0
0049              SUMA=0.0
0050              SUMA2=0.0
0051              DO 1200 IP=1,NP
0052                  IF (A(IM,IR,IP,IQ).NE.999999.0) GO TO 1100
0053                  NWS=NWS+1
0054                  GO TO 1200
0055          1100              K=K+1
0056                      WS(K)=A(IM,IR,IP,IQ)
0057                      SUMA=SUMA+WS(K)
0058                      SUMA2=SUMA2+WS(K)*WS(K)
0059          1200 CONTINUE
C          BUBBLE SORT OF ANSWERS TO A QUESTION
0060      DO 1400 K=2,NWS
0061          L=K-1
0062          DO 1300 I=K,NWS
0063              IF (WS(I).LT.WS(L)) L=I
0064          1300 CONTINUE
0065              TEMP=WS(K-1)
0066              WS(K-1)=WS(L)
0067              WS(L)=TEMP
0068          1400 CONTINUE

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C          CALCULATE WHICH INDEX WILL BE USED FOR LQ, MED, UQ
0066      X=NWS/4.0
0070      LX=NWS/4
0071      R=X-IX
0072      IU=IX+1
0073      MED=2*IX
0074      IUD=3*IX
0075      IF (R.LT.0.1) GO TO 1600
0076      IF (R.LT.0.3) GO TO 1500
0077      MED=MED+2
0078      IUD=IUD+2
0079      IF (R.LT.0.6) GO TO 1600
0080      LQ=IU+1
0081      GO TO 1600
0082      MED=MED+1
0083      IUD=IUD+1
0084      AMED(IM,IR,IQ)=WS(MED)
0085      ALQ(IM,IR,IQ)=WS(LQ)
0086      AUQ(IM,IR,IQ)=WS(IUD)
C          CALCULATE MEAN AND STD DEV FOR EACH ALMANAC STATEMENT
0087      AMEAN(IM,IR,IQ)=SUMA/NWS
0088      STD(IM,IR,IQ)=SQRT((SUMA2-NWS*AMEAN(IM,IR,IQ)*AMEAN(IM,IR,IQ))
1          /(NWS-1))
0089      1700 CONTINUE
0090      NP=NP2
0091      1800 CONTINUE
0092      IF (NVQ.EQ.1) GO TO 2400
C          DETERMINE INDEX & STD DEV FOR EACH VALUE STATEMENT
0093      NUP=NUP1
0094      DO 2200 IM=1,2
0095      DO 2100 IR=1,NUP
0096      DO 2100 IQ=1,NVQ
0097          LF(1)=0
0098          LF(2)=0
0099          LF(3)=0
0100          LF(4)=0
0101          LF(5)=0
0102      DO 2000 IP=1,NUP
0103          LF(VA(IM,IR,IP,IQ))=LF(VA(IM,IR,IP,IQ))+1
0104      2000 CONTINUE
0105      TOTF=LF(1)+LF(2)+LF(3)+LF(4)+LF(5)
0106      SCORE=LF(1)+2*LF(2)+3*LF(3)+4*LF(4)+5*LF(5)
0107      Y=SCORE/TOTF
0108      VI(IM,IR,IQ)=Y
0109      STD(IM,IR,IQ)=SQRT(((1-Y)*(1-Y)*LF(1)+(2-Y)*(2-Y)*LF(2)+
1          (3-Y)*(3-Y)*LF(3)+(4-Y)*(4-Y)*LF(4)+
2          (5-Y)*(5-Y)*LF(5))/TOTF)
0110      2100 CONTINUE
0111      NUP=NUP2
0112      2200 CONTINUE
C          ** SUCCESS ROUTINE - CALC SUCCESS **
0113      2400 DO 2500 IR=2,NR
0114      DO 2500 IQ=1,NQ
C          ** ALMANAC SUCCESS VIA STANDARDIZED **
0115      Y=AD(IQ)-AMEAN(IAM(IQ),1,IQ)
0116      IF (X.NE.0.0) X=X/STD(IAM(IQ),1,IQ)
0117      Y=AMED(IAM(IQ),IR,IQ)-AMEAN(IAM(IQ),1,IQ)
0118      IF (Y.NE.0.0) Y=Y/STD(IAM(IQ),1,IQ)
0119      Z=AMED(IAM(IQ),1,IQ)-AMEAN(IAM(IQ),1,IQ)
0120      IF (Z.NE.0.0) Z=Z/STD(IAM(IQ),1,IQ)
0121      R4R1S(IQ)=Y-Z
0122      ADR1S(IQ)=X-Z
0123      SSA(IR,IQ)=(Y-Z)/(X-Z)
0124      IS=(SSA(IR,IQ)+.005)*20.0
0125      IS=21-IS
0126      IASSFR(IR,IS)=IASSFR(IR,IS)+1
C          ** ALMANAC SUCCESS VIA NON-STANDARDIZED **
0127      SNSA(IR,IQ)=(AMED(IAM(IQ),IR,IQ)-AMED(IAM(IQ),1,IQ))/
1          (AD(IQ)-AMED(IAM(IQ),1,IQ))
0128      IS=(SNSA(IR,IQ)+.005)*20.0
0129      IS=21-IS
0130      IANSSFR(IR,IS)=IANSSFR(IR,IS)+1
C          ** ALMANAC SUCCESS VIA ERROR **
0131      X=ALOG(AD(IQ)/AT(IQ))
0132      Y=ALOG(AMED(IAM(IQ),1,IQ)/AT(IQ))
0133      Z=ALOG(AMED(IAM(IQ),IR,IQ)/AT(IQ))
0134      R4R1E(IQ)=Z-Y
0135      ADR1E(IQ)=X-Y
0136      SA(IR,IQ)=(Z-Y)/(X-Y)
0137      IS=(SA(IR,IQ)+.005)*20.0
0138      IS=21-IS
0139      IASFRE(IR,IS)=IASFRE(IR,IS)+1
0140      2500 CONTINUE
0141      IF (NVQ.EQ.1) GO TO 2900

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C          ** VALUE SUCCESS **
0142      DO 2800 IR=2,NVR
0143          DO 2800 IQ=1,NVQ
0144              IF (IVM(IQ).EQ.0) GO TO 2700
0145              R4R1V(IQ)=VI(IVM(IQ),IR,IQ)-VI(IVM(IQ),1,IQ)
0146              ADR1V(IQ)=VTD(IQ)-VI(IVM(IQ),1,IQ)
0147              SV(IR,IQ)=R4R1V(IQ)/ADR1V(IQ)
0148              IF (SV(IR,IQ).GT.1.0) GO TO 2600
0149              X=SV(IR,IQ)
0150              Y=X
0151              GO TO 2650
0152      2600      X=1.0-(SV(IR,IQ)-1.0)
0153              Y=1.0
0154      2650      IS=(X+.005)*20
0155              IS=21-IS
0156              IVSFRE(IR,IS)=IVSFRE(IR,IS)+1
0157              IS=(Y+.005)*20
0158              IS=21-IS
0159              IVSFR2(IR,IS)=IVSFR2(IR,IS)+1
0160              GO TO 1800
0161      2700      SV(IR,IQ)=0.0
0162      2800 CONTINUE
0163      2900 CONTINUE
C          ** WRITE OUT SUCCESS REPORT **
0164      IF (RPT1.EQ.0) GO TO 3205
0165      DO 3000 IR=2,NR
0166          WRITE (1PR,9100) IR
0167          IX1=Y5
0168          X2=Y9.9
0169          ACUM=0.0
0170          SCUM=0.0
0171          SNCUM=0.0
0172          VCUH=0.0
0173          VCUH2=0.0
0174          DO 3100 IS=1,21
0175              ACUM=1.0*IASFRE(IR,IS)/NVQ+ACUM
0176              SCUM=1.0*IASSFR(IR,IS)/NVQ+SCUM
0177              SNCUM=1.0*IANSSF(IR,IS)/NVQ+SNCUM
0178              VCUH=1.0*IVSFRE(IR,IS)/NVQ+VCUH
0179              VCUH2=1.0*IVSFR2(IR,IS)/NVQ+VCUH2
0180              IF (IS.EQ.1) GO TO 3000
0181              WRITE (1PR,9110) IX1,X2,IASSFR(IR,IS),SCUM,IANSSF(IR,IS),
1                  SNCUM,IASFRE(IR,IS),ACUM,IVSFRE(IR,IS),VCUH,
2                  IVSFR2(IR,IS),VCUH2
0182              IX1=IX1-5
0183              X2=X2-5.0
0184              GO TO 3100
0185      3000      WRITE (1PR,9120) IASSFR(IR,IS),SCUM,IANSSF(IR,IS),
1                  SNCUM,IASFRE(IR,IS),ACUM,IVSFRE(IR,IS),VCUH,
2                  IVSFR2(IR,IS),VCUH2
0186      3100 CONTINUE
0187      3200 CONTINUE
C          ** WRITE OUT SUCCESS MANIP DETAIL REPORT **
0188      3205 IF (RPT2.EQ.0) GO TO 3305
0189          WRITE (1PR,9130)
0190          WRITE (1PR,9135)
0191          IVQ=0
0192          DO 3300 IQ=1,NQ
0193              IF (NVQ.EQ.1) GO TO 3210
0194      3208      IVQ=IVQ+1
0195              IF (IVM(IVQ).EQ.0) GO TO 3208
0196              WRITE (1PR,9140) IQ,(SSA(IR,IQ),IR=2,NR),(SNSA(IR,IQ),IR=2,NR),
1                  (SA(IR,IQ),IR=2,NR),R4R1S(IQ),ADR1S(IQ),
2                  R4R1E(IQ),ADR1E(IQ),R4R1V(IVQ),ADR1V(IVQ),
3                  (SV(IR,IVQ),IR=2,NVR),IVQ
0197              GO TO 3300
0198      3210      WRITE (1PR,9145) IQ,(SSA(IR,IQ),IR=2,NR),(SNSA(IR,IQ),IR=2,NR),
1                  (SA(IR,IQ),IR=2,NR),
2                  R4R1S(IQ),ADR1S(IQ),R4R1E(IQ),ADR1E(IQ)

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0199      3300 CONTINUE
C          ** CONVERGENCE ROUTINE **
0200      3305 IF (RPT3.EQ.0) GO TO 3900
0201      DO 3500 IR=1,NR
0202          WRITE (IPR,9150) IR
0203          IVQ=0
0204          DO 3500 IQ=1,NQ
0205              CAM=ABS(ALOG(AUQ(IAM(IQ),IR,IQ)/AT(IQ))-
1                  ALOG(ALQ(IAM(IQ),IR,IQ)/AT(IQ)))
0206              CANM=ABS(ALOG(AUQ(IANM(IQ),IR,IQ)/AT(IQ))-
1                  ALOG(ALQ(IANM(IQ),IR,IQ)/AT(IQ)))
0207              X=1.0-AMEAN(IAM(IQ),IR,IQ)/STD(IAM(IQ),IR,IQ)
0208              Y=1.0-AMEAN(IANM(IQ),IR,IQ)/STD(IANM(IQ),IR,IQ)
0209              IF (NVQ.EQ.1) GO TO 3400
0210      3360      IVQ=IVQ+1
0211              IF (IVM(IVQ).EQ.0) GO TO 3360
0212              WRITE (IPR,9160) IQ,CAM,CANM,STD(IAM(IQ),IR,IQ),
1                  STD(IANM(IQ),IR,IQ),X,Y,
2                  VSTD(IVM(IVQ),IR,IVQ),VSTD(IANM(IVQ),IR,IVQ),IVQ
0213              GO TO 3500
0214      3400      WRITE (IPR,9160) IQ,CAM,CANM,STD(IAM(IQ),IR,IQ),
1                  STD(IANM(IQ),IR,IQ),X,Y
0215      3500      CONTINUE
0216      3600 CONTINUE
C          ** STABILITY ROUTINE **
0217      3900 IF (RPT4.EQ.0) GO TO 6010
0218      ISW=1
0219      4000 CONTINUE
0220      SP1=0.0
0221      SP2=0.0
0222      SP3=0.0
0223      SP4=0.0
0224      SP5=0.0
0225      SP6=0.0
0226      SP7=0.0
0227      SP8=0.0
0228      SP9=0.0
0229      SP10=0.0
0230      IF (ISW.EQ.1) GO TO 4020
0231      WRITE (IPR,9180)
0232      GO TO 4030
0233      4020 WRITE (IPR,9170)
0234      4030 WRITE (IPR,9170)
0235      DO 5000 IQ=1,NVQ
0236          IF (ISW.EQ.2) GO TO 4150
0237          IF (ISW.EQ.3) GO TO 4140
0238          IF (IAM(IQ).EQ.1) GO TO 4100
0239          NPM=NPM2
0240          NPNM=NPM1
0241          IM=2
0242          INM=1
0243          GO TO 4200
0244      4100      NPM=NPM1
0245          NPNM=NPM2
0246          IM=1
0247          INM=2
0248          GO TO 4200
0249      4140      IF (IVM(IQ).EQ.0) GO TO 4170
0250          GO TO 5000
0251      4150      IF (IVM(IQ).EQ.1) GO TO 4170
0252          IF (IVM(IQ).EQ.0) GO TO 5000
0253          NPM=NPM2
0254          NPNM=NPM1
0255          IM=2
0256          INM=1
0257          GO TO 4200
0258      4170      NPM=NPM1
0259          NPNM=NPM2
0260          IM=1
0261          INM=2
0262      4200      P1=0.0
0263          P2=0.0
0264          P3=0.0
0265          P4=0.0
0266          P5=0.0
0267          P6=0.0
0268          IF (ISW.EQ.2) GO TO 4340
0269          IF (ISW.EQ.3) GO TO 4340
0270          DO 4300 IP=1,NPM
0271              IF (A(IM,2,IP,IQ).NE.A(IM,1,IP,IQ)) P1=P1+1.0
0272              IF (A(IM,3,IP,IQ).NE.A(IM,2,IP,IQ)) P2=P2+1.0
0273              IF (A(IM,4,IP,IQ).NE.A(IM,3,IP,IQ)) P3=P3+1.0
0274      4300      CONTINUE
0275      GO TO 4340

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0276      4340      DO 4350 IP=1,NPM
0277          IF (VA(IM,2,IP,IQ).NE.VA(IM,1,IP,IQ)) P1=P1+1.0
0278          IF (VA(IM,3,IP,IQ).NE.VA(IM,2,IP,IQ)) P2=P2+1.0
0279          IF (VA(IM,4,IP,IQ).NE.VA(IM,3,IP,IQ)) P3=P3+1.0
0280      4350      CONTINUE
0281      4360      P1=P1/NPM
0282          P2=P2/NPM
0283          P3=P3/NPM
0284          IF (P1.LE.0.20) GO TO 4400
0285          IF (P2.LE.0.20) GO TO 4410
0286          IF (P3.LE.0.20) GO TO 4420
0287          IP7=5
0288          GO TO 4500
0289      4400      IP7=2
0290          GO TO 4500
0291      4410      IP7=3
0292          GO TO 4500
0293      4420      IP7=4
0294      4500      CONTINUE
0295          IF (P1.LE.0.15) GO TO 4550
0296          IF (P2.LE.0.15) GO TO 4560
0297          IF (P3.LE.0.15) GO TO 4570
0298          IP9=5
0299          GO TO 4590
0300      4550      IP9=2
0301          GO TO 4590
0302      4560      IP9=3
0303          GO TO 4590
0304      4570      IP9=4
0305      4590      CONTINUE
0306          IF (ISW.EQ.2) GO TO 4640
0307          IF (ISW.EQ.3) GO TO 4640
0308      DO 4600 IP=1,NPNM
0309          IF (A(INM,2,IP,IQ).NE.A(INM,1,IP,IQ)) P4=P4+1.0
0310          IF (A(INM,3,IP,IQ).NE.A(INM,2,IP,IQ)) P5=P5+1.0
0311          IF (A(INM,4,IP,IQ).NE.A(INM,3,IP,IQ)) P6=P6+1.0
0312      4600      CONTINUE
0313          GO TO 4660
0314      4640      DO 4650 IP=1,NPNM
0315          IF (VA(INM,2,IP,IQ).NE.VA(INM,1,IP,IQ)) P4=P4+1.0
0316          IF (VA(INM,3,IP,IQ).NE.VA(INM,2,IP,IQ)) P5=P5+1.0
0317          IF (VA(INM,4,IP,IQ).NE.VA(INM,3,IP,IQ)) P6=P6+1.0
0318      4650      CONTINUE
0319      4660      P4=P4/NPNM
0320          P5=P5/NPNM
0321          P6=P6/NPNM
0322          IF (P4.LE.0.20) GO TO 4700
0323          IF (P5.LE.0.20) GO TO 4710
0324          IF (P6.LE.0.20) GO TO 4720
0325          IP8=5
0326          GO TO 4800
0327      4700      IP8=2
0328          GO TO 4800
0329      4710      IP8=3
0330          GO TO 4800
0331      4720      IP8=4
0332      4800      CONTINUE
0333          IF (P4.LE.0.15) GO TO 4850
0334          IF (P5.LE.0.15) GO TO 4860
0335          IF (P6.LE.0.15) GO TO 4870
0336          IP10=5
0337          GO TO 4890
0338      4850      IP10=2
0339          GO TO 4890
0340      4860      IP10=3
0341          GO TO 4890
0342      4870      IP10=4
0343      4890      CONTINUE
0344          WRITE (IPR,9200) IQ,P1,P2,P3,P4,P5,P6,IP7,IP8,IP9,IP10
0345          SP1=SP1+P1
0346          SP2=SP2+P2
0347          SP3=SP3+P3
0348          SP4=SP4+P4
0349          SP5=SP5+P5
0350          SP6=SP6+P6
0351          SP7=SP7+IP7
0352          SP8=SP8+IP8
0353          SP9=SP9+IP9
0354          SP10=SP10+IP10
0355      4900      CONTINUE
0356          IF (IQ.GE.NQ.AND.ISW.EQ.1) GO TO 5100
0357      5000      CONTINUE
0358      5100      CONTINUE

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0357 SP1=SP1/NQ
0360 SP2=SP2/NQ
0361 SP3=SP3/NQ
0362 SP4=SP4/NQ
0363 SP5=SP5/NQ
0364 SP6=SP6/NQ
0365 SP7=SP7/NQ

0366 SP8=SP8/NQ
0367 SP9=SP9/NQ
0368 SP10=SP10/NQ
0369 WRITE (IPR,9210) SP1,SP2,SP3,SP4,SP5,SP6,SP7,SP8,SP9,SP10
0370 IF (NVQ.EQ.1) GO TO 6000
0371 IF (ISW.GE.3) GO TO 6000
0372 IF (ISW.EQ.2) ISW=3
0373 IF (ISW.EQ.1) ISW=2
0374 GO TO 4000
0375 6000 CONTINUE

C ** CONFIDENCE ROUTINE MANIP **
0376 6010 IF (RPT5.EQ.0) GO TO 8999
0377 IPAGE=60
0378 IMI=1
0379 DO 6400 IQ=1,NQ
0380 TSR1=0.0
0381 TSR4=0.0
0382 TP1=0.0
0383 TP2=0.0
0384 TP3=0.0
0385 TP4=0.0
0386 TP6=0.0
0387 TP7=0.0
0388 TP8=0.0
0389 IF (IAM(IQ).EQ.1) GO TO 6100
0390 NP=NP2
0391 IF=2
0392 GO TO 6200
0393 6100 NP=NP1
0394 IM=1
0395 6200 DO 6300 IP=1,NP
0396 P1=ALOG(A(IM,1,IP,IQ)/AT(IQ))
0397 P2=ALOG(A(IM,2,IP,IQ)/AT(IQ))
0398 P3=ALOG(A(IM,3,IP,IQ)/AT(IQ))
0399 P4=ALOG(A(IM,4,IP,IQ)/AT(IQ))
0400 P5=ALOG(AD(IQ)/AT(IQ))
0401 P6=P4-P1
0402 P7=ARS(P5-P1)
0403 IP8=SR(IM,4,IP,IQ)-SR(IM,1,IP,IQ)
0404 TSR1=TSR1+SR(IM,1,IP,IQ)
0405 TSR4=TSR4+SR(IM,4,IP,IQ)
0406 TP1=TP1+P1
0407 TP2=TP2+P2
0408 TP3=TP3+P3
0409 TP4=TP4+P4
0410 TP6=TP6+P6
0411 TP7=TP7+P7
0412 TP8=TP8+IP8
0413 IF (RPT6.EQ.0) GO TO 6280
0414 IF (IPAGE.LT.60) GO TO 6240
0415 WRITE (IPR,9220)
0416 WRITE (IPR,9240)
0417 IPAGE=7
0418 GO TO 6260
0419 6240 IPAGE=IPAGE+1
0420 6260 CONTINUE
0421 WRITE (IPR,9250) IQ,AP(IM,IP),SR(IM,1,IP,IQ),SR(IM,4,IP,IQ),
1 SR(IM,2,IP,IQ),SR(IM,3,IP,IQ),
2 P1,P2,P3,P4,P5,P6,P7,IP8
0422 6280 IF (RPT7.EQ.0) GO TO 6300
0423 6300 CONTINUE
0424 IF (IPAGE.LT.60) GO TO 6340
0425 WRITE (IPR,9220)
0426 WRITE (IPR,9240)
0427 IPAGE=8
0428 GO TO 6360
0429 6340 IPAGE=IPAGE+2
0430 6360 TSR1=TSR1/NP
0431 TSR4=TSR4/NP
0432 TP1=TP1/NP
0433 TP2=TP2/NP
0434 TP3=TP3/NP
0435 TP4=TP4/NP
0436 TP6=TP6/NP
0437 TP7=TP7/NP
0438 TP8=TP8/NP
0439 WRITE (IPR,9270) TSR1,TSR4,TP1,TP2,TP3,TP4,TP6,TP7,TP8
0440 6400 CONTINUE

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C          ** CONFIDENCE ROUTINE NON-MANIP **
0441      IFAGE=60
0442      IMT=0
0443      DO 7400 IQ=1,NQ
0444          TSR1=0.0
0445          TSR4=0.0
0446          TP1=0.0
0447          TP2=0.0
0448          TP3=0.0
0449          TP4=0.0
0450          TP6=0.0
0451          TP8=0.0
0452          IF (TANH(IQ).EQ.1) GO TO 7100
0453          NP=NP2
0454          IM=2
0455          GO TO 7200
0456 7100      NP=NP1
0457          IM=1
0458 7200      DO 7300 IP=1,NP
0459          P1=ALOG(A(IM,1,IP,IQ)/AT(IQ))
0460          P2=ALOG(A(IM,2,IP,IQ)/AT(IQ))
0461          P3=ALOG(A(IM,3,IP,IQ)/AT(IQ))
0462          P4=ALOG(A(IM,4,IP,IQ)/AT(IQ))
0463          P6=P4-P1
0464          IP8=SR(IM,4,IP,IQ)-SR(IM,1,IP,IQ)
0465          TSR1=TSR1+SR(IM,1,IP,IQ)
0466          TSR4=TSR4+SR(IM,4,IP,IQ)
0467          TP1=TP1+P1
0468          TP2=TP2+P2
0469          TP3=TP3+P3
0470          TP4=TP4+P4
0471          TP6=TP6+P6
0472          TP8=TP8+IP8
0473          IF (RPT6.EQ.0) GO TO 7280
0474          IF (IPAGE.LT.60) GO TO 7240
0475          WRITE (IPR,9230)
0476          WRITE (IPR,9240)
0477          IPAGE=7
0478          GO TO 7260
0479 7240      IPAGE=IPAGE+1
0480 7260      CONTINUE
0481          WRITE (IPR,9260) IQ,AF(IM,IP),SR(IM,1,IP,IQ),SR(IM,4,IP,IQ),
1              SR(IM,2,IP,IQ),SR(IM,3,IP,IQ),
2              P1,P2,P3,P4,P6,IP8
0482 7280      IF (RPT7.EQ.0) GO TO 7300
0483 7300      CONTINUE
0484          IF (IPAGE.LT.60) GO TO 7340
0485          WRITE (IPR,9230)
0486          WRITE (IPR,9240)
0487          IPAGE=8
0488          GO TO 7400
0489 7340      IFAGE=IFAGE+2
0490 7360      TSR1=TSR1/NP
0491          TSR4=TSR4/NP
0492          TP1=TP1/NP
0493          TP2=TP2/NP
0494          TP3=TP3/NP
0495          TP4=TP4/NP
0496          TP6=TP6/NP
0497          TP8=TP8/NP
0498          WRITE(IPR,9280) TSR1,TSR4,TP1,TP2,TP3,TP4,TP6,TP8
0499 7400      CONTINUE
0500          GO TO 8999
0501 8000      WRITE (IPR,9000) IM,IR,IP
0502          WRITE (IPR,9010) AF(IM,IP),(SR(IM,IR,IP,IQ),IQ=1,NQ)
0503          WRITE (IPR,9020) PART,(A(IM,IR,IP,IQ),IQ=1,7)
0504 8999      STOP

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0505 9000 FORMAT(9I3)
0506 9010 FORMAT(8F10.0)
0507 9020 FORMAT(80I1)
0508 9030 FORMAT(14,6X,50I1)
0509 9040 FORMAT(14,6X,7F10.0)
0510 9100 FORMAT('1ROUND ',I1,5X,'SUCCESS OF MANIPULATION'/
1      '0      'ACTUALLY BASED - (RI-R1)/(AD-R1)      'V',
2      'ALUE LADEN'/
3      '      X      STANDARDIZED      NON-STD.      ERROR      INDEX',
4      '      INDEX-2'/
5      'SUCCESS FREQ CUM % FREQ CUM % FREQ CUM % FREQ C',
6      'UM % FREQ CUM %'/)
0511 9110 FORMAT(13,'-',F4.1,3X,5(I2,2X,F5.2,4X))
0512 9120 FORMAT(3X,'100',5X,5(I2,2X,F5.2,4X))
0513 9130 FORMAT('1',27X,'SUCCESS OF MANIPULATION - DETAIL'/
1      '0      'ACTUALLY BASED DELPHI - (RI-R1)/(AD-',
2      'R1)      ----- TOTAL MOVEMENT ----- VALUE ',
3      'LADEN DELPHI'/
4      'ALMANAC      STANDARDIZED      NON-STANDARDIZED      ',
5      'ERROR      ACTUALLY BASED      VALUE LADEN      ',
6      'INDEX      VALUE'/)
0514 9135 FORMAT(' STATEMENT SUCCESS FOR ROUND SUCCESS FOR ROUND SUCCESS',
1      ' FOR ROUND STANDARDIZED ERROR INDEX SUCCES',
2      'S FOR ROUND STATEMENT'/
3      'NUMBER R2 R3 R4 R2 R3 R4 R2 ',
4      'R3 R4 R4-R1 AD-R1 R4-R1 AD-R1 R4-R1 AD-R1 R2 ',
5      'R3 R4 NUMBER'/)
0515 9140 FORMAT(5X,I2,2X,3(3F6.2,1X),1X,6F6.2,2X,3F6.2,5X,I2)
0516 9145 FORMAT(5X,I2,2X,3(3F6.2,1X),1X,4F6.2)

0517 9150 FORMAT('1ROUND ',I1,5X,'CONVERGENCE OF MANIPULATION'/
1      '0 ALMANAC * * * * * ACTUALLY BASED * * * * ',
2      ' * * * * * VALUE LADEN VALUE LADEN'/
3      ' STATEMENT QUARTILE RANGE STANDARD DEVIATION STDI',
4      'ZED STD DEV STANDARD DEVIATION STATEMENT'/
5      'NUMBER MANIP NON-MANIP MANIP NON-MANIP MANI',
6      'P NON-MANIP MANIP NON-MANIP NUMBER'/)
0518 9160 FORMAT(5X,I2,5X,F5.2,3X,F5.2,1X,2F12.2,2X,F6.2,2X,F6.2,
1      4X,F5.2,3X,F5.2,7X,I2)
0519 9170 FORMAT('1STABILITY OF MANIPULATION - ACTUALLY BASED DELPHI')
0520 9180 FORMAT('1STABILITY OF MANIPULATION - VALUE LADEN DELPHI')
0521 9190 FORMAT('0
1      '      20X      15X'/
1      '      % CHANGE BETWEEN ROUNDS      ',
1      'STABILITY FIRST STABILITY FIRST'/
2      ' STATEMENT MANIPULATED NON-MANIPULATED ',
3      'REACHED IN ROUND REACHED IN ROUND'/
4      'NUMBER 1-2 2-3 3-4 1-2 2-3 3-4 ',
5      'MANIP NON-MANIP MANIP NON-MANIP'/)
0522 9200 FORMAT(5X,I2,2(3X,F4.2,2X,F4.2,2X,F4.2),2(4X,I1,6X,I1,5X))
0523 9210 FORMAT('0AVERAGES ',3(F4.2,2X),1X,3(F4.2,2X),1X,4(F4.2,5X))
0524 9220 FORMAT('1',30X,'CONFIDENCE AND MANIPULATION')
0525 9230 FORMAT('1',34X,'CONFIDENCE AND NON-MANIPULATION')
0526 9240 FORMAT('0',25X,'SELF-RATING ANSWER DURING ROUND ',
1      'DESIRED ACTUAL DESIRED SELF-RATING'/
2      ' STATEMENT DURING ROUND (EXPRESSED ',
3      'AS ERROR) ANSWER CHANGE CHANGE CHANGE'/
4      'NUMBER PARTICIPANT SR1 SR4 SR2 SR3 A1 A2 A',
5      'A4 AD A4-A1 AD-A1 SR4-SR1'/)
0527 9250 FORMAT(5X,I2,7X,I4,7X,4(I1,3X),4(F5.2,1X),F6.2,FR.2,F7.2,6X,I2)
0528 9260 FORMAT(5X,I2,7X,I4,7X,4(I1,3X),4(F5.2,1X),9X,F5.2,13X,I2)
0529 9270 FORMAT(12X,'AVERAGE ',2F4.1,9X,4F6.2,8X,2F7.2,5X,F4.1/)
0530 9280 FORMAT(12X,'AVERAGE ',2F4.1,9X,4F6.2,8X,F7.2,12X,F4.1/)
0531 9800 FORMAT('0PARTICIPANTS OUT OF SEQUENCE',3I3)
0532 9810 FORMAT(15,6X,30I1)
0533 9820 FORMAT(15,6X,7F10.0)
0534 END

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## ROUND 3 SUCCESS OF MANIPULATION

% SUCCESS	FACTUALLY BASED - $(RI-R1)/(AD-R1)$						VALUE LADEN			
	STANDARDIZED		NON-STD.		ERROR		INDEX-1		INDEX-2	
	FREQ	CUM %	FREQ	CUM %	FREQ	CUM %	FREQ	CUM %	FREQ	CUM %
100	0	0.0	0	0.0	0	0.0	2	0.07	7	0.23
95-99.9	4	0.13	4	0.13	5	0.17	4	0.20	3	0.33
90-94.9	2	0.20	2	0.20	4	0.30	3	0.30	2	0.40
85-89.9	8	0.47	8	0.47	5	0.47	5	0.47	3	0.50
80-84.9	3	0.57	3	0.57	2	0.53	2	0.53	2	0.57
75-79.9	0	0.57	0	0.57	3	0.63	0	0.53	0	0.57
70-74.9	3	0.67	3	0.67	5	0.80	1	0.57	1	0.60
65-69.9	4	0.80	4	0.80	1	0.83	4	0.70	4	0.73
60-64.9	2	0.87	2	0.87	0	0.83	2	0.77	2	0.80
55-59.9	0	0.87	0	0.87	1	0.87	3	0.87	3	0.90
50-54.9	0	0.87	0	0.87	0	0.87	0	0.87	0	0.90
45-49.9	0	0.87	0	0.87	0	0.87	0	0.87	0	0.90
40-44.9	0	0.87	0	0.87	1	0.90	2	0.93	1	0.93
35-39.9	1	0.90	1	0.90	2	0.97	0	0.93	0	0.93
30-34.9	2	0.97	2	0.97	0	0.97	1	0.97	1	0.97
25-29.9	0	0.97	0	0.97	0	0.97	1	1.00	1	1.00
20-24.9	0	0.97	0	0.97	0	0.97	0	1.00	0	1.00
15-19.9	0	0.97	0	0.97	1	1.00	0	1.00	0	1.00
10-14.9	1	1.00	1	1.00	0	1.00	0	1.00	0	1.00
5-9.9	0	1.00	0	1.00	0	1.00	0	1.00	0	1.00
0-4.9	0	1.00	0	1.00	0	1.00	0	1.00	0	1.00

## ROUND 4 SUCCESS OF MANIPULATION

% SUCCESS	FACTUALLY BASED - $(RI-R1)/(AD-R1)$						VALUE LADEN			
	STANDARDIZED		NON-STD.		ERROR		INDEX-1		INDEX-2	
	FREQ	CUM %	FREQ	CUM %	FREQ	CUM %	FREQ	CUM %	FREQ	CUM %
100	4	0.13	4	0.13	4	0.13	3	0.10	13	0.43
95-99.9	4	0.27	4	0.27	6	0.33	5	0.27	2	0.50
90-94.9	5	0.43	5	0.43	5	0.50	5	0.43	3	0.60
85-89.9	5	0.60	5	0.60	5	0.67	0	0.43	0	0.60
80-84.9	4	0.73	4	0.73	0	0.67	3	0.53	3	0.70
75-79.9	0	0.73	0	0.73	2	0.73	6	0.73	3	0.80
70-74.9	1	0.77	1	0.77	3	0.83	2	0.80	2	0.87
65-69.9	2	0.83	2	0.83	1	0.87	2	0.87	2	0.93
60-64.9	2	0.90	2	0.90	0	0.87	3	0.97	1	0.97
55-59.9	0	0.90	0	0.90	1	0.90	0	0.97	0	0.97
50-54.9	0	0.90	0	0.90	0	0.90	0	0.97	0	0.97
45-49.9	0	0.90	0	0.90	0	0.90	0	0.97	0	0.97
40-44.9	1	0.93	1	0.93	2	0.97	0	0.97	0	0.97
35-39.9	1	0.97	1	0.97	0	0.97	0	0.97	0	0.97
30-34.9	0	0.97	0	0.97	0	0.97	1	1.00	1	1.00
25-29.9	0	0.97	0	0.97	0	0.97	0	1.00	0	1.00
20-24.9	0	0.97	0	0.97	1	1.00	0	1.00	0	1.00
15-19.9	1	1.00	1	1.00	0	1.00	0	1.00	0	1.00
10-14.9	0	1.00	0	1.00	0	1.00	0	1.00	0	1.00
5-9.9	0	1.00	0	1.00	0	1.00	0	1.00	0	1.00
0-4.9	0	1.00	0	1.00	0	1.00	0	1.00	0	1.00

# SUCCESS OF MANIPULATION - DETAIL

ALPHANAC	FACTUALLY BASED DELPHI - (RI-R1)/(AD-R1)									----- TOTAL MOVEMENT -----						VALUE LADEN DELPHI			VALUE
	STANDARDIZED			NON-STANDARDIZED			ERROR			FACTUALLY BASED			VALUE LADEN			INDEX			
STATEMENT NUMBER	SUCCESS R2	FOR R3	ROUND R4	SUCCESS R2	FOR R3	ROUND R4	SUCCESS R2	FOR R3	ROUND R4	STANDARDIZED R1-R1	AD-R1	R4-R1	AD-R1	INDEX R4-R1	AD-R1	SUCCESS R2	FOR R3	ROUND R4	STATEMENT NUMBER
1	0.71	0.86	1.00	0.71	0.86	1.00	0.79	0.90	1.00	0.49	0.49	0.89	0.88	-0.67	-0.53	0.81	1.00	1.25	1
2	0.31	0.31	0.62	0.31	0.31	0.63	0.38	0.38	0.69	0.31	0.50	0.41	0.59	-0.63	-0.60	0.89	1.06	1.06	2
3	0.42	0.67	0.67	0.42	0.67	0.67	0.47	0.72	0.72	0.39	0.50	0.34	0.47	-0.70	-0.50	1.27	1.60	1.40	4
4	0.45	0.72	0.72	0.45	0.72	0.72	0.50	0.76	0.76	0.32	0.44	0.30	0.40	-0.63	-0.83	0.32	0.84	0.76	5
5	0.83	0.85	0.92	0.83	0.85	0.92	0.80	0.81	0.91	-0.65	-0.71	-0.41	-0.45	0.60	0.57	0.65	0.86	1.06	6
6	0.08	0.13	0.16	0.08	0.13	0.16	0.10	0.15	0.20	0.14	0.83	0.08	0.43	-0.60	-0.67	0.70	0.90	0.90	8
7	0.78	0.87	0.91	0.78	0.87	0.91	0.86	0.92	0.95	1.09	1.19	1.13	1.19	-0.90	-0.90	0.93	1.15	1.00	9
8	0.56	0.69	0.83	0.56	0.69	0.83	0.65	0.77	0.88	0.97	1.16	0.69	0.79	0.30	0.37	0.18	0.73	0.82	11
9	0.82	0.88	0.94	0.82	0.88	0.94	0.78	0.85	0.92	-0.41	-0.43	-0.51	-0.55	0.83	0.67	0.45	0.95	1.25	12
10	0.33	0.67	0.67	0.33	0.67	0.67	0.26	0.58	0.58	-1.04	-1.55	-0.41	-0.69	-0.67	-0.63	0.32	0.84	1.05	13
11	0.48	0.86	0.95	0.48	0.86	0.95	0.56	0.89	0.97	1.02	1.07	0.69	0.72	-0.87	-0.70	0.81	1.00	1.24	15
12	0.91	0.99	1.00	0.91	0.99	1.00	0.69	0.97	1.00	-0.39	-0.37	-2.68	-2.68	-0.63	-0.77	0.52	0.57	0.83	16
13	0.67	0.72	0.83	0.67	0.72	0.83	0.76	0.86	0.89	1.43	1.71	0.81	0.92	0.63	0.63	0.53	1.11	1.00	18
14	0.13	0.38	0.38	0.13	0.38	0.38	0.14	0.40	0.40	0.83	2.21	0.09	0.23	0.50	0.50	0.80	0.93	1.00	22
15	0.71	0.83	0.86	0.71	0.83	0.86	0.76	0.86	0.89	0.83	0.97	0.47	0.53	-0.53	-0.73	0.27	0.32	0.73	23
16	0.63	0.63	0.86	0.63	0.63	0.86	0.70	0.70	0.90	1.00	1.16	0.65	0.73	0.50	0.63	0.32	0.42	0.79	24
17	0.36	0.86	0.86	0.36	0.86	0.86	0.41	0.88	0.88	0.72	0.84	0.76	0.41	-0.57	-0.77	0.35	0.65	0.74	27
18	0.27	0.64	0.64	0.27	0.64	0.64	0.35	0.71	0.71	0.55	0.86	0.49	0.69	-0.40	-0.60	0.44	0.61	0.67	31
19	0.50	0.80	0.80	0.50	0.80	0.80	0.42	0.74	0.74	-0.34	-0.42	-0.51	-0.69	0.50	0.60	0.61	0.56	0.83	32
20	0.43	0.65	0.87	0.43	0.65	0.87	0.53	0.73	0.91	0.60	0.69	0.69	0.77	-0.50	-0.80	0.42	0.67	0.62	33
21	0.78	0.95	0.95	0.78	0.95	0.95	0.93	0.98	0.98	0.94	0.99	3.14	3.19	-0.63	-0.67	0.50	0.65	0.95	34
22	0.76	0.95	0.95	0.76	0.95	0.95	0.82	0.97	0.97	0.55	0.57	0.69	0.72	0.77	0.83	0.44	0.66	0.92	36
23	0.63	0.87	0.87	0.63	0.88	0.88	0.73	0.92	0.92	1.15	1.32	0.88	0.96	-0.77	-0.73	0.86	0.95	1.05	38
24	0.20	0.33	0.40	0.20	0.33	0.40	0.21	0.35	0.41	0.83	2.19	0.05	0.12	-0.70	-0.63	0.21	0.26	0.32	41
25	0.58	0.93	1.00	0.58	0.93	1.00	0.73	0.96	1.00	0.22	0.22	1.35	1.35	-0.57	-0.73	0.50	0.68	0.77	42
26	0.54	0.72	0.91	0.54	0.72	0.91	0.47	0.66	0.88	-0.47	-0.52	-0.48	-0.54	0.43	0.63	0.32	0.58	0.68	44
27	0.77	0.93	0.93	0.77	0.93	0.93	0.83	0.95	0.95	0.87	0.93	0.69	0.73	-0.50	-0.53	0.81	0.81	0.94	46
28	0.57	0.86	0.97	0.57	0.86	0.97	0.63	0.88	0.98	0.78	0.80	0.45	0.46	-0.97	-0.70	0.81	1.05	1.38	48
29	0.50	0.83	0.83	0.50	0.83	0.83	0.43	0.79	0.79	-0.83	-0.99	-0.44	-0.56	-0.60	-0.63	0.63	0.89	0.95	49
30	0.53	0.95	1.00	0.53	0.95	1.00	0.40	0.91	1.00	-0.30	-0.30	-1.00	-1.00	-0.70	-0.67	0.60	0.95	1.05	50

## ROUND 1 CONVERGENCE OF MANIPULATION

ALMANAC STATEMENT NUMBER	*****		FACTUALLY BASED		*****		VALUE LADEN		VALUE LADEN STATEMENT NUMBER
	QUARTILE RANGE		STANDARD DEVIATION		STDIZED STD DEV		STANDARD DEVIATION		
	MANIP	NON-MANIP	MANIP	NON-MANIP	MANIP	NON-MANIP	MANIP	NON-MANIP	
1	2.71	1.50	28.65	14.58	0.41	0.12	0.92	0.75	1
2	1.10	1.20	3174.92	2712.49	0.67	-0.22	0.93	0.92	2
3	0.70	0.92	10290.25	12486.58	-0.42	-0.34	1.13	1.02	4
4	0.88	0.98	1649.49	2716.20	-0.22	0.12	1.10	0.92	5
5	0.60	0.60	91.88	98.40	-1.00	-0.71	0.54	0.67	6
6	0.92	1.24	592.14	880.45	-0.37	0.05	0.81	0.79	8
7	2.30	1.65	192525.06	225276.63	0.10	0.03	0.98	1.02	9
8	0.97	0.58	30.94	40.97	-0.16	-0.17	1.04	0.95	11
9	1.34	1.20	19580.55	19563.32	-0.29	-0.44	0.96	0.72	12
10	0.29	0.64	5.79	5.49	-2.13	-1.80	0.83	0.84	13
11	1.56	0.78	19599.35	20516.57	-0.26	-0.76	1.19	1.09	15
12	2.51	2.62	37730.36	158926.94	0.20	0.53	0.88	1.40	16
13	0.95	0.99	52.56	36.79	-0.27	-0.49	1.14	1.19	18
14	0.16	0.13	3.42	2.89	-7.52	-9.52	0.94	0.93	22
15	1.46	0.98	362634.19	883655.75	-0.40	0.12	0.82	0.92	23
16	1.10	1.67	2.75	3.79	-0.44	-0.15	1.18	0.90	24
17	0.56	0.64	16.59	17.76	-0.81	-0.67	1.06	0.95	27
18	1.61	1.61	636.10	1829.60	-0.06	0.44	1.02	0.98	31
19	1.10	1.39	1184.27	1729.85	-0.14	0.03	0.99	0.96	32
20	1.55	0.69	6.71	12.43	-0.04	0.12	0.97	0.90	33
21	2.64	4.54	18321.14	14719.32	0.50	0.36	1.00	0.96	34
22	1.19	0.83	10270.10	18581.08	-0.05	-0.08	0.95	0.79	36
23	1.20	0.83	6072.16	4956.58	-0.13	-0.41	0.99	0.93	38
24	0.11	0.05	6.84	5.91	-15.61	-17.85	0.90	1.23	41
25	2.30	1.74	961.13	529.47	0.53	0.45	1.06	0.92	42
26	0.30	0.69	1047.96	1025.25	-0.49	-0.09	1.20	1.01	44
27	1.58	1.20	34.65	41.68	-0.00	0.10	0.98	0.89	46
28	1.50	1.10	2176.23	1449.34	-0.40	-0.49	1.23	1.25	48
29	0.80	0.92	302.91	343.03	-1.31	-0.95	1.05	0.97	49
30	0.78	1.39	321.48	231.44	0.23	0.00	0.99	1.10	50

## ROUND 2 CONVERGENCE OF MANIPULATION

ALMANAC STATEMENT NUMBER	*****		FACTUALLY BASED		*****		VALUE LADEN		VALUE LADEN STATEMENT NUMBER
	QUARTILE RANGE		STANDARD DEVIATION		STDIZED STD DEV		STANDARD DEVIATION		
	MANIP	NON-MANIP	MANIP	NON-MANIP	MANIP	NON-MANIP	MANIP	NON-MANIP	
1	0.51	0.92	9.26	6.01	-1.15	-0.78	0.93	0.55	1
2	0.41	0.98	884.19	1442.61	-1.72	-0.96	0.79	0.54	2
3	0.47	0.57	3610.13	7378.10	-2.61	-0.77	0.75	0.36	4
4	0.34	0.53	949.92	698.21	-1.08	-1.00	0.96	0.84	5
5	0.29	0.33	46.09	32.80	-2.09	-3.79	0.46	0.56	6
6	0.49	0.42	432.84	284.62	-1.26	-1.84	0.66	0.54	8
7	0.47	0.47	104311.50	173972.50	-1.61	-0.34	0.96	0.88	9
8	0.62	0.41	18.19	13.29	-1.53	-1.67	1.05	0.76	11
9	0.69	0.78	7242.27	13635.94	-1.16	-1.03	0.68	0.67	12
10	0.49	0.53	4.36	5.07	-2.41	-1.83	0.81	0.65	13
11	0.41	0.29	12845.38	7350.75	-1.32	-3.76	0.99	1.01	15
12	1.43	1.56	12004.40	16505.19	0.48	0.08	0.75	1.31	16
13	0.37	0.37	44.12	22.79	-1.56	-1.49	0.93	1.17	18
14	0.12	0.13	3.42	2.47	-8.43	-11.47	0.60	0.72	22
15	0.21	0.41	190367.81	229076.38	-2.73	-1.60	0.98	0.76	23
16	0.41	0.92	1.77	2.52	-1.70	-0.53	1.11	0.70	24
17	0.29	0.64	10.66	10.00	-2.35	-1.78	0.84	0.86	27
18	0.59	0.69	327.95	302.82	-1.12	-0.55	0.94	0.83	31
19	0.69	0.82	638.23	832.21	-0.41	-0.58	1.11	0.76	32
20	0.69	0.69	3.86	2.25	-0.81	-1.18	0.87	0.80	33
21	0.59	2.93	15606.58	13853.68	-0.05	0.31	0.88	0.73	34
22	0.29	0.69	7243.61	6900.84	-1.62	-1.33	0.93	0.69	36
23	0.49	0.47	3982.73	3426.32	-1.59	-0.97	1.12	0.75	38
24	0.09	0.04	7.08	5.84	-15.47	-18.09	0.82	0.97	41
25	1.32	0.96	555.38	387.81	0.36	0.45	0.96	0.75	42
26	0.58	0.55	560.87	791.72	-1.03	-0.41	1.16	0.88	44
27	0.48	0.69	31.15	12.53	-0.78	-0.96	0.75	0.83	46
28	0.32	0.86	1331.10	1223.41	-1.91	-0.89	1.16	0.92	48
29	0.51	0.59	344.26	226.85	-0.86	-2.08	0.82	0.67	49
30	0.69	0.92	261.12	117.39	0.49	-0.67	1.03	0.95	50

## ROUND 3 CONVERGENCE OF MANIPULATION

ALMANAC STATEMENT NUMBER	QUARTILE RANGE MANIP NON-MANIP		FACTUALLY BASED STANDARD DEVIATION MANIP NON-MANIP		STDIZED STD DEV MANIP NON-MANIP		VALUE LADEN STANDARD DEVIATION MANIP NON-MANIP		VALUE LADEN STATEMENT NUMBER
1	0.37	0.76	8.79	5.64	-1.58	-0.90	0.94	0.54	1
2	0.56	0.56	900.00	1252.09	-1.93	-1.22	0.62	0.56	2
3	0.47	0.44	3990.26	4191.79	-2.28	-1.95	0.70	0.81	4
4	0.34	0.41	599.18	650.51	-2.24	-1.20	0.94	0.73	5
5	0.12	0.15	34.15	26.07	-2.76	-5.02	0.37	0.50	6
6	0.41	0.18	308.28	224.76	-1.68	-2.67	0.63	0.48	8
7	0.16	0.20	89565.44	130886.50	-2.25	-0.76	0.81	0.85	9
8	0.49	0.29	14.30	10.23	-2.68	-2.37	1.02	0.66	11
9	0.41	0.41	4399.18	9726.98	-2.11	-1.46	0.73	0.67	12
10	0.41	0.29	3.47	4.71	-2.56	-2.11	0.75	0.58	13
11	0.29	0.09	9548.13	3906.88	-2.68	-7.87	0.93	0.94	15
12	0.92	1.32	2347.76	8331.28	0.07	-0.21	0.75	1.18	16
13	0.34	0.37	33.22	21.52	-2.75	-1.68	0.80	1.19	18
14	0.12	0.10	3.67	2.28	-7.98	-12.43	0.64	0.81	22
15	0.27	0.29	189506.00	147697.56	-2.03	-3.37	0.76	0.60	23
16	0.41	0.69	1.74	2.09	-1.86	-0.78	1.00	0.65	24
17	0.17	0.41	7.18	0.71	-4.24	-3.07	0.75	0.81	27
18	0.69	0.51	348.01	382.36	-1.11	-0.23	0.92	0.71	31
19	0.47	0.69	429.88	571.15	-0.69	-1.10	1.09	0.76	32
20	0.41	0.54	3.46	2.15	-1.15	-1.40	0.76	0.72	33
21	0.24	2.35	15065.77	13714.16	-0.22	0.31	0.89	0.68	34
22	0.29	0.59	5405.40	4124.93	-2.53	-2.54	0.81	0.50	36
23	0.26	0.37	3399.96	2374.94	-2.33	-1.79	0.99	0.63	38
24	0.09	0.04	7.72	5.38	-14.47	-19.74	0.70	1.00	41
25	0.41	0.63	543.38	128.74	0.30	-0.00	0.80	0.76	42
26	0.29	0.44	474.10	766.60	-1.10	-0.45	1.19	0.59	44
27	0.22	0.37	20.68	14.97	-1.65	-0.77	0.70	0.80	46
28	0.26	0.68	985.69	1071.21	-3.19	-1.11	1.11	0.89	48
29	0.29	0.59	221.65	237.21	-1.47	-1.93	0.79	0.51	49
30	0.47	0.92	263.44	96.51	0.56	-0.99	0.90	0.84	50

## ROUND 4 CONVERGENCE OF MANIPULATION

ALMANAC STATEMENT NUMBER	QUARTILE RANGE MANIP NON-MANIP		FACTUALLY BASED STANDARD DEVIATION MANIP NON-MANIP		STDIZED STD DEV MANIP NON-MANIP		VALUE LADEN STANDARD DEVIATION MANIP NON-MANIP		VALUE LADEN STATEMENT NUMBER
1	0.26	0.76	8.47	5.55	-1.71	-0.93	0.80	0.51	1
2	0.56	0.41	848.18	1139.93	-2.22	-1.37	0.56	0.50	2
3	0.47	0.37	3947.82	3970.62	-2.37	-2.04	0.59	0.73	4
4	0.32	0.41	562.06	606.96	-2.50	-1.32	0.79	0.73	5
5	0.12	0.10	32.19	24.32	-2.91	-5.45	0.25	0.48	6
6	0.39	0.13	384.96	129.37	-1.73	-5.67	0.63	0.45	8
7	0.10	0.12	83389.38	110482.75	-2.62	-1.08	0.63	0.72	9
8	0.26	0.24	13.19	9.82	-3.18	-2.45	1.02	0.71	11
9	0.41	0.41	3598.53	7335.29	-2.59	-2.12	0.68	0.56	12
10	0.41	0.29	3.31	4.51	-2.64	-2.20	0.79	0.44	13
11	0.19	0.09	6693.74	3782.09	-4.59	-8.16	0.97	0.88	15
12	0.69	1.10	2027.01	8130.59	0.05	-0.20	0.76	1.05	16
13	0.41	0.29	33.93	20.81	-2.79	-1.78	0.82	1.14	18
14	0.20	0.10	3.83	2.08	-7.80	-13.70	0.65	0.58	22
15	0.19	0.22	163677.66	139939.75	-3.66	-3.65	0.59	0.48	23
16	0.18	0.69	1.61	2.01	-2.20	-0.76	1.02	0.60	24
17	0.22	0.31	7.70	8.26	-3.81	-2.24	0.64	0.73	27
18	0.69	0.51	367.70	244.31	-1.20	-0.66	0.83	0.60	31
19	0.47	0.69	341.28	588.03	-0.91	-0.88	1.04	0.60	32
20	0.41	0.41	3.30	1.96	-1.36	-1.57	0.81	0.70	33
21	0.24	1.95	8822.03	11157.16	-0.85	0.21	0.84	0.54	34
22	0.31	0.59	4705.69	3708.95	-3.12	-2.87	0.67	0.54	36
23	0.26	0.37	3366.52	2552.14	-2.46	-1.63	0.98	0.58	38
24	0.09	0.04	7.83	5.10	-14.30	-20.95	0.71	0.97	41
25	0.41	0.63	540.39	128.45	0.28	-0.01	0.80	0.56	42
26	0.29	0.41	473.81	759.51	-1.05	-0.48	1.19	0.59	44
27	0.22	0.32	19.03	18.30	-1.94	-0.53	0.73	0.70	46
28	0.18	0.55	973.83	1041.98	-3.35	-1.21	1.12	0.88	48
29	0.41	0.59	225.88	229.07	-1.38	-2.08	0.80	0.43	49
30	0.41	0.51	263.94	93.94	0.59	-1.09	0.84	0.84	50

## STABILITY OF MANIPULATION - FACTUALLY BASED DELPHI

STATEMENT NUMBER	% CHANGE BETWEEN ROUNDS						20%		15%	
	MANIPULATED			NON-MANIPULATED			STABILITY FIRST REACHED IN ROUND		STABILITY FIRST REACHED IN ROUND	
	1-2	2-3	3-4	1-2	2-3	3-4	MANIP	NON-MANIP	MANIP	NON-MANIP
1	0.70	0.40	0.17	0.47	0.17	0.07	4	3	5	4
2	0.57	0.20	0.20	0.47	0.30	0.17	3	4	5	5
3	0.60	0.27	0.20	0.47	0.37	0.20	4	4	5	5
4	0.67	0.33	0.23	0.47	0.20	0.13	5	3	5	4
5	0.53	0.27	0.23	0.43	0.33	0.17	5	4	5	5
6	0.40	0.23	0.10	0.53	0.23	0.23	4	5	4	5
7	0.67	0.33	0.20	0.60	0.20	0.17	4	3	5	5
8	0.67	0.40	0.33	0.33	0.23	0.13	5	4	5	4
9	0.40	0.30	0.13	0.50	0.37	0.23	4	5	4	5
10	0.57	0.50	0.20	0.23	0.13	0.20	4	3	5	3
11	0.40	0.50	0.27	0.53	0.40	0.10	5	4	5	4
12	0.70	0.47	0.33	0.43	0.30	0.07	5	4	5	4
13	0.73	0.43	0.20	0.37	0.13	0.17	4	3	5	3
14	0.33	0.20	0.20	0.20	0.10	0.13	3	2	5	3
15	0.50	0.20	0.23	0.60	0.30	0.23	3	5	5	5
16	0.57	0.23	0.20	0.47	0.30	0.17	4	4	5	5
17	0.57	0.37	0.27	0.30	0.27	0.20	5	4	5	5
18	0.50	0.37	0.20	0.47	0.23	0.23	4	5	5	5
19	0.60	0.27	0.17	0.50	0.33	0.20	4	4	5	5
20	0.53	0.37	0.33	0.27	0.17	0.20	5	3	5	5
21	0.67	0.27	0.30	0.47	0.30	0.37	5	5	5	5
22	0.67	0.23	0.30	0.37	0.23	0.13	5	4	5	4
23	0.67	0.30	0.30	0.43	0.20	0.10	5	3	5	4
24	0.33	0.33	0.07	0.03	0.17	0.07	4	2	4	2
25	0.77	0.50	0.20	0.50	0.43	0.10	4	4	5	4
26	0.43	0.47	0.23	0.33	0.23	0.17	5	4	5	5
27	0.57	0.43	0.23	0.57	0.37	0.27	5	5	5	5
28	0.50	0.37	0.17	0.40	0.23	0.20	4	4	5	5
29	0.47	0.30	0.10	0.43	0.20	0.13	4	3	4	4
30	0.67	0.47	0.23	0.43	0.17	0.03	5	3	5	4
AVERAGES	0.57	0.34	0.22	0.42	0.25	0.17	4.33	3.77	4.87	4.37

## STABILITY OF MANIPULATION - VALUE LADEN DELPHI

STATEMENT NUMBER	% CHANGE BETWEEN ROUNDS MANIPULATED			NON-MANIPULATED			20% STABILITY FIRST REACHED IN ROUND		15% STABILITY FIRST REACHED IN ROUND	
	1-2	2-3	3-4	1-2	2-3	3-4	MANIP	NON-MANIP	MANIP	NON-MANIP
1	0.37	0.17	0.20	0.17	0.10	0.07	3	2	5	3
2	0.47	0.30	0.13	0.30	0.03	0.10	4	3	4	3
4	0.67	0.27	0.10	0.37	0.10	0.20	4	3	4	3
5	0.30	0.30	0.23	0.40	0.20	0.10	5	3	5	4
6	0.37	0.13	0.10	0.33	0.07	0.10	3	3	3	3
8	0.47	0.20	0.07	0.23	0.07	0.10	3	3	4	3
9	0.57	0.33	0.20	0.27	0.10	0.10	4	3	5	3
11	0.20	0.17	0.17	0.30	0.10	0.03	2	3	5	3
12	0.53	0.33	0.30	0.27	0.20	0.13	5	3	5	4
13	0.27	0.27	0.23	0.37	0.27	0.20	5	4	5	5
15	0.47	0.33	0.27	0.27	0.30	0.23	5	5	5	5
16	0.37	0.23	0.27	0.33	0.23	0.17	5	4	5	5
18	0.33	0.27	0.13	0.17	0.20	0.10	4	2	4	4
22	0.37	0.13	0.17	0.33	0.13	0.13	3	3	3	3
23	0.13	0.30	0.27	0.27	0.23	0.17	2	4	2	5
24	0.40	0.37	0.23	0.33	0.20	0.10	5	3	5	4
27	0.43	0.43	0.13	0.20	0.20	0.13	4	2	4	4
31	0.23	0.23	0.07	0.30	0.17	0.20	4	3	4	5
32	0.43	0.03	0.13	0.30	0.13	0.23	3	3	3	3
33	0.40	0.20	0.17	0.40	0.07	0.07	3	3	5	3
34	0.53	0.23	0.17	0.30	0.13	0.17	4	3	5	3
36	0.37	0.27	0.17	0.20	0.17	0.10	4	2	5	4
38	0.50	0.20	0.13	0.27	0.23	0.07	3	4	4	4
41	0.33	0.20	0.03	0.17	0.27	0.17	3	2	4	5
42	0.53	0.20	0.10	0.43	0.20	0.10	3	3	4	4
44	0.37	0.17	0.10	0.33	0.23	0.13	3	4	4	4
46	0.40	0.07	0.13	0.27	0.17	0.17	3	3	3	5
48	0.37	0.23	0.17	0.33	0.03	0.03	4	3	5	3
49	0.40	0.23	0.20	0.43	0.23	0.13	4	4	5	4
50	0.50	0.27	0.07	0.30	0.13	0.23	4	3	4	3
AVERAGES	0.40	0.24	0.16	0.30	0.16	0.13	3.70	3.10	4.27	3.80

## STABILITY OF MANIPULATION - VALUE LADEN DELPHI

STATEMENT NUMBER	% CHANGE BETWEEN ROUNDS MANIPULATED			NON-MANIPULATED			20% STABILITY FIRST REACHED IN ROUND		15% STABILITY FIRST REACHED IN ROUND	
	1-2	2-3	3-4	1-2	2-3	3-4	MANIP	NON-MANIP	MANIP	NON-MANIP
3	0.23	0.13	0.17	0.23	0.23	0.13	3	4	3	4
7	0.20	0.17	0.20	0.27	0.27	0.10	2	4	5	4
10	0.27	0.20	0.17	0.17	0.13	0.03	3	2	5	3
14	0.20	0.17	0.23	0.17	0.17	0.13	2	2	5	4
17	0.13	0.37	0.10	0.27	0.23	0.10	2	4	2	4
19	0.27	0.17	0.17	0.33	0.27	0.03	3	4	5	4
20	0.30	0.27	0.13	0.20	0.30	0.13	4	2	4	4
21	0.27	0.17	0.10	0.27	0.23	0.13	3	4	4	4
25	0.27	0.13	0.03	0.17	0.17	0.20	3	2	3	5
26	0.23	0.20	0.10	0.23	0.20	0.13	3	3	4	4
28	0.23	0.13	0.07	0.37	0.13	0.13	3	3	3	3
29	0.30	0.07	0.10	0.27	0.17	0.0	3	3	3	4
30	0.23	0.07	0.23	0.40	0.33	0.13	3	4	3	4
35	0.30	0.03	0.17	0.30	0.10	0.0	3	3	3	3
37	0.27	0.30	0.17	0.20	0.10	0.03	4	2	5	3
39	0.20	0.07	0.20	0.10	0.13	0.07	2	2	3	2
40	0.30	0.20	0.23	0.27	0.20	0.20	3	3	5	5
43	0.30	0.27	0.20	0.23	0.23	0.10	4	4	5	4
45	0.37	0.13	0.23	0.13	0.17	0.13	3	2	3	2
47	0.13	0.03	0.10	0.33	0.27	0.07	2	4	2	4
AVERAGES	0.17	0.14	0.10	0.16	0.13	0.07	1.93	2.03	2.50	2.47
	0.15	0.10		0.15	0.10	0.10	2.10	2.05	2.15	2.20

## CONFIDENCE AND MANIPULATION

STATEMENT NUMBER	PARTICIPANT	SELF-RATING DURING ROUND				ANSWER DURING ROUND (EXPRESSED AS ERROR)				DESIRED ANSWER AD	ACTUAL ANSWER A4-A1	DESIRED CHANGE IAD-A11	SELF-RATING CHANGE SR4-SR1
		SR1	SR4	SR2	SR3	A1	A2	A3	A4				
1	684	3	3	1	6	0.92	-0.18	-0.18	-0.18	0.29	-1.10	0.63	0
1	706	3	2	4	4	-0.59	0.11	0.33	0.33	0.29	0.92	0.08	-1
1	1489	2	2	1	4	-2.89	-0.59	-0.18	-0.18	0.29	2.71	3.18	0
1	1720	2	2	5	8	-0.59	0.11	0.11	0.11	0.29	0.69	0.88	0
1	1854	1	2	8	8	0.51	0.51	0.51	0.51	0.29	0.0	0.22	1
1	2008	4	5	6	2	-0.59	-0.59	-0.25	-0.25	0.29	0.34	0.08	1
1	2225	4	4	3	6	-0.18	0.11	0.11	0.11	0.29	0.29	0.47	0
1	2376	2	3	1	8	-2.89	0.33	0.33	0.33	0.29	3.22	3.18	1
1	2451	3	3	1	4	-2.89	-0.41	0.20	0.20	0.29	3.09	3.18	0
1	2639	3	2	8	2	0.51	0.51	0.0	0.29	0.29	-0.22	0.22	-1
1	2665	4	4	1	6	-0.81	-0.25	-0.25	-0.25	0.29	0.56	1.10	0
1	2947	1	1	1	7	-2.89	0.11	0.11	0.11	0.29	3.00	3.18	0
1	3217	3	2	6	1	-1.28	-1.28	0.80	0.80	0.29	2.08	1.57	0
1	3497	1	1	1	5	2.12	0.11	0.44	0.44	0.29	-1.68	1.03	0
1	4015	1	2	6	6	-0.18	-0.18	-0.18	-0.18	0.29	0.0	0.47	1
1	4080	1	2	1	6	-0.59	0.0	0.0	0.0	0.29	0.59	0.88	1
1	5371	2	1	4	5	-0.59	0.11	0.33	0.33	0.29	0.92	0.88	-1
1	5578	2	1	4	4	-2.89	-0.59	-0.18	0.33	0.29	3.22	3.18	-1
1	5823	2	1	4	6	-0.59	0.37	0.37	0.37	0.29	0.96	0.88	-1
1	6436	3	3	1	6	-2.89	0.11	0.11	0.11	0.29	3.00	3.18	0
1	6493	4	3	3	5	-0.59	0.11	0.37	0.37	0.29	0.96	0.88	-1
1	6520	1	2	9	8	0.33	0.33	0.33	0.33	0.29	0.0	0.04	1
1	6966	2	1	5	9	-0.18	0.37	0.37	0.29	0.29	0.47	0.47	-1
1	7244	4	3	1	4	-2.89	-0.12	0.33	0.33	0.29	3.22	3.18	-1
1	7366	3	4	6	6	-2.89	-2.89	-2.89	-2.89	0.29	0.0	3.18	1
1	7536	2	3	6	6	1.02	1.02	1.02	1.02	0.29	0.0	0.73	1
1	8150	2	2	4	9	-1.10	0.44	0.44	0.44	0.29	1.54	1.39	0
1	8224	2	2	6	6	0.11	0.11	0.11	0.11	0.29	0.0	0.18	0
1	8806	4	2	2	5	-2.89	0.11	0.20	0.25	0.29	3.14	3.18	-2
1	9091	1	1	5	6	16.93	0.58	0.58	0.37	0.29	-10.56	10.64	0
	AVERAGE	2.4	2.3			-0.58	-0.05	0.11	0.13		0.71	1.82	-0.1
2	684	3	4	6	6	0.24	0.24	0.24	0.24	0.27	0.0	0.03	1
2	706	3	3	6	6	-0.10	-0.10	-0.10	-0.10	0.27	0.0	0.36	0
2	1489	1	3	7	8	-0.32	-0.32	-0.32	-0.32	0.27	0.0	0.59	2
2	1720	2	2	2	6	1.19	0.32	0.32	0.32	0.27	-0.86	0.92	0
2	1854	1	3	1	8	5.90	0.09	0.09	0.09	0.27	-5.81	5.63	2
2	2008	3	3	6	8	0.09	0.09	0.24	0.24	0.27	0.15	0.18	0
2	2225	3	4	2	6	-3.31	-1.01	-1.01	-1.01	0.27	2.30	3.58	1
2	2376	1	1	6	8	0.60	0.37	0.37	0.27	0.27	-0.33	0.33	0
2	2451	2	2	6	6	-0.32	-0.32	-0.32	-0.32	0.27	0.0	0.59	0
2	2639	2	3	7	6	-0.10	-0.10	-0.10	-0.10	0.27	0.0	0.36	1
2	2665	2	2	7	6	-0.10	-0.10	-0.10	-0.10	0.27	0.0	0.36	0
2	2947	1	1	4	8	-1.70	-0.10	-0.10	-0.10	0.27	1.61	1.97	0
2	3217	2	2	2	6	0.60	-0.61	-0.61	-0.61	0.27	-1.20	0.33	0
2	3497	2	2	5	4	-0.61	-0.20	0.24	0.24	0.27	0.85	0.88	0
2	4015	1	2	6	5	-1.70	-1.70	-0.32	-0.32	0.27	1.39	1.97	1
2	4080	1	2	6	6	-0.32	-0.32	-0.32	-0.32	0.27	0.0	0.59	1
2	5371	3	3	4	4	-0.32	-0.10	0.24	0.27	0.27	0.59	0.59	0
2	5578	1	3	2	6	-1.30	-0.42	-0.42	-0.42	0.27	0.88	1.57	2
2	5823	2	2	6	6	-0.61	0.27	0.27	0.27	0.27	0.88	0.88	0
2	6436	2	2	6	6	-0.32	-0.32	-0.32	0.02	0.27	0.34	0.59	0
2	6493	3	3	6	6	-0.32	-0.32	-0.32	0.09	0.27	0.41	0.59	0
2	6520	1	1	6	6	0.09	0.09	0.09	0.09	0.27	0.0	0.18	0
2	6966	3	2	3	4	-0.61	-0.10	0.27	0.27	0.27	0.88	0.88	-1
2	7244	2	2	2	6	-2.06	-0.61	-0.61	-0.10	0.27	1.97	2.33	0
2	7366	3	3	6	6	-1.37	-1.37	-1.37	-1.37	0.27	0.0	1.64	0
2	7536	3	2	2	8	1.70	-0.32	-0.32	-0.32	0.27	-2.01	1.43	-1
2	8150	1	2	5	8	1.13	0.24	0.24	0.24	0.27	-0.69	0.86	1
2	8224	3	3	2	6	-1.01	0.09	0.09	0.18	0.27	1.19	1.78	0
2	8806	1	3	4	6	0.60	0.24	0.24	0.24	0.27	-0.36	0.33	2
2	9091	1	2	4	4	-1.01	-0.32	0.27	0.27	0.27	1.28	1.28	1
	AVERAGE	2.0	2.4			-0.18	-0.22	-0.11	-0.07		0.11	1.10	0.4

## CONFIDENCE AND NON-MANIPULATION

STATEMENT NUMBER	PARTICIPANT	SELF-RATING DURING ROUND				ANSWER DURING ROUND (EXPRESSED AS ERROR)				DESIRED ANSWER	ACTUAL CHANGE	DESIRED CHANGE	SELF-RATING CHANGE
		SR1	SR4	SR2	SR3	A1	A2	A3	A4				
1	138	2	2	9	9	-0.59	-0.59	-0.59	-0.59		0.0		0
1	302	3	3	6	6	-0.18	-0.18	-0.18	-0.18		0.0		0
1	351	1	2	5	8	-1.10	-0.81	-0.81	-0.81		0.29		1
1	900	2	3	4	6	-1.28	-0.81	-0.81	-0.81		0.47		1
1	1114	4	3	1	6	-2.89	-1.10	-1.10	-1.10		1.79		-1
1	1446	4	4	6	6	0.33	0.33	0.33	0.33		0.0		0
1	1500	1	2	1	6	0.33	0.11	0.11	0.11		-0.22		1
1	2087	2	3	3	6	-1.79	-1.50	-1.50	-1.50		0.29		1
1	2096	4	5	7	7	-0.41	-0.41	-0.41	-0.41		0.0		1
1	2384	3	4	6	6	-2.89	-2.89	-2.89	-2.89		0.0		1
1	3421	4	3	5	6	-0.94	-0.69	-0.69	-0.69		0.25		-1
1	3431	1	3	6	6	-0.41	-0.41	-0.41	-0.41		0.0		2
1	3641	2	3	7	6	-2.89	-2.89	-2.89	-2.89		0.0		1
1	3813	2	3	4	4	0.61	0.0	-0.18	-0.33		-0.93		1
1	4132	4	3	1	4	-2.89	-0.25	-0.41	-0.41		2.48		-1
1	4344	3	3	6	6	0.11	0.11	0.11	0.11		0.0		0
1	4688	2	2	6	6	-0.18	-0.18	-0.18	-0.18		0.0		0
1	4705	4	2	6	4	-1.50	-1.50	-0.59	-0.59		0.92		-2
1	5585	1	1	5	6	1.43	-0.18	-0.18	-0.18		-1.61		0
1	5828	2	2	6	6	-0.41	-0.41	-0.41	-0.41		0.0		0
1	6817	1	3	9	6	-0.59	-0.59	-0.59	-0.59		0.0		2
1	6873	3	2	8	8	-1.10	-1.10	-1.10	-0.81		0.29		-1
1	6954	1	1	4	4	0.33	-0.12	-0.25	-0.25		-0.58		0
1	7645	3	3	6	4	-1.28	-1.28	-0.94	-0.94		0.34		0
1	8136	2	3	4	6	-1.79	-0.69	-0.69	-0.69		1.10		1
1	8728	3	4	3	6	0.0	-0.18	-0.18	-0.18		-0.18		1
1	8811	3	3	8	6	-0.94	-0.94	-0.94	-0.94		0.0		0
1	9214	1	3	5	5	0.11	-0.18	-0.18	-0.18		-0.29		2
1	9902	2	2	4	6	-1.28	-0.94	-0.94	-0.94		0.34		0
1	9965	3	3	8	6	-2.20	-2.20	-2.20	-2.20		0.0		0
	AVERAGE	2.4	2.8			-0.88	-0.75	-0.72	-0.72		0.16		0.3
2	138	1	3	8	8	-0.32	-0.32	-0.32	-0.32		0.0		2
2	302	1	2	4	4	-0.79	-0.61	-0.32	-0.20		0.59		1
2	351	1	4	6	6	-0.61	-0.61	-0.61	-0.61		0.0		3
2	900	2	4	6	6	-0.61	-0.61	-0.61	-0.61		0.0		2
2	1114	1	1	1	2	-4.92	-1.01	-0.61	-0.10		4.83		0
2	1446	2	2	8	3	-0.61	-0.61	-0.32	-0.32		0.29		0
2	1500	1	1	4	9	-1.81	0.09	0.09	0.09		1.90		0
2	2087	1	4	6	2	0.60	0.60	0.09	0.09		-0.51		3
2	2096	2	2	4	4	0.78	0.37	0.24	0.09		-0.69		0
2	2384	2	3	3	6	0.60	0.37	0.37	0.37		-0.22		1
2	3421	3	2	6	4	0.37	0.37	0.24	0.09		-0.29		-1
2	3431	1	3	6	6	-0.10	-0.10	-0.10	-0.10		0.0		2
2	3641	1	3	3	4	1.13	-1.01	-0.10	-0.10		-1.22		2
2	3813	2	4	6	6	-0.10	-0.10	-0.10	-0.10		0.0		2
2	4132	2	3	9	6	-0.32	-0.32	-0.32	-0.32		0.0		1
2	4344	3	3	6	6	0.93	0.93	0.93	0.93		0.0		0
2	4688	2	3	6	6	0.60	0.60	0.60	-0.10		-0.69		1
2	4705	3	3	6	6	-0.61	-0.61	-0.61	-0.61		0.0		0
2	5585	1	2	5	7	1.47	0.09	0.09	0.09		-1.39		1
2	5828	3	2	4	5	0.75	0.24	-0.10	-0.10		-0.84		-1
2	6817	3	2	7	6	0.31	0.31	0.31	0.31		0.0		-1
2	6873	2	2	2	8	-0.61	-0.32	-0.32	-0.32		0.29		0
2	6954	1	1	8	4	-0.32	0.37	0.24	0.24		0.56		0
2	7645	2	3	6	6	-0.61	-0.61	-0.61	-0.61		0.0		1
2	8136	2	2	1	6	-4.01	0.09	0.09	0.09		4.09		0
2	8728	2	4	3	6	-0.32	-0.22	-0.22	-0.22		0.10		2
2	8811	2	3	5	8	-1.30	-0.61	-0.61	-0.61		0.69		1
2	9214	1	2	7	7	0.60	0.60	0.60	0.60		0.0		1
2	9902	1	2	5	9	0.60	-0.10	-0.10	-0.10		-0.69		1
2	9965	1	3	8	6	-0.10	-0.10	-0.10	-0.10		0.0		2
	AVERAGE	1.7	2.6			-0.31	-0.09	-0.07	-0.08		0.23		0.9