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A SIMULTANEOUS PREFERENCE REPORTING METHODOLOGY APPLIED TO THE NEBRASKA AGRICULTURAL COMMUNITY

Bonnie R. Nutt-Powell and Levi Sorrell

MIT Energy Laboratory Technical Report
No. MIT-EL-78-040

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PREPARED FOR THE UNITED STATES

DEPARTMENT OF ENERGY

Under Contract No. EX-76-A-01-2295
Task Order 37

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PV Agricultural Field Test and Exhibit, University of Nebraska Agricultural Experimental Station, Mead, Nebraska

Photo by Richard Amster

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NOTE: Appendices are available on request from:

MIT Energy Laboratory
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ABSTRACT

One of a series of publications which are part of the institutional analysis research conducted under the Department of Energy's Photovoltaic (PV) Program, this paper describes the Simultaneous Preference Reporting Methodology and reports the results of collecting data in conjunction with an agricultural field test of PV in Mead, Nebraska. The authors find that in the Nebraska Agricultural Community, PV is an undifferentiated innovation. They also conclude that the Simultaneous Preference Reporting Methodology is a promising diagnostic and predictive tool regarding the acceptance of institutional innovation.

The Energy Laboratory of the Massachusetts Institute of Technology, under contract with the US Department of Energy (DOE), is investigating the economic, marketing, and institutional factors which will affect the adoption and use of photovoltaic energy systems in the United States. This paper is one portion of the institutional analysis. The data analyzed here were collected in September 1977 at the Nebraska State Fair in Lincoln, Nebraska. They represent an attempt to develop a new reporting methodology for ascertaining citizen preference and ability to differentiate with regard to the expenditure of public (federal) monies on the research and development of a new technology -- photovoltaic (PV) solar energy.

In institutional analysis, large groups (or masses) of the citizenry are "collectivities" -- one of six institutional entities. In order to understand and analyze the factors influencing the acceptance by collectivities of an innovation (in this case, photovoltaic energy systems), it is necessary to develop a means for diagnosing and/or predicting collectivity response to innovation. This paper discusses a technique for achieving that purpose. It has been labeled a Simultaneous Preference Reporting Methodology.

This methodology has two objectives: (1) diagnosing the state of innovation acceptance within a specific institutional arena by ascertaining the extent to which collectivities express differentiated preferences with regard to allocation of money; and (2) predicting future acceptance

of innovation by collectivities in the studied or in comparable institutional arenas. These objectives serve DOE's goal: defining points and means of intervention to accelerate acceptance of photovoltaic solar energy. Clearly, the facilitation of supportive and the minimization of hindering institutional response would be a part of this effort.

In the Simultaneous Preference Reporting Methodology, employed here, respondents were asked to complete a survey instrument which modified the budget pie technique with a pricing method. Respondents allocated finite funds (a "budget dollar") among seven possible research and development categories. This paper analyzes the relationship between collectivities and their perceptions (represented by their budget dollar allocations) of the requirements of federal funding to advance a specific technological innovation (PV). When these responses were analyzed, it was found that within the Nebraska agricultural community (AgCom), PV is an almost totally undifferentiated innovation. There was minimal (and in many instances, no) differentiation among budget dollar allocations. However, the simultaneous preference reporting methodology does appear promising as a diagnostic and predictive tool for understanding the extent to which collectivities within an institutional arena are prepared to accept innovation.

This paper summarizes the theory and decisions that led to use of a simultaneous preference reporting technique. It also briefly describes the overall PV research effort; outlines the theory of institutional analysis applied here; explains the Simultaneous Preference Reporting Methodology; analyzes the data collected in conjunction with the PV

agricultural field test at Mead, Nebraska; and offers conclusions on this research as well as recommendations for further development of the methodology.

PROJECT BACKGROUND

Until very recently, photovoltaic (PV) technology, a process which directly converts sunlight into electricity, was virtually unknown outside of the aerospace industry and a handful of research institutions. (See the brochure in Appendix 3 for a simplified explanation of the operation of a solar PV system.) It is still often confused with solar-thermal technology, a heat-transformation process which is the "solar energy" currently in limited residential use. It is solar-thermal to which most people refer when they speak of "solar energy." Although the basic principles of PV have been understood for some years, PV, today, is a technology "still in its infancy." PV is not merely an alternative source of energy; it is, in fact, a technological innovation.

The US Department of Energy (DOE) [and, prior to the creation of DOE the US Energy Research and Development Administration] has established as a major program objective: "... exploring the applicability of solar photovoltaic (PV) systems to meet real, near term energy needs ..." (DOE, 1977). The technology of PV is now primitive -- and expensive. DOE wants to reduce costs while refining the "hardware." In late 1976, MIT's Lincoln Laboratory began a series of field tests and applications of PV systems. A primary objective of the field tests is establishing the technical credibility of PV through actual demonstration (DOE, 1977).

Though other field tests are planned (residential, institutional, and so on) and DOE, in cooperation with Lincoln Lab and the National Park Service, is now developing a PV system for Natural Bridges National Monument in Utah (scheduled to be operational in the summer of 1979), the

only large-scale PV field test now in operation is an agricultural application near Mead, Nebraska. This PV system runs a ten-horsepower irrigation pump, moving 720,000 gallons of water in a twelve-hour day through an automated gate system[1] to irrigate eighty acres of corn. The PV system is also used for crop-drying. The 12,000 bushels of corn harvested from the eighty acres have been dried in crop-drying bins powered by PV.

The decision to have an agricultural application as the first large field test of PV stemmed partially from the research need to proceed with a sufficiently large experiment to provide an adequate body of performance data.[2] Also, the agricultural sector offered the opportunity for a large-scale field test with many fewer obstacles than residential, institutional, industrial, or central power tests, eliminating, for example, building compatibility tests, permitting procedures, negotiation with utilities, and rate setting.[3] While such research will eventually occur, it was necessary to begin to monitor long-term performance while the equipment was in actual use. Also, if PV systems and applications are to be available for more general use in the 1980s (DOE's timetable), the agricultural sector provides a unique opportunity for testing, given the volume and pattern of its energy use, i.e., the "average" farm uses larger amounts of energy than does the "average" residence. Moreover, energy provision in the sector is expensive, given the capital costs of power line installation to highly dispersed users, as well as the purchase and maintenance of "back-up" power sources (diesel generators, for example) by users.

Irrigation, in particular, consumes large amounts of energy. Because of the pattern of peak demand, powering an irrigation system with PV is a fairly obvious choice of an initial agricultural field test.

There were (and are) several reasons for placing this first large-scale PV field test in Nebraska. Among locational criteria were: high rates of agricultural production; widespread use of irrigation; limited indigenous energy resources; and a highly visible, readily available geographical location for the field test. Several states were considered then rejected as field-test sites. Texas was eliminated because it has large amounts of indigenous fuel; New Mexico and Arizona are already experimenting with irrigation systems powered by solar-thermal energy systems. In short, Nebraska was the only state that met all the criteria. Additionally, the Institute of Agriculture and Natural Resources (IANR) of the University of Nebraska-Lincoln (UN-L) was available to assist Lincoln Lab in installing and operating the PV system as part of UN-L's ongoing agricultural experimentation. IANR provided a site for the field test at the University Field Laboratory near Mead, which is about forty miles from the university's main campus in Lincoln. The field lab is part of IANR's Agricultural Experiment Station. A field test at this location is assured of high visibility, within the state's agricultural community, especially in July when the university's Agriculture Engineering Department sponsors its annual Tractor Day. Tractor Day, when an estimated 25,000 people visit the Mead station, is a display of new farm equipment and techniques. Since the field test will be in active operation for five years, each Tractor Day allows for

continuing the exposure of this population to the new technology.

As work progressed on construction of the test PV system, other researchers at MIT's Energy Laboratory concentrated their efforts on research designs for the economic, marketing, and institutional analysis components of the PV project. While it was clear that the field test offered unique opportunities to collect non-technical data, it was equally clear that the study of an innovation such as PV presented unique difficulties. There is, of course, a broad literature on innovation diffusion. (For reviews of this material, see Landers and Nutt-Powell, 1978; Lilien, 1978; and Nutt-Powell et.al., 1978 a and b.) It is generally agreed that the currency of innovation is information. Innovation becomes convention through a process of information acquisition and incorporation (Nutt-Powell, et.al., 1978 b). Thus, it became critical to the non-technical project elements to provide information on PV to the population to be studied -- the agricultural community in Nebraska. This need for information provision was partially filled by general publicity within Nebraska as the university released information and announcements, including a brochure on the field test (See Appendix 1.) With the mid-May "formal" announcement of the field test by UN-L and Lincoln Lab, political interest was generated, and several of Nebraska's ranking elected officials, including the governor, indicated their wish to participate in the "opening" of the solar demonstration scheduled for 27 July, the day before Tractor Day. Lincoln Lab, the Energy Lab, and especially UN-L began serious planning for "Dedication Day." In

addition to the usual ribbon-cutting, speech-making, and lunch-providing, it was suggested that an "exhibit" that would explain PV and the field test be prepared. This idea, which was implemented, became an important component of the marketing and institutional research areas. It served as the exposure (the "experiment") for the market research, and it also served as the source of information, the perturbation prompter, for institutional data collection. PV is clearly an innovation, but its mere existence is an inadequate alteration of an institutional arena. Thus, the exhibit and its accompanying brochures served as an attention-getter for the public.

Project staff involved in institutional analysis joined with staff at Lincoln Lab in drawing up guidelines and overseeing design and construction of an exhibit. The fifteen-panel exhibit explains in simple prose the technology of PV and the purpose of the field test. Three working models allow spectators to "switch on (or off) the sun" in understanding the basics of PV technology. Figure 1 is a photograph of the exhibit in place at the Mead field test site.

It was decided that a second "exhibit," similar in style and content to the permanent Mead exhibit, would also be constructed. This exhibit would be portable and could be displayed at any location where explanation of PV and the field test might be useful. This portable exhibit was first used at the Nebraska State Fair in September 1977.

It was the acquisition of these exhibits that provided the opportunity and thus led to the decision to collect the data discussed in this paper.

INSTITUTIONAL ANALYSIS

Since the data collection and analysis discussed here were done under the rubric of institutional analysis, it is important to briefly define such work. (For a detailed discussion of these theories, see Nutt-Powell, et.al., 1978b.) An "institution" is defined as a discernible entity that carries or is the respository for social meaning. Institutions are characterized by function, activity, and role. There are six types of institutional entities: formal and informal organizations (the US Department of Transportation, a gang); members (an IBM executive); persons (Sally Ferguson); collectivities, whether known or unknown to members (the Environmental Movement); and social orders (the importance of education.) The institutional arena is the network of social exchanges between/among institutions. These exchanges, which occur over time, combine to yield a resource configuration. Thus, institutional analysis is the study of how and in what forms social meaning is created, transmitted, maintained, and/or changed.

In the PV study, it was posited that innovation is a deliberate and substantive alteration in the institutional arena. Information, which is, as noted earlier, the currency of innovation, is of two types: (1) Technical -- What do you trust?; and (2) Personal -- Whom do you trust? Institutions are considered to be risk averse, and innovation creates the condition for risk by disrupting social meaning. Thus, institutions will be more likely to accept an innovation (i.e., institutionalize it) if their information about that innovation is personal, since such exchanges are

more likely to link to routine, stable meaning (Nutt-Powell, et.al., 1978 b).

The central focus of the institutional analysis component of the PV study was to identify and explicate the ways in which the Nebraska agricultural community (AgCom), which was the institutional arena under consideration, handled the introduction of an innovation (PV). The disposition and reactions of various institutional entities and of the institutional arena as a whole were under study.

While the research design for institutional analysis could incorporate in-depth study of five of the six types of institutional entities, obtaining information on the response of collectivities to innovation presented problems. Time, funds, and personnel that would be needed to obtain sufficient data were not available,and traditional means seemed lacking to identify exchanges between/among institutional collectivities and assess the types of information exchanged. That is, it is possible to identify and interview representatives of various collectivities (i.e., by age, sex, profession, church affiliation, and the like), but it was impossible in this study to undertake such a task. Also, there was still the problem of providing potential respondents with accurate, understandable information on photovoltaic solar energy. The availability of the permanent exhibit at the Mead site on Dedication and Tractor Days and placement of the portable exhibit at the Nebraska State Fair in Lincoln provided this stimulus (via direct exposure to PV technology at the test site and through the explanation of PV in the exhibit) as well as the opportunity to obtain data on collectivity reaction

to PV. It also prompted the consideration of alternative (and perhaps more appropriate) methodologies for studying collectivity response to innovation.

RESEARCH DESIGN

Data were collected in connection with the exhibits at Mead and the State Fair to test the following propositions regarding the responses to innovation of various institutional collectivities within the Nebraska AgCom:

1. Collectivities will distinguish among types of activities in support of PV research and development to the extent that the information encountered is personal. Conversely, collectivities will be unable to differentiate activities to the extent that the information is technical.
2. There will be differences among collectivities regarding stages of innovation differentiation.

It could be said that the null hypothesis is that collectivities will not differentiate about innovation no matter what type of information is provided. This idea is further refined in institutional analysis by the notion that there are several stages of innovation acceptance and that during the initial stage only the introducer(s) of the innovation differentiate ideas about or actions involving the innovation.

Though it is difficult to predetermine the full range of collectivities which exist within an institutional arena, it was concluded that those which did exist could be identified, at least in this initial effort, by reference to sex, age, occupation (both primary and secondary), and organizational affiliation. No assumptions were made as to which

collectivities would be more likely to encounter PV information as personal. It was assumed that differences identified among collectivities would be transferable to other comparable institutional arenas where they would be diagnostic of innovation differentiation and predictive of the probable response of these collectivities to PV applications. Presumably, this predictive quality would enable the Department of Energy to devise an intervention strategy into such institutional arenas to accelerate the acceptance of photovoltaic solar technology.

It was decided to collect data at both Mead and the State Fair because the State Fair would provide access to a substantial cross-section of the entire Nebraska AgCom. The State Fair has an attendance of nearly one million during its eight days (The population of Nebraska is approximately 1.5 million.); Dedication and Tractor Days at Mead, attract a smaller (and narrower) portion of the population.

The potential respondents at Mead were presumed to be more likely to consider information about PV to be personal because of: (1) their interest in new equipment and techniques; (2) their greater likelihood of using PV in routine (everyday) activities; and (3) their source (the agricultural experiment station) of information is a trusted one where they normally (routinely) acquire materials on innovations. It was further presumed that the State Fair exhibit would provide personal information for at least some of the respondents because it described the field test at Mead (the trusted information source) and because people expect to find new information at the State Fair. In short, it was hypothesized that responses would reflect the way in which information is valued.

The survey instrument,described in detail in another section, asked respondents to divide a budget dollar among possible research and development activities. In considering possible responses by collectivities, it was thought that there might be differences in allocation between hardware and software activities, with hardware receiving higher value because of the relative ease of visualizing product innovations (things) as compared with/to process innovations, therefore,again increasing the likelihood that the exchanges on hardware/product would tend to be perceived as personal information. Also, because energy is a high cost item in Nebraska, and because a PV system would be a large capital expense, and because respondents would be more likely to understand (take as personal information) operating and capital (purchase) costs (two of the six) possible allocation categories), it was thought that these categories would receive higher allocations.

Description of Data Collection Sites

As previously noted, data were to be gathered at two locations -- the Mead Agricultural Station on Dedication Day (of the PV field test) and on Tractor Day, and at the Nebraska State Fair. At Mead, respondents would view not only the exhibit but also the PV and irrigation systems in the field test. The site, containing eighty acres of corn,was necessarily a large one. At the State Fair, the exhibit was located in the main Exhibition Hall. The State Fair display duplicated the Mead exhibit (on a somewhat smaller scale) with the addition of panels containing photos and text explaining the PV and irrigation

systems at Mead. At both locations, visitors picked up brochures as they entered the exhibit areas. (See Appendices 2 and 3 for examples of the brochures.) At Mead, each brochure contained a questionnaire. At the State Fair, questionnaires were stacked on a table, large enough for use by several respondents at the same time, between the last panel of the exhibit and the exit. Pencils were available at both sites. At both locations, the participation of the University of Nebraska was prominently noted.

Potential respondents viewed the entire exhibit, carrying with them brochures that followed the same story line as the panels of the displays. The last panel in each exhibit asked for their help in charting future directions for photovoltaic research, i.e., asked visitors to complete questionnaires. Thus, the survey instrument was self-administered, and respondents themselves chose whether or not to participate (self-selection). Research staff collected completed questionnaires at the close of each day.

The brochures for both sites were designed to be attractive and informative. A big, bright logo, with the slogan, "Switch on the Sun," was designed for use on exhibit panels and in the brochures. An effort was made to design the brochure so that it was colorful and eye-catching and could be used as a small poster. The text of both brochures provided information about the technology, the field test, and the opportunities for future use of PV. The chosen combinations of text and graphics were designed to encourage exhibit viewers to take the brochures home with them. Multicolored pencils, printed with the slogan, were also take-home items. In this instance, the research team was

providing information in a manner that is comparable to activities generally undertaken by product vendors -- encouraging public contact with the innovation (PV) through typical promotional information. (Again, for a more complete discussion of the overall institutional analysis methodology, see Nutt-Powell et.al., 1978b.)

Methodology

In the initial planning stages for this data collection, it was assumed that by obtaining data at Dedication and Tractor Days and then later at the State Fair through one-shot case studies (in traditional research terms -- X O),[5] it would be possible, useful,and necessary (given the weaknesses of the one-shot study) to compare (or contrast) the results of the two studies. Even if the respondent groups were highly dissimilar, it seemed reasonable to assume that it would be helpful to identify the variations in responses. As will be explained in later sections of this paper, such comparisons were not feasible. However, the important point here is the identification of the research design -- the one-shot case study. Campbell and Stanley (1963) identify this approach as a pre-experimental design and clearly point out its weaknesses, in particular,threats to the internal validity (the reliability) of the research at hand. The concern is, of course, that there are rival plausible hypotheses that better explain the obtained responses and, thus, the researchers' conclusions.

Reliability is necessarily a matter of priority; however,

it was decided that several factors mitigated fears about acquiring reliable data. First, the categorization of collectivities on the survey instrument (age, sex, occupation, and so on) would allow for an identification of bias as indicated in the assumptions discussed earlier. Second, while these assumptions had to be made explicit in the overall research design to maintain a level of quality in the research, this explicitness also defined the preconceptions that research staff believed would stimulate respondent interest in solar energy. For instance, it was assumed respondents under thirty years of age would express more positive reactions to PV than would over thirty respondents. Third, despite the research tradition of measuring a population prior to introducing the experimental X, research staff in this undertaking were not concerned with measuring knowledge about photovoltaics prior to the stimulus. Given the fact that PV technology is only now being developed and thus relatively little information has been published, it seemed reasonable to assume that very few potential respondents would have knowledge of PV prior to seeing the exhibit or the field test. The innovation had to be introduced into public consciousness before data could be collected on reactions and responses to PV. Thus, the usual concerns about the effects of testing on those being tested took on a different character. It was intended that the test (the exhibits, the brochures, and the survey instruments) have <u>some</u> effect on potential respondents. The problem, of course, was to stimulate response without controlling it.

As might be inferred from previous references to the materials in the exhibits and brochures, much attention was focused on what information to present

and how to present it. A glance at the brochures indicates that information on PV was provided in simple, straightforward terms, attempting to minimize technical language. It was also pointed out that PV is a "future" technology. The brochures reflected the material on the large exhibit panels. The exhibits used color photographs and working models: exhibit panels were done in bright orange and yellow. Bright colors were chosen as eye-catchers, to interest people in learning about the innovation. Multi-colored pencils, imprinted with the "Switch on the Sun" slogan, were also distributed. Intentionally, this approach is more reflective of a marketing strategy (by a vendor) than a traditional research design. It was felt that such an effort was necessary if potential respondents were to notice the innovation particularly because the information offered on the innovation, despite efforts to simplify, could not help but be complex.

The vendor strategy for information dissemination and data collection meant that the weaknesses associated with self-selection and self-administration in surveys would appear. It was assumed that respondents would include higher numbers of people opposed to and supportive of solar energy (or alternative energy sources in general) than a true random sample. Consequently, it is necessary to exercise certain cautions in projecting responses onto a larger population from this one-shot survey. These limitations could be mitigated if more sophisticated research designs were employed -- time series or multiple group testing, for example.

After much discussion, the research team decided to focus the items on the survey instrument on allocation of federal monies for research and development activities with regard to photovoltaic technology. A major

hypothesis of this research is that collectivities would differentiate among the suggested activities to the extent that they considered the information to be personal (as opposed to technical). Thus, if some or all collectivities understood (differentiated among) the allocation of dollars to the research and development activities, this information could be defined as personal either because of its perceived institutional impact (cutting energy costs) and/or because of the credibility of Mead or the State Fair. If such differentiation were observed, research staff could themselves differentiate among collectivities, indicating to ERDA (now DOE) which collectivities considered the information and/or the source as personal, thus providing points of possible intervention into the institutional arena -- collectivities that would facilitate institutional acceptance of PV. Such identification would also offer some indication of what might constitute a common data base for future and continuing use.

Also, as noted earlier, another portion of the overall PV research deals with marketing, including the development of a market model. (See Lilien, 1978.) This institutional data collection was seen as a step before the "would you buy" question since it was attempting to identify the acceptability of the new technology as a (potentially marketable) product to be developed with public monies. Hopefully, these institutional data could chart points of institutional entry for market researchers.

Because the dollars respondents were asked to allocate are public (tax) monies, it was thought important to impress upon respondents that resources are limited. For the same reason, it was necessary to incorporate

the range of research/development choices available to federal agencies. The critical issue, then, was the institutional allocation of limited public resources. Such allocations are not matters of independent preference, rather they are a series of normative, simlutaneous judgments (or assignments). It was this recognition of the simultaneity of allocations for research that initially led to the decision to focus the survey instrument on research and development issues. Also, people do make binary choices when they are permitted; however, a format that forces simultaneous judgments will push most respondents into more than two answers.

Once the decision was made to obtain simultaneous preference data, finding a format for the survey instrument was an obvious, though difficult, next step. (The next section of this paper is an item-by-item description of the design of the survey instrument.) McIver and Ostrom (1976) discuss the difficulties of obtaining information on citizen preference, pointing out that payment for public goods is separated from the delivery of such goods, thus:

> ... most individuals want "more" rather than "less" of any public goods, as long as they place a positive value on the goods. (Most individuals also prefer more of most private goods to less of them, but the necessity of paying for any amount of such goods forces them to reveal their preferences for goods in light of their costs.) (p.88).

Berry and Horton (1974) discuss at length the problems of "pricing" public goods. McIver and Ostrom dismiss the use of survey questions that simply ask respondents if they would like more or less of something. They turn to Clark (1974) who discusses various ways of asking survey questions to encourage respondents to "truthfully" reveal their

preferences for different levels of public goods in light of a budgetary constraint. Clark suggests the use of a budget pie:

> The budget pie is an appealing format in generating, tentatively, more information about values than many alternative instruments. But, if in principle it can achieve many ideals, precise results depend on several structural supports that can give way: conversion of money to utility, honest preference revelations, etc. These suggest that for certain populations, under certain conditions, the budget pie can be ideal, but for others it is grossly improper (p. 26).

In this instance, it was felt that self-selection would most likely screen out those respondents for whom a budget pie is an inappropriate form of survey research. It is conjectured that lower socioeconomic and less educated individuals are prime candidates for self-elimination (McIver and Ostrom, 1976, p. 91.). Research staff agreed that "honest preferences" could and would be assumed -- in any survey, some "joke" questionnaires are returned and must be eliminated. The conversion of money to performance and the direct relation of money to utility are clearly complex and confusing concepts. Respondent understanding of these aspects affects validity of the research. However, it was felt that by utilizing the budget pie format in this instance, staff could, at least, determine whether or not the format was at all useful in this institutional arena and replicable in others.[6]

McIver and Ostrom define two important validation criteria: convergent validity and construct validity. They write that: "Convergent validity may be thought of as confirmation by independent measurement procedures" (p. 92). They suggest using multiple measures and establishing correlations between these other measures and the data obtained via the budget pie.

In the research effort discussed in this paper, it was impossible, for a variety of reasons, to apply other techniques for measuring citizen preference. Consideration was given to developing two types of survey instruments and then distributing them alternately to potential respondents. While this approach will probably be used in future acquisition of data on collectivities, project staff felt that in this initial effort there was not sufficient time to develop two reliable survey instruments.

Consequently, no claims of convergent validity are made for this research. It is worth noting that, as further similar research is conducted, not only will McIver and Ostrom's guidelines for validation be applied, but the research design will also incorporate the materials on convergent validity developed by Campbell and Fiske (1959).

McIver and Ostrom say of construct validity:

> For scientific purposes, the most important characteristic of a measuring instrument or test is its construct validity. This type of a measure, or test, of a construct is the degree to which it ties into a network of related concepts (p. 94).

Kerlinger writes that:

> ... construct validation and empirical scientific inquiry are closely allied. It is not simply a question of validating a test. One must try to validate the theory behind the test (p.449).

Cronbach (1960) theorizes that construct validation is tripartite: (1) suggesting what construct accounts for test performance; (2) deriving hypotheses from the theory involving the construct; and (3) empirically

testing the hypotheses (p. 121).

Once again, as attempts were made to apply traditional research methodology to this hybrid effort, difficulties arise. Construct validity is obviously of importance with regard to the diagnostic and predictive qualities of a data base. Although the original assumptions included the notion that budget-pie allocations would enable researchers to predict responses for similar collectivities, this assumption was more of a hope than an underlying hypothesis of the research. Thus, while prediction was of interest, it was not paramount. What was (and is) a first priority is ascertaining whether or not collectivities will accept the proffered information as personal and thus differentiate among allocative activities. Of secondary importance was determining whether or not a budget pie format could be successfully used in the agricultural institutional arena at this stage of differentiation. In short, if respondents made discrete differentiations among research and development activities, then the construct on the two types of information and collectivities' acceptance of information could be considered valid. That is, some collectivities would view the information as personal, or at least more personal than would other collectivities. If such differentiations did not occur, then: (1) the construct may be invalid; (2) the survey instrument may be "improper;" (3) the modified null hypothesis may be correct -- that during this first stage of innovation, only introducers will have information sufficient to permit differentiated opinions on the innovation; (4) or some combination of the three explanations.

McIver and Ostrom suggest a simplified linkage model to test construct validity. They focus on public agency response to citizen preference and citizen satisfaction with services from "more responsive" public agencies (p. 94). This model could not be applied to ERDA (now DOE) research and development activities since ERDA officials were only beginning to voice their concerns about responding to citizen opinion. Most of the solar bureaucrats expressed interest in citizen preference but admitted that they had little or no information and that thus far ERDA had been unable to be "responsive" to public preferences. Also, since research and development activities are not services per se, it was thought that citizen satisfaction with these activities might not be a relevant concept. At best, it appeared that some collectivities would indicate dissatisfaction with spending any tax dollars on research. Finally, the vulnerabilities of the sample population (that is, the lack of control researchers had in obtaining a sample) would cast serious doubts on most of the traditional statistical measures of correlation. Given the limitations of the data set, the research group's decision was to eliminate such detailed statistical analysis in this study. It was decided to interpret responses in simple terms. A high preference (large allocation) to a particular activity would mean that, within limits (See next section on survey instrument design.), the information had been perceived as personal. Further, perception of information as personal would indicate an initial acceptance of the

innovation. A large allocation to a particular activity would indicate either that the respondent valued that activity highly or considered the current level of activity to be insufficient. It was thought unlikely that this latter response would occur with any frequency since the only information respondents were likely to have on PV research and development was provided through the exhibits and brochures where there was no indication of which activities had what amount of funds.

The Survey Instrument

As noted previously, two separate survey instruments were designed. In point of fact, the second questionnaire was a modification of the first effort, which was, in Clark's terms, "grossly improper." The decision to utilize a limited resource budget pie format requiring allocation of dollars to specific activities clearly indicated that the survey instrument would be composed of close-ended items. Also, the need to identify collectivities meant that to avoid overdependence on researcher judgment (i.e., to maintain uniformity) on categorization, it was vital that these items permit respondents to choose their own answers but within reasonable limits, to ensure that a manageable number of collectivities might be identified and coded.

Brevity was a crucial issue. While, as Payne (1951) points out, "...there is little tangible evidence..." proving that brevity and

simplicity are "actually important," it appears from respondents' confusion when faced with "loose," long questions with many large words that it is impossible to collect reliable data if brevity and simplicity are overlooked. Consequently, Payne's dictums (pp. 135 and 136) on number of words per question and use of difficult words were carefully (though perhaps not as successfully as one might hope) applied in writing each item. It was of course difficult to explain photovoltaic technology in simple prose. This difficulty was exacerbated by use of the budget pie format which is simple in style but complex in execution. Thus, much effort was expended on writing each item in language the AgCom would find familiar -- use of conversational English and use of words (subsidy, purchase price) that are identified with agriculture. As Payne emphasizes:

> The most critical need for attention to wording is to make sure that the particular issue which the questioner has in mind is the particular issue on which the respondent gives his answers (p.9.).

The first four items of both survey instruments were geared toward identification of collectivities, asking respondents their sex, age, occupation, and organizational memberships. (It will be helpful while reading this section to refer to Appendices 4 and 5, which contain copies of both survey instruments.) Inquiry as to sex and age (by ten-year cohorts) is straightforward, allowing for simple "Place a check in the appropriate box" questions. The items on occupational and organizational membership are modified open-ended questions. That is, limited space was provided for answers and examples of occupations were included in that question to guide respondents' answers. It is worth noting here that the decision to ask respondents to provide information on "secondary occupation" and

organizational affiliation stemmed from a background analysis of the agricultural community (McCaffrey, 1977 and Nutt-Powell, et.al., 1978 a) which indicated: (1) that many farmers (owners and operators) work at other jobs,especially during the winter months,though some maintain small businesses (repair shops, insurance agencies), year-round; and (2) that certain organizations (churches, the Grange, etc.) structure much of the social activity, and, thus, it was hypothesized, many information exchanges within the agricultural institutional arena. Also, it was hoped, as noted earlier, that farmers as a collectivity would differentiate among allocations in ways that would be significantly different from allocations by other collectivities. This hope was a major factor in deciding to focus on occupational collectivities. A modified version of the US Bureau of the Census Standard Occupational Codes(eliminating numerous categories and adding separate ones, such as farmer, student, and homemaker) was devised to categorize occupations when these data were coded. (See Appendix 6.)

Traditional budget pie formats use the dial and multiple cuts approaches, focusing on cutting up the circle or "slicing up the pie." These approaches were deemed too confusing for use in this instance, a caution raised in the literature (Clark, 1974; McIver and Ostrom, 1976). Instead, a thermometer approach was designed for use on Dedication and Tractor Days, asking respondents to pencil in, on the picture of a dollar bill, a level of funding for each activity. (See Appendix

4.) During the design stages, it was thought that the "cleverness" of this approach would encourage visitors to complete the questionnaires. Six categories of research and development activity were defined: purchase price, operating costs, design, technology, technical assistance, institutional and financial aids. A seventh semi-open-ended category, separate from the list of six, asked for "additional activities." Separating this activity from the close-ended ones resulted in respondents ignoring it. The one-dollar bill thermometer approach proved to be even more confusing than the dial method. Responses obtained at Mead can best be described as muddled, and ultimately, all data collected on Dedication and Tractor Days were discarded. While the thermometer approach must be deemed as unworkable (clever though it may be), there were other external factors (discussed in the next few pages) that contributed to the failure in data collection at Mead.

The final item on the survey instrument asked respondents where they would obtain further information on photovoltaic solar energy. This question was included as an effort to begin to identify the institutional networks between and among collectivities. Also, and more specifically, the agricultural community overview had indicated that, in most agricultural states, the USDA-funded Agriculture Extension Service was highly visible and considered highly credible. It was thought that if agricultural actors (particularly farmers and high school students--the next generation of farmers) indicated the Extension

Service as a probable source of information, it would be useful for ERDA to develop programs with the extension agents to further acceptance of PV.

Several weeks after Tractor Day, when it became clear that questionnaires had not been completed at the field test site nor were more than a handful mailed back to Cambridge (The Mead survey forms were mailers, with postage prepaid.), the survey instrument was thoroughly reviewed. As noted, the thermometer approach was discarded. For data collection at the Nebraska State Fair, a pricing method was devised. (See Appendix 5.) The same six categories of research and development activities, with minimal rewriting, were used, and again effort was directed toward simplifying the language employed. The seventh allocative category provided on the new form was simply labeled "other;" it was open-ended in that it allowed respondents to fill in whatever activity they chose within the limits of the budget dollar. On this form this category was listed with the other six. It was this category that allowed for a binary choice in that respondents could indicate monies should not be spent on developing photovoltaic technology but should be spent on research on other forms of energy (e.g., nuclear) or should be spent on totally unrelated activities (.e.g, farm price supports). This choice proved to be too subtle in that very few respondents allocated funds to this category, though it was not totally ignored as the seventh category had been at Mead.

Rubber stamps, in ten-cent increments, were available on a rotating rack;

bright green ink pads surrounded the rack. For each activity, respondents were able to stamp dollar amounts in a pricing circle. Respondents who wished to make even finer allocational decisions (i.e., other than in ten-cent increments) could use "Switch on the Sun" pencils, which were available for the taking.

A quick glance at the two survey instruments indicates large differences in layout. The Mead survey form is difficult to read, set in small type, and printed in brown ink on white paper, which provides little contrast for the eye. There are no subheads to break up the copy. The State Fair form has bold black headings as well as subheads and graphics to break up the density of the copy. Also, the Mead form was folded (partially to make it useable as a mailer); it was decided that the information was less confusing and appeared less formidable when laid out on a single page. The folded questionnaire seemed unending and was confusing. The simple questions on page one (sex, age, etc.) do not prepare the potential respondent for the complexities of simultaneous preference reporting on pages two and three. Thus, the State Fair form is a single, legal-sized sheet of paper.

Other problems with the Mead site were identified as: lack of a comfortable place to fill out the questionnaires; the exhibit lacked a clear entrance and exit; and there was no one to "help" or counsel potential respondents. To counter these problems at the State Fair,a large "lean-on" height table was provided; the table contained survey instruments, boxes of pencils, rubber stamps, ink pads, and an outsized calculator. Also, the exhibit panels and waist-high

curtain-and-pole dividers were utilized to create an environment which contained only the PV exhibit. There was a clear entrance and a definite exit. Structuring the physical arena in this way also forced respondents to walk by the data collection table and a panel asking for their help as they exited. The large calculator often caught their attention, and they stopped to fill out forms. Despite limited field staff, it was decided that one staffer could be "on duty" throughout the week of the State Fair. While not administering the survey, one person could encourage visitors to respond and could explain intricacies in the survey instrument. Redesign of the survey instrument combined with careful site design, including provision of an appropriate place to complete a self-administered questionnaire, and placement of one field staffer to encourage participation made the data collection at the State Fair a success.

DATA COLLECTION

The report which follows focuses on data collected at the Nebraska State Fair between 2 and 11 September, 1977. Since the first weekend of the fair was a holiday weekend, Labor Day, State Fair officials projected their largest attendance for the first four days. It would appear that such a projection can be considered to be substantially correct since the largest numbers of completed survey instruments were obtained during that weekend. The heavy rains clearly held down attendance on the first two days, as the local press and media regularly noted. Table 1 displays a breakdown of numbers of completed survey forms obtained on each day of the State Fair.

Since the collection sites, survey forms, data collection methods, and other materials provided have been described in detail in the preceding section of this paper, information on these items will not be repeated here.

It is, however, worth noting here that most of the State Fair respondents did not answer two of the items on the survey instrument. Very few completed forms contained information on organizational affiliation. In fact, these data were dropped from the analysis since it was felt such small amounts had been obtained as to be unrepresentative. The current working hypothesis is that respondents were unable to see any connection between that question and the rest of the survey and thus chose to ignore it. It is also possible that the notion that most members of

the agricultural community participate in various farm-social activities is no longer valid. The only definite information to be reported here is that data in this category were not obtained from respondents at the Nebraska State Fair.

The second item which was even more generally disregarded was the question (the last item on the survey form) seeking information on where respondents would look for more information on PV. It may be that once repondents had completed the budget pie portion of the questionnaire, they were disinclined to answer any more questions. It may also be the case that these respondents are not interested in obtaining further information on photovoltaic solar energy. Again, all that can be said is that data on this subject were not obtained from respondents at the Nebraska State Fair.

The remaining items on the survey forms (sex, age, occupation, and budget pie allocations) were coded and keypunched. A standard satistical package (Nie, et.al., 1975) was employed for the computer analysis. Results are discussed in the next section of this paper.

TABLE 1 Breakdown, by Day, of Completed Survey Forms Obtained at the Nebraska State Fair

Date	Number of forms
Friday, 2 September	0[a]
Saturday, 3 September	53
Sunday, 4 September	114
Monday, 5 September (Labor Day)	102
Tuesday, 6 September	68
Wednesday, 7 September	47
Thursday, 8 September	44
Friday, 9 September	40
Saturday, 10 September	99
Sunday, 11 September	50
TOTAL	617

[a]Since exhibit did not arrive in Lincoln until Saturday morning, it was impossible to distribute survey forms on Friday. Distribution began during the afternoon on Saturday.

DATA ANALYSIS AND RESULTS

Of the 617 completed survey forms, 475 were filled out by male respondents and 134 by females. (See Table 2.) There were eight "no answers." The high proportion of males to females (almost four to one) is somewhat unusual. One somewhat chauvinistic explanation is that males are more likely to be interested in new technologies than are females. Also, one of the field staff who "personed" the exhibit during the State Fair observed that, with "some" (though, unfortunately, uncounted) frequency, a male/female couple would walk through the exhibit, and only the male would complete a survey form.

Table 3 displays a breakdown of respondents by ten-year age cohorts. The largest number of respondents (41 percent of the total) fell within the twenty-to-twenty-nine-year-old age group. It is thought that this disproportionate representation is a function of respondent self-selection. It seems reasonable to conclude that this age group will tend to be more interested in solar energy (i.e., more open to alternative ideas); more responsive to attractive exhibits; more willing to fill out survey forms; or a combination of two or more of these suppositions.

The most frequently represented occupational collectivity was that of farmer -- 126 of 617 respondents, or 20.4 percent. Again, it is only possible to hypothesize on the reasons for this occurrence. Nebraska is, after all, an agricultural state, and the State Fair, despite its size is very much a rural one, focusing on animal shows and country entertainment.

Also, the exhibit on PV told of an agricultural application of the new technology, presumably of more interest to farmers than to other viewers. The second largest collectivity represented was homemaker -- 99/617, or 16 percent. Students were third -- 53 for 8.6 percent; non-college teachers were fourth -- 32 for 5.2 percent, probably another effect of respondent self-selection. The fifth largest occupational collectivity was engineers -- 20 for 3.2 percent. Again, it seems reasonable to assume that respondent self-selection would result in more technically oriented collectivities to notice a display telling of a new technology and presumably be more likely to hold and offer opinions on it. Appendix 7 presents a summary of primary and secondary occupations.

The secondary occupations reported do not seem to support the original assumption that many farm owners/operators work at non-farming jobs at least during the winter months, since, again, the occupation listed most often was that of farmer -- 35 of 1978 respondents reporting secondary occupations, or 19.6 percent. Possibly, some secondary jobs turned out to be more profitable than farming, and a switch occurred, but that is conjecture. Other secondary occupations fall into more predictable categories: retail sales -- 8.9 percent; homemaker -- 6.7 percent (Presumably, listing homemaker as a secondary occupation reflects not only the increasing numbers of women with careers but also the growing recognition that homemaking is a very real occupation.); non-college teacher -- 11 or 6.2 percent (The assumption here is that these persons are substitute public school teachers or self-employed music and art instructors.); and student -- 10, or 5.6 percent. In total, 28.8 percent of the 617

respondents reported secondary occupations. It is, of course, impossible to know how many respondents chose to list only one professional responsibility when, in fact, they do have more than one form of employment. However, only 4.9 percent of the 617 respondents failed to list a primary occupation which lends some credence to the belief that most respondents simply did not consider themselves to have two forms of employment. By far, the most interesting listing of primary and secondary occupations was that of farmer and philospher. The most predictable (and most depressing) dual listing was homemaker and husband-pleaser.

As previously noted, data on organizational affiliation have been eliminated from this analysis.

Simultaneous preference allocations obtained through use of the redesigned budget pie format are summarized in Tables 4, 5, and 6. Appendix 8 contains the complete printouts of all allocations for each research and development activity. Table 4 displays (from highest to lowest) the mean and median allocations to each pricing category. Table 5 indicates the range of allocations. It is interesting to note that not one respondent assigned the entire $1.00 to a single research/development activity, although a $1.00 stamp was provided. Table 6 indicates the number and percent of respondents assigning some monies to each activity and the number and percent of respondents assigning no monies to each activity.

Probably "Other," the semi-open-ended item, should be considered a flaw in the design of the survey instrument. As noted earlier, the opportunity to use that item to indicate a binary choice -- in particular,

TABLE 2 Respondent Breakdown by Sex

Category Label	Absolute Frequency	Adjusted Frequency (Percent)
Male	475	78.0
Female	134	22.0
No Answer	8	Missing
TOTAL	617	100.0

Valid Cases 609 Missing Cases 8

TABLE 3 Respondent Breakdown by Age

Category Label	Absolute Frequency	Adjusted Frequency (Percent)
10-19	81	13.2
20-29	255	41.7
30-39	131	21.4
40-49	65	10.6
50-59	53	8.7
60 and over	27	4.4
No Answer	5	Missing
TOTAL	617	100.0

Valid Cases 612 Missing Cases 5

TABLE 4 Distribution, Mean, Median, Mode, of Simultaneous Preference Allocations/Budget Pie Technique

Research and Development Activity	Mean ¢	Median ¢	Mode ¢
Technology[a]	25.5	20.4	20.0
Design	21.5	20.0	20.0
Purchase Price	20.1	19.6	10.0
Operating Costs	18.9	19.6	10.0
Technical Assistance	13.0	10.2	10.0
Institutional and Financial Aids	12.8	10.1	10.0
Other	02.4	07.8	0.0

[a]Definitions of these categories as provided to survey respondents can be found in Appendix 5.

TABLE 5 Range of Simultaneous Preference Allocations/Budget Pie Technique

R&D Activity	Range (in ¢)[a]
Purchase Price	0 to 99
Technical Assistance	0 to 99
Other	0 to 99
Technology	0 to 85
Design	0 to 75
Operating Costs	0 to 70
Institutional and Financial Aids	0 to 70

[a]The broadest possible range is from 0¢ to $1.00.

TABLE 6 Numbers/Percentages of Respondents Assigning Some or No Funds by Research and Development Activity

Research and Development Activity	Respondents assigning some Funds		Respondents assigning no funds	
	Number	Percent	Number	Percent
Technology	579	93.8	38	6.2
Design	564	91.4	53	8.6
Operating Costs	530	85.9	87	14.1
Purchase Price	495	80.2	122	19.8
Technical Assistance	492	79.7	125	20.3
Institutional and Financial Aids	458	74.2	159	25.8
Other	83	13.5	534	86.5

N=617

to prefer not to spend federal dollars on photovoltaic research and development -- proved to be too subtle a distinction for most respondents. Most likely, if further research is conducted with a self-administered survey form, less obscure opportunities will be offered respondents so that it will be possible to compare reaction to PV research with opinions on other energy research. In this survey, only one respondent referred to another energy form, allocating $.05 to "Other," with the comment: "Stop oil company ripoff." One homemaker allocated $.15, saying: "More industry and jobs in central Nebraska." Two male respondents allocated no money to "Other," but both wrote: "Don't use tax dollars." One added: "Let me keep." Of the designations in this activity, the only groupings of categories (appearing more than three times) were labeled as advertising, promotion, or public education -- thirteen in all. Two respondents opted for practical demonstrations of PV -- perhaps influenced by the field test at Mead. Three persons suggested funding private industry to develop PV, and two others indicated research as their reason for allocating funds to the "Other" category -- thereby reminding us of Payne's dictum to be sure that the survey instrument is asking what respondents are answering. Most likely, when a self-administered, basically close-ended survey instrument is utilized, open-ended questions will fare about as well as this one did, i.e., a majority (86.5 percent) of the respondents will disregard them. A summary statement on this category is the $.03 allocation with this note:

> Hire someone To make up questionnaire (sic) on Reaction on PV so common Country folk can understand it.

In short, when all similar items are close-ended, it would be wise to eliminate even a semi-open-ended item unless the survey can be staff-administered.

The means and medians for allocations to other activities seem to indicate at least some minimum differentiation for the AgCom in general. As mentioned, the activities in Table 4 are arranged in order from highest to lowest mean/median. This order is not the one in which items appeared on the survey form, so at least this differentiation occurred. At first glance, it appears that some differentiation exists between hardware (Technology, Design, Price, Operating Costs) and software items (Technical Assistance and Institutional and Financial Aids). (Further analysis on this supposition appears in the section on factor analysis.) The four hardware items display means and medians that cluster around $.20. The software items show means of around $.13 and medians of $.10. Some effort was directed toward applying appropriate tests of statistical significance to the distributions of means and medians. However, upon consideration, it was felt that any conclusions based on traditional statistical tests that had been applied to a non-random sample (even utilizing various fudge factors to predict probability of occurrence for these distributions) begged the questions of rigor. It was decided to eliminate that information since it cannot be said to be statistically indicative of significance.

Table 6 indicates that almost three-quarters (74.2 percent) of the respondents assigned some money to every category (except "Other"). The

similarity (or evenness) of money assignment) casts some doubt on the notion that the AgCom, in general, differentiated amongst research/development activities. The fact that very few respondents allocated 0 cents to any category cannot be ignored (except, of course, to "Other").

It is interesting to note that the two activities with the highest means/medians and the largest number of respondents reporting do not display as broad a range as several other activities. The upper end of the budget dollar (above $.85) does not appear in the allocations for these activities.

It is thought that, given the number and amount of allocations to the activity, "Technology," that the information presented in the exhibit and brochure clearly communicated that PV is an "infant technology" and that much work remains to be done to develop it to market-level. Again, if more data are collected, further redesign of the survey instrument might concentrate on renaming this category to see whether or not the same definition with a different label would again display the highest mean and the largest number of responses.

Though various significance testing has been discarded -- because of concerns of validity/reliability stemming from the lack of a random sample, other analytic techniques have been employed. Before reporting on those results, it is worth noting that the few responses obtained to the final item on the questionnaire -- Where would you look for further information on PV? -- offer marginal support to the initial assumption that the AgCom finds the University of Nebraska (10 responses)

and the Extension Service (5 responses) credible informants and, perhaps, that the information obtained from those sources is perceived as personal. However, since so few respondents filled in this item (and most who did simply wrote in ERDA), these few responses cannot be considered to be significant.

Factor Analysis

To perform a factor analysis, it was first necessary to recode the fifty-three occupational categories into a more manageable number. These recodes are summarized in Table 7 and are displayed in full in Appendix 6.

As noted in the reporting of frequencies above, upon initial examination, the allocation pattern of simultaneous preferences seemed to indicate higher expenditures for technology-related variables -- price, operating costs, design, and "technology" -- and lower expenditures (or allocations) for non-technology variables -- technical assistance and institutional and financial support. In other words, hardware versus software. Since a large percentage of people (86.5) responded with a "zero" allocation for "Other," it was dropped from this analysis.

There are some dangers in using correlations as a method of analysis for a budget pie (dollar) survey instrument. Because it is close-ended, money allocated to one activity is necessarily taken away from the other activities. The result, then, is that two correlations may be set up where only one exists. This problem may well invalidate the

TABLE 7 Recodes for Occupational Categories (Primary Occupation Only)

Recode Number	Included Occupations
1	Professional, managerial, technical
2	Sales, secretarial, and service workers
3	Skilled and unskilled laborers and other operatives
4	Farmers and ranchers
5	Students
6	Homemakers
7	Miscellaneous (including military, retired)

TABLE 8 Factor Analysis Display

Variable	EST Communality	Factor	Eigen Value	Percent of Variable	Cumulative Percentage
Price	0.39422	1	1.67817	28.0	28.0
Opcost	0.23403	2	1.21826	20.3	48.3
Design	0.23570	3	1.01090	16.8	65.1
Technology	0.37797	4	0.93961	15.7	80.8
Assist	0.16743	5	0.87938	14.7	95.4
Instfin	0.15829	6	0.27366	4.6	100.0

After 15 iterations, communality of one or more variables exceeded 1.0. PA 2 factoring terminated at Iteration 14. Variables appear in the same order in which they are presented on the survey instrument.

TABLE 9 Communality of Variables

Variable	Communality	Factor	Eigen Value	Percent of Variable	Cumulative Percent
Price	0.65441	1	1.37572	53.9	53.9
Opcost	0.07355	2	0.67291	26.3	80.2
Design	0.55888	3	0.50549	19.8	100.0
Technology	0.98860				
Assist	0.11972				
Instfin	0.15897				

TABLE 10 Varimax Rotation

	Factor 1	Factor 2	Factor 3
Price	-0.43172	-0.35666	0.58380
Opcost	-0.25826	-0.07185	0.04107
Design	0.07554	0.74312	0.03071
Technology	0.98877	-0.01665	0.10323
Assist	0.02360	0.00384	-0.34517
Instfin	-0.11670	-0.20324	-0.32256

TABLE 11 Quartimax Rotation

	Factor 1	Factor 2	Factor 3
Price	-0.45554	-0.34499	0.57261
Opcost	-0.26185	-0.06027	0.03672
Design	0.10981	0.73819	0.04359
Technology	0.98547	-0.06467	0.11515
Assist	0.02827	0.00807	-0.34475
Instfin	-0.12185	-0.19251	-0.32720

use of factor analysis in budget-dollar surveys. Further analyses need to be performed in order to determine the validity of factor analysis in these instances. The inappropriateness of this technique may be the price that is paid for introducing the realistic concept of finite (even scarce) resources into survey analysis.

The factor analysis here is "Principal Factoring With Iteration," described in the SPSS Manual (Nie, et.al., 1975). Both varimax and quartimax rotations were utilized to approach simple structure; however, the results between the two rotations differed only in the second and third decimal places. The factor analysis is displayed in Tables 8 and 9. Three factors with eigenvalues greater than 1.0 were generated. (See Table 8.) Varimax and quartimax rotations are shown in Tables 10 and 11. The quartimax looks almost exactly the same as the varimax. The communality of the variables with these three factors indicates that only three of the variables (Price, Design, Technology) have a moderate-to-high communality, which is the variance in each of the items that is explained by the factors the program derives. (See Table 9 .) Remarkable, of course, is the extremely high communality of technology.

When the three factors are examined, the only variables with high factor loadings are Purchase Price, Design, and Technology, the same variables having high communalities. Technology loads primarily onto Factor 1 with a moderate contribution to this Factor from Price, which has a loading about half that of Technology. Design loads primarily onto Factor 2, while Price again has a moderate loading -- about half that of Design. Price has the highest loading of the variables contributing to Factor 3, but this loading is a moderate one and is not much higher than the loadings for Price

on Factors 1 and 2. Price is thus discredited because it does not load primarily onto one factor after rotation. Factor 3, then, has only low to moderate contributions from Technical Assistance and Institutional/Financial. In large part, Factors 1 and 2 may each be described by one variable (Technology and Design, respectively) since Price loads almost evenly across all three factors.

The original proposition that there would be two factors -- hardware, representing the four technological variables, and software, representing the two non-technological variables -- that appeared to be at least minimally supported by a look at the frequencies of allocation preferences, is not exhibited in the factor analysis.

Discriminant Analysis

To examine the influence of the identified occupational collectivities on allocation preferences, the seven recoded occupational collectivities (See Table 7.) were used in a discriminant analysis, where the discriminating variables were the budget-dollar items: Purchase Price, Operating Costs, Design, Technology, Technical Assistance, Institutional and Financial Aids (InstFin), and Other (the semi-open-ended item). The discriminatory criterion was the Rao's V. This method adds variables to the analysis until the point is reached where the addition of another variable results in less rather than more discriminatory power, as expressed in "distance between groups." The Rao's V process generated two variables for analysis: Institutional and Financial Aids (InstFin) and Other. Table 12 displays this information.

The analysis derived two functions -- the maximum number since only two variables were employed in the analysis. The standardized coefficients indicate that Function 1 is primarily composed of InstFin, while Function 2 is primarily composed of Other. Each coefficient represents the relative contribution of the associated variable to a function. Thus, in Function 1, InstFin is about four times as important as Other, while in Function 2, Other is about five times as important as InstFin. The standardized coefficients are displayed in Table 13.

In order to judge the importance of the two functions, it is necessary to examine two criteria: associated canonical correlations and Wilks' Lambda. Attention must be paid to each stage of derivation. Table 14 shows these statistics. The canonical correlation squared is the proportion of variance in the discriminant function that is explained by the occupational groups. It can be seen from Table 14 that the first function is somewhat correlated (though clearly not highly) and that the second function is slightly correlated. However, both correlations are low. The second criterion, Wilks' Lambda, is an inverse measure of the discriminating power that has not been accounted for by earlier functions -- beginning with zero functions. Thus,the larger the Lambda, the less information remaining. Both functions have relatively high Lambdas. Because there is no random sample, when associated significance tests are applied, the results must be viewed with caution. Hopefully, in future research, random samples will be obtained, and a more complete discriminant analysis can be performed.

Table 15 reports the centroids which summarize the occupational groups or collectivities in the reduced space defined by the discriminant functions.

Function 1 distinguishes Group 6 (homemakers) from the other groups, while Function 2 distinguishes Group 2 (Service Workers) and Group 5 (students) from the other five groups. There is, then, some discriminating power displayed, however, there is considerable overlap among the occupational groups, and they are not clearly separated. The overlap and lack of separation are further evidenced when reclassification of all cases is attempted in order to place the cases in groups based on discriminatory functions. See Table 16. The low percentage of correctly classified cases -- 15.02 percent -- is an almost painfully clear indication of these problems.

Therefore, the results of this discriminatory analysis suggest that the occupational groupings (collectivities) appear to be poor indicators of allocation preferences. It would seem at this time that collectivities defined by occupation have little predictive value that would enable researchers to identify intervention points in the agricultural institutional arena. Diagnostically, there is no differentiation.

Cross-Tabulations

Finally, a series of cross-tabulations were run as a last attempt to ascertain dependency between occupations and allocation preferences. The seven recoded occupational groups identified the columns of the contingency tables, while the research/development activities with their range of possible resource allocations formed the rows of the matrix. Clearly, attempting to use contingency tables put project staff on shaky ground. As has been pointed out in this paper, this research lacks a true

TABLE 12 Variables Generated Via Rao's V

Variable	Rao's V	Change in Rao's V	Sig. of Change[a]
InstFin	24.04959	24.04959	0.001
Other[b]	31.59552	7.54593	0.273

[a] Chi-square significance of change for large number of cases

[b] In this case, Other does not seem significant, but it was retained since it met Rao's criterion.

TABLE 13 Standardized Discriminant Function Coefficients

	Function 1	Function 2
Instfin	0.97849	-0.21196
Other	0.25933	0.96702

TABLE 14 Canonical Correlations and Wilks' Lambda

Discriminant Function	Eigenvalue	Relative Percentage	Canonical Correlation	Functions Derived	Wilks' Lambda
1	0.04383	80.31	0.205	0	0.9478
2	0.01075	19.69	0.103	1	0.9894

TABLE 15 Centroids of Groups in Reduced Space

		Function 1	Function 2
Group	1	-0.11575	-0.01255
Group	2	0.12934	0.25845
Group	3	-0.06942	0.00290
Group	4	-0.19250	-0.01701
Group	5	0.12429	-0.20399
Group	6	0.38646	-0.01774
Group	7	-0.20052	0.11112

TABLE 16 Prediction Results

Actual Group	Number of Cases	Predicted Group Membership Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Group 1	149	0 0.0%	12 8.1%	0 0.0%	**20** 13.4%	47 31.5%	26 17.4%	44 29.5%
Group 2	55	0 0.0%	9 16.4%	0 0.0%	3 5.5%	20 36.4%	10 18.2%	13 23.6%
Group 3	79	0 0.0%	9 11.4%	0 0.0%	10 12.7%	23 29.1%	15 19.0%	22 27.8%
Group 4	131	0 0.0%	11 8.4%	0 0.0%	19 14.5%	31 23.7%	22 16.8%	48 36.6%
Group 5	53	0 0.0%	1 1.9%	0 0.0%	6 11.3%	24 45.3%	13 24.5%	9 17.0%
Group 6	99	0 0.0%	8 8.1%	0 0.0%	7 7.1%	42 42.4%	31 31.3%	11 11.1%
Group 7	20	0 0.0%	5 25.0%	1 5.0%	2 10.0%	6 30.0%	1 5.0%	5 25.0%
Ungrouped Cases	31	0 0.0%	3 9.7%	0 0.0%	0 0.0%	10 32.3%	7 22.6%	11 35.5%

Percent of "Grouped" Cases Correctly Classified: 15.02%

random sample of the population under study. Since the null hypothesis applied in significance testing of contingency tables is that all observed differences are the result of sampling fluctuations, a random sample is a necessity. It was recognized that a serious analysis of the cross-tabs would be impossible, but it was thought that displaying the data in this way might provide new insights -- certainly no significant results had been obtained with factor and discriminant analyses.

The results of the cross-tabs were not as useful as the researchers had hoped. In other words, knowing the occupational collectivity of a respondent does not, at this point in time, help to predict that person's allocation preferences regarding PV. Similarly, as found in the discriminant analysis, there is no differentiation among collectivities in dollar allocations for PV. The innovation remains undifferentiated in the Nebraska AgCom.

What proved to be of enormous use, however, was simply the display of frequencies the contingency tables provided. Clearly, the effort to obtain a random sample might well be justified in order to rigorously analyze these finer delineations of frequencies. For instance the allocational preferences of the 131 farmers-ranchers do seem to lend some credence to the original hardware/software hypothesis. It is possible to "eyeball" the difference between the four technology-related activities and the remaining two (eliminating "Other"). Because a differentiation could be seen (though it could not be determined to be statistically significant) it

is interesting to speculate, on the basis of this differentiation, that because the exhibit, brochure, and survey instrument were agricultural in content and tone, the information came closer to being personal for farmers than for any other occupational collectivity. However, it must be admitted that such differentiation was not observed in the other six occupational collectivities. In any event, the matrices obtainable through cross-tabulations should prove useful in future research when a random sample can be obtained.

Cross-tabs by age and by sex were also generated. Again, the results of these tabulations were not statistically significant. However, it seems highly probable that the ten-year age cohort collectivities may prove useful in the future.

CONCLUSIONS AND COMMENTS

The analysis of data collected at the Nebraska State Fair in Lincoln indicates that the null hypothesis -- that collectivities will not differentiate about innovation no matter what type of information is provided -- cannot be rejected. In the Nebraska AgCom, photovoltaic solar technology is quite clearly an innovation that must be said to be in its initial undifferentiated stage; apparently, only introducers of PV (such as this project staff) are currently able (and willing) to differentiate among allocations for PV research and development activities.

There were no statistically significant observable differences among allocational preferences of the occupational collectivities in this sample. Most respondents spread their budget dollars across the entire range of research and development activities -- with, of course, the exception of the semi-open-ended category, which was fairly generally disregarded. There were a few "single-shot" large allocations, but these preferences did not emerge as representative of collectivity preference.

It seems clear that, despite efforts to make information on PV (the innovation) personal (i.e., indicating the information was provided via credible, already personal, sources, such as the University of Nebraska and the Field Experiment Station at Mead), none of the responding collectivities perceived the information as personal and thus accepted it sufficiently to distinguish, more than minimally, among budget dollar allocations. At this stage of innovation, identifying information as possibly personal is obviously not a sufficient stimulus for institutional collectivities to accept that information as personal. It seems reasonable to conclude, then, that

the AgCom respondents in this survey perceived none of the information on PV as personal; they did not place enough value on it to apply it when making choices about resource allocation. This lack of differentiation does seem to provide some validation for the underlying institutional analysis construct that these two types of information exist.

The discriminant analysis indicated that occupational groupings have little or no predictive value. Consequently, the hoped for ability to identify intervention points (for DOE to accelerate acceptance of PV) in the institutional arena has not been acquired through this survey. It is not possible, at this point in time, to use occupationally defined collectivities as entry points into the agricultural arena. Discriminant analysis also provides evidence that PV is an undifferentiated innovation.

While the factor analysis offers no support to a differentiation of allocation by AgCom respondents between hardware and software, observation of the frequencies of allocation does seem to imply that some minimal differentiation did occur. This notion will be pursued during an analysis of data collected on SunDay in Boston, Massachusetts.[7] The allocational preferences obtained in Boston will be compared with those collected in Nebraska. If the same indication, minimal though it is, of hardware/software differentiation appears, then efforts will be made to develop a rigorous means for testing it.

The problems with survey instrument design that have been thoroughly dissected in other portions of this paper will not be repeated here. What is important to note is the success, with the redesigned survey form, of the budget-pie format as instrumentation for a Simultaneous Preference Reporting Methodology. Despite the agonies of redesign and the cautions in

the literature, the budget-dollar pricing technique was understood by respondents from the Nebraska AgCom. Though it is possible that the lack of differentiation may partially result from confusion over syntax and definition, since respondents were able to correctly complete the forms, the more likely conclusion is that the survey instrument works and that the innovation (PV) is undifferentiated.

However, from the perspective of methodological development, some alternative propositions must be examined. Perhaps occupationally defined collectivities are not viable research entities in the agricultural arena. It may be that they are not useful in any institutional setting. Again, data from SunDay may shed some light on this murkiness. Certainly, at some point in the future, other definitions of collectivities should be developed and tested. A future survey instrument might dispense with the subtlety of merely implying that other forms of energy exist. It is quite possible that asking for opinions on other energy sources as compared with PV would contribute to personalizing the information and thus leading to differentiation among preferences. At the very least, it might indicate whether or not information on other "alternative" energy sources is perceived as personal. Other types of measurements should be developed at least as instruments to confirm or deny validity.

It would, of course, be extremely helpful from a statistical viewpoint to obtain a random sample, eliminating the problems of self-selection and the glossing over of construct validity that have been necessary in this effort. Also, randomness would allow for rigorous discriminant analysis as well as significance testing of data displayed in contingency tables.

It is important to remember that all institutional arenas are composed of institutional entities which, in turn, are composed of individual human beings. Thus, the survey discussed in this paper, or any other survey for that matter is:

> ... trying to discover certain aspects of what we might call an individual's assumptive world, a world which he himself has constructed during the course of a life as he has attempted to work out a set of conditions within which he can satisfy the urges that characterize him as a human being. [8]

No matter how profound the hypotheses, or how impeccable the research design, or how clever the approach, discovering those "certain aspects" will necessarily take some time.

NOTES

[1]An automated gated pipe irrigation system is also an innovation in that unlike many other irrigation methods, papes are run the length of the field to the head of each furrow which insures even watering. The system also contains a soil-water-content-sensing mechanism which activates a pump, which, in turn, starts water flowing through the system. The sensing mechanism activates the pump only when the soil needs water. Center-pivot irrigation is a more widely used system which also provides for the direct, uniform application of water and fertilizer on a controlled schedule. However, the gated pipe system was chosen for the PV field test because it uses less energy than any other irrigation method.

[2]That this field test is a giant step in PV application can best be understood in comparitive terms. The Mead PV system is designed to produce 25,000 watts, or 25 kilowatts, of maximum power. Previous PV applications have been systems powering buoys and a refrigerator producing a few kilowatts of maximum power.

[3]It is worth noting that sector (eg, agricultural, service-commercial, residential, and so on) designation, definition, and recognition of primary and secondary energy needs is an early product of the PV Project at MIT's Energy Laboratory. Currently, work is in progress to develop a heuristic screening matrix that can be utilized in choosing field test locations.

[4]Insolation is the solar radiation incident on the earth. The term usually includes the rate of delivery of such radiation per unit of area surface.

[5]Throughout this paper, most of the terminology used to describe the research design is drawn from Campbell and Stanley (1963).

[6]The use of paired comparisons on the survey instrument was considered; this approach was eliminated because this survey is not attempting to obtain an ultimate preference of one item over all others. Also, it was felt that such a survey form would be too cumbersome to lend well to self-administration.

[7]An exhibit was erected on the Boston Common, and field staff distributed, though they did not administer, questionnaires. The survey instrument developed for use at the Nebraska State Fair was utilized in Boston. The initial assumption is that the respondent population (again, unfortunately, not a random sample) is likely to be more knowledgeable about solar energy as well as more sophisticated in their opinions about resource allocations.

[8]This quote is drawn from Hadley Cantril's "Foreward" to Payne (1951).

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