OHIO CONSUMERS’ PROFILES, WILLINGNESS TO PAY, AND ATTITUDES REGARDING ANAEROBIC DIGESTION ON DAIRY FARMS

THESIS

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By

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ABSTRACT

The continuing trend toward fewer, larger dairy production facilities has led to increasing concerns about issues such as odor and water quality degradation, exacerbated by growing rural-urban pressures. These issues, along with an increasing U.S. desire for renewable energy sources, have a potential solution in anaerobic digestion.

This thesis examines consumers’ attitudes towards anaerobic digestion as a means of determining sectors of support. Consumers were contacted as part of a larger Ohio-wide survey of households regarding food, agricultural, and environmental issues. Specific to this project, consumers were asked about their attitudes towards anaerobic digestion, reasons for supporting renewable energy premiums, and willingness to pay for digester outputs. In the balance of the survey, consumers were asked about personal and household energy use and conservation, food purchases, and socio-demographic factors. The results were analyzed using logistic regression and partitional cluster analysis.

Four core clusters emerged from the analysis. They were (1) older, less educated, lower income consumers; (2) well-educated, well-paid consumers; (3) politically liberal, environmentally proactive consumers, and (4) younger consumers. The politically liberal, environmentally proactive consumers were the most supportive of backing anaerobic digestion through premiums on their utility bills. These consumers also cited
reducing greenhouse gases as the most important reason to purchase renewable energy. For the other clusters, reducing foreign oil dependence was the strongest reason by far. Consumers who indicated that they would not purchase renewable energy for any reason were, as a whole, older, less educated, and had lower incomes. Regarding knowledge of emerging renewable energy sources, most consumers thought that they possessed less than median level knowledge of renewable energy sources. Those consumers who thought they had more than median level knowledge were, on average, better educated, had higher incomes, and were more environmentally proactive.
DEDICATION

Dedicated to my family, without whom I would have never aspired to nor accomplished this effort.
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CHAPTER 1

PROBLEM IDENTIFICATION

As the American population and economy have grown, the availability of energy sources to drive this growth has become increasingly constrained. The majority of the energy consumed in this country is produced from fossil fuels. By their very nature, fossil fuels are finite in supply. Regardless of the position taken in regards to the argument over the exact sizes of the world’s reserves of petroleum and other fossil fuels, it is conceptually clear that there is some limit on their availability. Further, the negative environmental externalities of these sources have become a major concern. At virtually every point along the energy chain, from production to refining to consumption through combustion, pollution byproducts are produced. As a result, there has been increasing interest in and development of clean (non-polluting) energy sources, such as wind power, solar energy, wave energy, and biomass.

Livestock production in this country is in the midst of a seemingly unstoppable, irreversible trend toward fewer, larger production facilities. At the same time, the contact between rural and urban residents is increasing, as higher numbers of individuals are living in areas that have traditionally been considered rural. With this increased contact, there have been mounting concerns regarding issues such as water quality and odor control, and these debates have become progressively more divisive as the public
concern has increased. At the junction of these two independent issuing is a common technology: anaerobic digestion.

Anaerobic digesters utilize microbial decay to produce a combustible gas from organic materials. These organic materials are, in almost every instance, organic wastes, thus producing clean energy from products which have no value as food. In addition to producing energy, this process provides pollution control through the capture of methane, which does much more damage as a greenhouse gas than the more widely-discussed carbon dioxide. Furthermore, the anaerobic digestion process destroys nearly all of the odor-causing volatile organic acids, leaving an odor-free, nutrient-rich effluent. This odor-elimination frees up more storage and disposal options, allowing producers to hold the wastes for better weather and spread them in areas where their odor would have previously prevented their use. Greater flexibility in the management of the wastes can also help improve water quality, among other things, by significantly reducing over-application necessary under the older constraints.

Currently, there are a limited number of digesters in the U.S. One of the largest barriers to the adoption of this technology is the very large initial capital investment, which can be difficult to generate. Our question is whether there could be premiums available from consumers willing to pay for anaerobic digestion benefits such as renewable energy and odor control. Voluntary premiums would be paid as part of the consumer’s utility bill, and these premiums would then be transferred to producers to assist in offsetting the producers’ costs. For premiums such as these to work, willing consumers would need to be identified and characterized so that these consumer groups could be connected with willing producers.
2.1. Anaerobic digestion and digesters

Anaerobic digestion is a naturally occurring chemical/biological process whereby microbes break down organic compounds in the absence of oxygen (Angelidaki, Ellegaard, & Ahring, 2003; Chynoweth, Owens, & Legrand, 2001). Anaerobic digestion is comprised of four stages, each of which requires some specific conditions to be successful. Notably, factors such as temperature, pH, nature of the feedstock, and presence/absence of contaminants have a strong effect on the efficiency of the process (Braber, 1995). The process produces a biogas which is generally 65% methane, 35% carbon dioxide, and trace amounts of carbon monoxide, water vapor, hydrogen sulfide, and free hydrogen (Angelidaki, Ellegaard, & Ahring, 2003; Chynoweth, Owens, & Legrand, 2001; NRCS, 2007). The composition of the biogas depends on the digester and the feedstock. ‘Richer’ feedstocks such as food waste will produce more methane than animal wastes, and animal wastes may produce higher levels of the trace gases (Chynoweth, 1987; NRCS, 2007).\(^1\) Of these trace gases, hydrogen sulfide is the most problematic, as it is naturally corrosive and can create sulphuric acid when burned.

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\(^1\) In this context, ‘richer’ refers to a greater concentration of complex organic compounds. As the material in animal waste has already been digested once, there is less remaining energy than may be found in some other materials, such as food production wastes, as they have not been previously digested.
The biogas itself is flammable, and can be flared off, used to fire a boiler, power a modified engine, or even cleaned to pipeline quality natural gas (Chynoweth, Owens, & Legrand, 2001). The remaining output is an effluent that is effectively sterile, has little or no odor, and is rich in nutrients such as phosphorous and potassium.

The capture and combustion of methane that would normally be emitted into the atmosphere reduces the potential for this gas to negatively impact global warming. The authoritative body on global warming and climate change is the Intergovernmental Panel on Climate Change (IPCC). The IPCC estimates that the global warming potential of atmospheric methane is 25, as compared to carbon dioxide’s 1 (Forster, et al., 2007). The market for carbon credits trades in equivalent metric tons of carbon dioxide. In this manner, a metric ton of methane that is captured is equivalent to capturing 25 metric tons of carbon dioxide. Supposing that a cow daily produces 65 ft³ of biogas that is 65% methane with a density of 0.717 kg/m³, the cow could produce enough methane in a year to be equivalent to 7.83 metric tons of carbon dioxide.

There are a number of different designs for anaerobic digesters, each of which is best suited to a specific type of feedstock, intended use, and location. Nearly all designs incorporate a sealed reactor vessel into which the feedstock is pumped, and from which the effluent and biogas are captured (Chynoweth, 1987). In batch reactors, the vessel is filled with the feedstock, and then allowed to go through the process in its entirety (Angelidaki, Ellegaard, & Ahring, 2003; Chynoweth, 1987). These systems are generally simpler and less capital intensive, but do not produce biogas at a near constant production
level. In contrast, continuous digestion reactors introduce some new material each day and remove some digested effluent each day. As a result, the production of biogas is much more consistent, as there is a relatively constant amount of material in each stage of the process (Angelidaki, Ellegaard, & Ahring, 2003).

Wastes with lower total solids, such as municipal solid wastes, are likely to be digested in a continuously stirred tank reactor. These reactors pump in some portion of feedstock each day, usually around 5% of the total volume of the reactor, and pump out an equal amount (Chynoweth, 1987; Fannin & Biljetina, 1987; NRCS, 2007). Wastes with higher total solids, such as animal manures, are more likely to employ a plug flow digester system (NRCS, 2007). These systems employ a long, relatively narrow reactor vessel. Similar to the tank reactor, equal measures of wastes are introduced and removed each day, although in the plug-flow system, the addition and removal are done at opposite ends (Chynoweth, 1987; NRCS, 2007). This design allows for continuous, nearly even gas production, while ensuring that there is no short-circuiting of the system. Further, by moving in one direction while progressing through the process, the stages of the process are effectively separated, which minimizes their ability to interfere with each other (Chynoweth, 1987).

Regardless of the system in question, all reactors must provide certain environmental conditions. Perhaps most importantly, the system must maintain temperature correctly. Most digesters operate in the mesophilic area of 95°F or the thermophilic area of 135°F (Angelidaki, Ellegaard, & Ahring, 2003). Gas production

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2 Short-circuiting occurs when wastes exit the reactor before completing the digestion process; these wastes are not fully broken down, and may have odors and/or bacteria.
falls off notably if the digester is either too warm or too cold (Angelidaki, Ellegaard, & Ahring, 2003). All digesters must provide some means to keep the feedstock stirred to prevent settling or crust formation. Settling and crust formation can reduce the volume of the digester overall, and can lead to short-circuiting due to reduced time spent in the digester (NRCS, 2007). Good designs should also incorporate some means of retaining or rapidly reintroducing the bacterial colonies that perform the work in the digester.

2.2. Dairy farms and anaerobic digestion

Anaerobic digesters may provide opportunities to dairy farms. Of particular importance is the digestion process’ ability to significantly reduce the odor of the manure (Angelidaki, Ellegaard, & Ahring, 2003). Odor control is an increasingly important issue for dairies of all sizes, especially those dairies that are large and/or new to the area that they are operated in. For these dairies, maintaining a good relationship with the community is an important part of their potential success. Further, the captured biogas can provide a source of energy on the farm, either through electricity production or through boiler-based heating (NRCS, 2007).

However, the capital outlays for the construction of the digester are quite significant, and can be an insurmountable barrier for many farmers wishing to install a digester (NRCS, 2007). There are relatively very few anaerobic digesters operating on dairy farms in the U.S., each of which was built with regards to site-specific constraints. As a result, it is difficult to determine “average” capital costs with any precision. Engler, et al. (1999), Lusk (1998), Mallon and Weeksink (2007), Mehta (2002), Moser, et al, (1998), Stokes, Rajagopalan, and Stefanou (2008), and Wright, et al. (2004) all present
some estimates of the capital costs, generally in ranges. A scan of these articles would produce estimates of construction costs that range from $500 to $1000 per cow. If the values from the NRCS (2007) are applied to a 1000 cow dairy, the capital costs to construct the digester and its required peripheral equipment would be approximately $700,000. The installation of electricity generation would cost another $400,000, with as much as $200,000 in connection costs if the producer wishes to deliver power to the grid.

For this reason, there is generally a size constraint to installing a digester, as dairies need to be large enough to process enough wastes to make the investment worthwhile. The specific size constraint depends largely on factors such as the type of digester constructed, the use of the biogas, and the presence and/or absence of grant monies.

2.3. Attributes of “green” consumers

In their 2003 article in Business Strategy and the Environment, Rowlands, Scott, and Parker had two objectives. The goals were to profile consumers who had progressively higher stated willingness to pay values for green electricity, and to detail business strategies that would follow from these profiles. The authors administered a survey to 1390 individuals in southwest Ontario; the effective response rate was 34%, with 466 usable surveys. The profiling focus was essentially focused on three particular areas: demographic characteristics, attitudinal characteristics, and socialization characteristics. The strong impact of the attitudinal characteristics was one of the more immediate realizations from the survey conducted. Specifically, the researchers found that ecological concern was a highly important characteristic of high premium
consumers. Specifically, these consumers were concerned about the direct impact of their energy consumption on the environment. The researchers also found political liberalism to be a characteristic common to the high willingness to pay consumers. Demographically, there was statistical significance determined for the variables education, income, and age. Education and income were positively correlated with willingness to pay, while age had a negative correlation.

Granzin and Olsen (1991) had the intent to determine the characteristics of those individuals who participated in activities that demonstrated an environmental or conservation motivation. Specifically, the authors examined donation of items for reuse, recycling newspapers, and walking as a means of transportation when possible for environmental or conservation reasons. There were a number of characteristics that were studied, the sum of which could be broken down into three broad categories. There were demographic variables, such as age, gender, marital status, income, and education. There were variables relating to personal values, including altruism, the importance of the environment and the beauty of the natural world, and religiosity and Bible readership. The third category, which encompassed knowledge and information sources, had variables such as magazines, television, and books on the environment, as well as helping characteristics, such as the sense of “we-ness”, empathy for society, and common threat. The researchers tested their hypotheses through a survey of 348 adult respondents in a western metropolitan area. In particular, they found that youth and income were significant characteristics for certain behaviors. They also found that the personal values of the respondents were important in characterizing the participants, leading the authors
to conclude that simple demographic descriptors of environmentally conscious respondents would not fully describe or delineate these consumers. The authors also compared their results to a collection of previous research. Within this comparison, it is seen that the inverse relationship between age and environmentally motivated behaviors is historically repeated. In addition, the positive relationships between education and income and environmental actions are reinforced.

Although renewable energy sources are often lumped together without differentiation of the different sources involved, there are some clear differences in the costs and benefits of each. In an article in *Energy Policy*, Borchers, Duke, and Parsons (2007) endeavor to derive potential differences in willingness to pay for the different renewable energy sources. The authors considered this work to be a continuation of the earlier willingness to pay work done by Roe, et al. (2001). The work here was to be complete through a contingent choice experiment administered through intercept surveys. The intercept surveys were completed outside of Department of Motor Vehicles offices in Delaware. The contingent choice experiment was conducted by showing respondents pairs of labels about electricity products. The labels included the additional premium per month, the percentage of their electricity consumption that was replaced, and the source of the renewable electricity. From a demographic standpoint, the researchers found that individuals less than 30 years old or over 50 years old were more likely to prefer the green alternative. Further, those individuals who expressed ecological concerns were also more likely to prefer the green alternative. The authors also reported that green energy sources were not all the same in the eyes of the consumers. Solar was preferred to
the generic green energy source. However, biomass and farm methane developed negative parameters, indicating that consumers derived less utility from these sources than they did from the generic green energy source.

Schwepker and Cornwell (1991) examined the ecologically motivated consumers from a different perspective. The motivational concern here is the increasing amount of non-biodegradable packaging that is used in the US. These packaging wastes dominate the waste stream and filling of landfills. As one part of a three-pronged research approach, the researchers’ intent was to differentiate useful characteristics for identifying ecologically concerned consumers. Of concern to the researchers was the somewhat inconsistent prior research in the field, which was presented to demonstrate the nature of the problems that were being considered. The authors themselves employed a modified mall-intercept survey method to question respondents. The core of their findings demonstrated that sociopsychological variables are much more important than demographic variables in identifying and distinguishing the consumers who have the strongest ecologically friendly consumption motivations.

The power of environmentally friendly behaviors and attitudes as predictors is born out by other works as well. Arkesteijn and Oerlemans (2005) examined characteristics of early adopters of green electricity in a study of Dutch households. Employing a telephone survey, the researchers asked respondents about subjects such as their perception on the ease of switching to green electricity, their level of trust with the supplier, their income, and their attitudes relating to the environment. Again, the researchers found that the sociopsychological attributes had a much greater impact on the
green electricity adoption choice than more standard demographic variables. Similarly, Bhate and Lawler (1997) examined adoption of environmentally friendly products in an article in Technovation. The researchers conducted interview surveys relating adoption with three classes of explanatory variables, psychological, demographic, and situational, e.g. price and availability. The authors concluded that psychological and situational variables were much more important in identifying those individuals who would become adopters of the more environmentally friendly products.

One of the best examinations of willingness to pay for green electricity appeared in Energy Policy in 2001 in the work of Roe, et al. The researchers examined stated willingness to pay values developed from a survey and compared these to actual premiums paid. The willingness to pay values employed a conjoint model that had respondents choose between pairs of energy labels with different attributes. Respondents were essentially offered the choice between a decrease in emissions, a decrease in emissions with an increase in renewable energy, or a decrease in emissions and an increase in nuclear power production. From this, the researchers were able to develop a hedonic pricing model for the value of the individual attributes. Overall, there were positive correlations between education, income, environmental affiliation, and willingness to pay. Further, respondents were willing to pay premiums for the emissions reductions without the renewable energy portfolio increase. The comparison of the stated values and the actual premiums collected aligned relatively well, but the authors were able to demonstrate that this linkage is strongly dependent on the relative mix of fuels and the percentage of genuinely new renewables that are used in the mix.
The disconnect between stated willingness to pay and actual premiums is not insignificant. In the work of Farhar (1999) and Farhar and Houston (1996), a comparison of stated willingness to pay values and actual premiums paid was undertaken. This work used market research data compiled by utility companies investigating the market potential. In these studies, a majority of the respondents indicated that they would be willing to pay a modest premium in addition to their regular monthly electricity bill to support renewable electricity. However, the evidence from established green power pricing programs is that the number of individuals who actually carry through to committing to the purchase is less than 10 percent.

2.4. Producers’ attitudes

Although there are some clear benefits to anaerobic digestion, farmers will still need to be convinced that this new technology will work on their farms and will provide benefits sufficient to make the investments of capital, time, and personal energy worthwhile. The best means of understanding these attitudes is to talk to the producers directly.

The first contact with the producers’ side for this project was through a key informant interview with a large dairy producer who had recently installed a digester on his dairy. The farm was milking more than 3,500 cows, housed in standard drive-through six row freestall barns. The manure from the barns and the milking facility’s holding pen was put through a sand separator to remove any of the sand bedding that had gotten into the manure, and then pumped into the digester itself. Digested effluent was

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3 In the interests of protecting this individual’s privacy and confidential information, his farm and digester setup will be discussed in generalities.
divided, with some effluent going into storage lagoons for eventual field spreading, and some being processed through screw presses to separate out the solids. The gas collected from the digester was collected and used to power two modified natural gas engines. Each engine was attached to a 600 kW generator, allowing the farm to produce, at maximum capacity, 1.2 MW continuously. The producer expected that when the system was running normally at full capacity, it would produce about one megawatt continuously. The whole of this electricity was sold through the local grid to a midsize regional electricity producer that generates power and wholesales it to member retail cooperatives that distribute it to the end consumers.

The real core of this project emerged when the producer spoke about the reasons that he installed the digester. This individual had done some careful thinking about the financial aspects of installing the digester, including benefits such as accumulated carbon credits as well as electricity revenues. However, this financial analysis was not directed to the question: “Is this profitable?” It was focused much more on: “Is this feasible?” The difference here lies in the motivation to install the system. As this producer repeatedly emphasized, the digester served to minimize odors and to maintain and improve relationships with the surrounding neighbors. The dairy had not been warmly accepted when it was first proposed, and there was quite a bit of concern about issues such as odors, manure management, and the like. As part of the efforts to integrate more fully into the community, the producer made numerous different efforts, including the digester. Anaerobic digestion was included in the plans for the dairy from the start as a means to manage the odor. It also served to present the farm as “green” so that the
surrounding community had a sense that the dairy not only cared about the environment, but was proactive in managing its own issues in an ecologically positive manner. From this perspective, items like carbon credit sales and electricity revenues could be seen more accurately as cost minimization, rather than revenue generation. The digester could lose relatively small amounts of money each year and still be considered a success, as a result of the odor control. For this dairy producer, odor control and waste management were the key components.

Not all the producers in this state operate at the same size as the digester owner, so it was necessary to gain an understanding of their perspectives as well. These farmers were met through a pair of extension meetings providing information on anaerobic digestion. The producers in these meetings were much smaller, generally with less than 150 cows in production. For these farmers, cost was a much more significant issue than for the larger producer. There was recognition of the benefits of anaerobic digestion, especially in the potential to displace some or even all of the on-farm energy consumption. However, the cost of these systems was seen as simply too much to be financially feasible, at least at the scale of the full sized systems. Smaller covered lagoon systems or even self-constructed improvised systems were somewhat more attractive to these farmers, but only to the more progressive among them. This level of interest is what really lay at the heart of the issue. The large dairy producer was conscious of his dairy’s odor, and of the public’s attention to his facility. The small producers, on the other hand, did not seem to perceive a similar problem. For many of these producers, they had been in their current locations for decades, so acceptance was not an issue.
They had odor, but on such a scale that they did perceive it to be problem. As a result, they were unwilling to make an effort to reduce a problem that they did not have.

Digester technology was seen as appealing from a renewable energy perspective, but not as an important potential tool in the overall manure management system.
CHAPTER 3

DATA COLLECTION

The data regarding consumers’ attitudes was collected as part of a larger mail survey of Ohio households in 2008. The survey in question was selected due to its proven ability to generate solid return rates, as well as its proximity to our research team and the existing working relationship with the survey’s producers.

3.1. Mail Surveys

The mail survey method was chosen for this project for a number of reasons. Among the most important was the cost of doing the survey. Mail surveys are one of the least expensive means of collecting data (Salant & Dillman, 1994). Although there are often more physical resources involved, e.g., letters, survey booklets, envelopes, etc., these are generally less expensive than the labor of hiring multiple individuals to make calls in a phone survey, and certainly less expensive than sending surveyors door-to-door through selected neighborhoods. The exception to this cost comparison would be the emerging system of Internet surveys. These surveys are generally much less expensive, as they eliminate the physical resources and the labor needed to handle them, as well as the data entry. This last point is a critical part of survey research that can be overlooked at times, but one which requires a considerable portion of any survey project’s budget. However, the Internet survey has two particular drawbacks. One, respondents need to
have Internet access; although access has exploded over the last decade, it has not achieved the universality of mailing addresses. The second point of concern is getting through to the respondent in question. Spam filters and pop-up blockers have become quite advanced, and although the survey may have the best of intentions, it may still be rejected. The comparison could be made to mail surveys being tossed as junk mail, but it would seem more likely that a mailed survey bearing the appropriate university logos would get a more in-depth examination.

Mail surveys also offer the advantage of relative anonymity, and are less likely to be biased than other methods (Salant & Dillman, 1994). Although almost all surveys contain tracking numbers to allow the researchers to effectively contact non-respondents for the repeated rounds of materials, it is clearly promised and absolutely sacrosanct that researchers allow no connection between personal information and provided answers. Beyond that, because respondents answer the questions by themselves, without replying to an interviewer or physically turning in the survey to a researcher, it is more likely that the respondents will answer each question truthfully. One particular concern in survey research is the “halo-effect”, in which consumers respond in a manner in which they feel the researcher would prefer, or in which they want themselves to be viewed.

The final advantage to mail surveys is their ability to minimize sampling error at relatively low cost (Salant & Dillman, 1994). Relatively accurate and up-to-date address lists can be purchased from several sources. Good survey design employing accurate data sets in combination with the near universal access of postal mail mean that researchers can select samples that are highly likely to be close to the true population.
For this survey, the sampling frame was Ohio households, which number more than 4 million; as a rule of thumb, 1,067 respondents usually provide a 3% sampling error or better (Salant & Dillman).

3.2. Ohio Survey of Food, Agricultural, and Environmental Issues

The survey from which the data for the consumer portion of this project was taken was the Ohio Survey of Food, Agricultural, and Environmental Issues. It is a biennial survey conducted by The Ohio State University’s Department of Human and Community Resource Development across the state to examine Ohioans’ attitudes and concerns about current issues in food, agriculture, and the environment (Sharp, 2008). The survey contains both “regular” questions that appear on the survey each year, as well as “theme” questions, which relate to the broad theme of the survey. The theme for this particular survey was energy, mostly related to household energy efficiency and consumers’ attitudes and goals relating to energy conservation and efficiency. There are also sections of the surveys that are purchased by researchers who want to ask questions related to food, agricultural, or environmental issues. This project was one that purchased such a section of questions.

The survey was administered in May of 2008. The sample was 3,500 Ohio households, with half of these (1,750) drawn from the 22 metropolitan counties and half (1,750) from the sixty-six metropolitan fringe and nonmetropolitan counties (Adua & Sharp, 2009). This division intentionally oversampled households in the metropolitan fringe / nonmetropolitan counties. The survey’s principal investigators wanted to be sure to achieve enough respondents in these areas to be able to accurately describe them.
Given the nature of the survey, these residents are some of those with the most relevant opinions; however, given their relatively small portion of the population, it was important to get more responses than might be normal in order to have a sufficiently in-depth sample. The list of addresses was purchased from a private vendor, Experion (Adua & Sharp, 2009).

Households selected as part of the sample were first mailed a prenotification letter alerting them to their selection and explaining the survey’s purpose (Adua & Sharp, 2009). The letter was followed shortly by the survey packet, which included a cover letter with two one-dollar bills attached, the survey instrument, and a return envelope (Adua & Sharp, 2009). The letter reiterated the purpose of the survey, as well as providing instructions for who was to fill it out and how it was to be completed. The instructions on how it was to be filled out asked for either an adult female or adult male to complete the survey, with the request for a male or female being evenly split and randomly distributed among the questionnaires (Adua & Sharp, 2009). The letter also clearly explained the confidentiality measures of the survey, as well as the respondent’s right to skip questions and/or not complete the survey at all (Adua & Sharp, 2009). The two one-dollar bills were included to boost the response rate. Respondents were freely allowed to keep the money without ever completing the survey. However, the psychological need for reciprocation is very strong (Cialdini, 2001). Respondents are more likely to complete surveys in which they received something as part of the initial presentation. Non-respondents were mailed a reminder postcard, a replacement packet, and a second postcard, at intervals of roughly ten business days (Adua & Sharp, 2009).
The questions on the survey from this project asked consumers about their attitudes towards anaerobic digesters, green energy premiums to support them, and related topics. The balance of the survey contained questions about energy conservation, food and shopping habits, environmental concerns, and other topics. A copy of the survey is provided in Appendix B.

Of the 3500 households in the initial sample, 318 were returned as undeliverable (Adua & Sharp, 2009). Another 29 were removed as not part of the population, leaving an effective sample size of 3,153 (Adua & Sharp, 2009). There were 1,521 usable surveys returned, for an effective response rate of 48.2% (Adua & Sharp, 2009). The average age is of respondents was 54.22 years. The average education of the respondents was 13.79 years, corresponding to a high school diploma and some post-secondary education. The average political score was 4.43, just to the conservative side of moderate. The average household income for the sample was $62,477.

3.3. Anaerobic digestion section

There were multiple questions in the anaerobic digestion section, some of which asked for responses to anaerobic digestion specifically, while others were targeted at more general renewable energy issues. There are four specific pieces of the section that were used by this project.

1) Awareness of emerging renewable energy sources

Respondents were asked to rate their knowledge of emerging renewable energy sources on a scale from one to seven. Regarding the scale, one was marked as
“not at all knowledgeable”, four was marked as “somewhat knowledgeable” and seven was marked as “very knowledgeable.”

2) Reasons to purchase renewable electricity

Respondents were provided with eight reasons to purchase renewable energy and asked to rank their top three choices by marking them with a one, two, and three, respectively. Respondents were also offered a check box to mark if they would not purchase renewable energy for any reason. Simple counts of the different ranks assigned to a reason fail to account for the implicit weight that is used in ranking the reasons. It would be reasonably expected that a person would put more emphasis on a reason that he or she ranked first than on the reason that he or she may have ranked third. To bring some sense of this weight into the process, the rankings were assigned simple reversed scores. Thus, a reason observation that was ranked first was given a score of three points. Likewise, rankings of second and third received scores of two and one points, respectively, while an unranked observation received no points.

The eight choices that they were provided were:

- a) To reduce greenhouse gas emissions
- b) To reduce coal mining
- c) To reduce dependence on foreign oil
- d) To improve water quality
- e) To reduce acid rain
- f) To improve air quality
- g) To support Ohio farmers
- h) To benefit Ohio’s economy
3) Willingness to pay

Respondents were asked how much more they would be willing to pay, per month, for electricity and for natural gas from anaerobic digesters. The choices that they were given were $0, $5, $10, $15, $25, $35, $50, and more than $50. They were also asked how much they would be willing to pay, per year, anaerobic digesters to effectively eliminate odor. The choices provided were $0, $1-$25, $25-$50, $50-$100, $100-$250, $250-$500, $500-$1000, and more than $1000.  

4) Attitudes towards anaerobic digesters

Respondents were given four statements regarding anaerobic digestion and asked to mark their level of agreement with the statements on a scale from one to five, with one being “strongly disagree” and five being “strongly agree.” The questions were in a Likert-style format, whereby individuals respond to a number of opinions, both positive and negative (Reckase, 2000). The data developed in this manner is at least ordinal, and there are some empirical applications that would indicate that the data can be handled as interval data (Reckase, 2000). However, for this project, the data will be considered ordinal. The four statements provided were:

a) I would be comfortable with an anaerobic digester being constructed near my home.

b) An anaerobic digester would be a welcome addition to my local municipality’s waste treatment system.

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4 The existence of overlapping data ranges is clearly an error, and was a typographical mistake that was recognized only after the survey had been fielded. However, there are no indications that there was any confusion or mistaken answers on the part of the respondents.
c) Potential problems, such as odor or accidental leakages, outweigh the benefits of an anaerobic digester.

d) An anaerobic digester can be an important tool in managing the waste from large livestock operations.

3.4. Extracted variables

There are some key sociopsychological and demographic variables that can be used to differentiate ideal green consumers for anaerobic digestion premiums. These variables are reflective of the important factors that were seen in Chapter 2. There are a total of five variables that will be employed in the oncoming analysis, each of which is pulled from the Ohio Survey.

3.4.1. Age

Age was a variable that turned up repeatedly in the literature on this topic. It is expected that younger consumers will be more interested in green products and services than older consumers. The survey collected age data from the consumers by asking the respondents to list their age, in years, as of their last birthday.

3.4.2. Education

Education is another variable that repeatedly appears in the literature regarding green consumers’ distinguishing attributes. It is generally hypothesized that more educated consumers will be more aware of the current environmental travails, and will be more willing to pay for green products and services. The survey collected education data from the respondents by asking them to write in the number of years of education that
they had completed. As an example, respondents were told that a high school diploma or a GED was equivalent to twelve years of education.

3.4.3. Income

A third common demographic variable is household income. Those individuals with higher incomes have more ability to purchase premium green products, and are thus more likely to be consumers of these goods than lower income consumers, all else constant. However, income is a difficult subject to question respondents about, given its sensitive nature in our society. As a result, income questions are almost always the last questions on a survey, and generally involve asking respondents to mark a range, rather than provide an exact number. The ranges for this survey were: less than $9,999, $10,000 to $19,999, $20,000 to $34,999, $35,000 to $49,999, $50,000 to $74,999, $75,000 to $99,999, and $100,000 or more.

3.4.4. Political attitudes

It has been observed that attitudes and behaviors are much stronger predictors of green consumer behavior than the more common demographic variables (Rowlands, Scott, & Parker, 2003). One of these variables is political views. Individuals who are more politically liberal are generally more concerned with ecological issues. These issues are more often brought up as important goals for the more liberal political agendas. This survey asked respondents to rate their political views on a seven point scale, whereby one was “extremely liberal”, four was “middle of the road”, and seven was “extremely conservative.”
3.4.5. Environmental stewardship

Given the importance of attitudes in understanding green consumers, it is important to include some measure of environmental responsibility in the variables employed (Borchers, Duke, & Parsons, 2007; Granzin & Olsen, 1991; Rowlands, Scott & Parker, 2003; Schwepker & Cornwell, 1991). Given the numerous environment-related questions, the best option is to combine the various relevant points into an overall environmental stewardship score that would convey a summary of sorts of the person’s attitudes.

The important question, therefore, is what are the relevant data points? There are a number of questions in the survey that are related to environmental matters; however, not all of these are relevant to the stewardship score. The questions can be broken into two broad categories: attitudes and actions. Attitudes are those questions that ask the respondent to rate their attitude toward or belief in some statement. Actions are those questions that discern what activities the respondent has actually engaged in.

For the composition of the environmental stewardship score, actions would seem to be more predictive. Although the attitudes that an individual holds are certainly a strong motivator in a person’s actions, statements on attitudes alone could be insufficient to convey a person’s core motivations. An individual responding as a “strongly agree” to a positive statement about increased energy conservation may not believe in environmental protection, but could be simply reacting to increased gasoline prices. As a result, attitude statements alone cannot judge the depth or duration of a belief.
There are several questions relating to actions undertaken by individuals who are potentially motivated by environmental concerns. The key word, however, is “potentially.” Walking instead of driving or buying a fuel-efficient car could just as easily be inspired by volatile fuel prices as any concern for the environment. In order to separate those actions that were environmentally-based in nature or at least appearance, all actions that could yield a physical or financial return, either directly or through savings, were eliminated. This purge essentially left five questions, pulled from two different sections. The first two questions were in Section II.A., questions f. and g. These questions asked how often the respondent engaged in various behaviors, with the first question asking about tote bag use when shopping, and the second about recycling. For both of these questions, the data was entered as follows: “never” = 1, “seldom” = 2, “occasionally” = 3, and “frequently” = 4. These data points were left as point scores.

The remaining three questions asked respondents about actions undertaken in the last year. The first of the three asked if he or she had stopped using a product due to environmental concerns, the second asked if he or she had attended a public hearing on an environmental issue, and the third asked about volunteering or contributing to an environmental group. Each of these questions was answered as either “yes” or “no.” In this way, the integration of the two types of questions poses some problems. Clearly, a “no” answer needs a lower score than that of a “yes” answer. Further, to match up to the first group of questions, the lowest point score possible is 1, while the score is capped at 4. As a result, the score for a “no” answer should be between the lower bound of 1 and the midpoint of 2.5, while the score for a “yes” answer should be between the midpoint of
2.5 and the upper bound of 4. Centering the score within the appropriate range for each answer yields a score of 1.75 for a “no” answer, and a score of 3.25 for a “yes” answer. Logically, these values make sense in a qualitative fashion as well. Due to the truncation of the time span at one year for the second set, given no limitation on the first, it would seem incorrect to award a “no” response the same value as a “never” response. In the same fashion, a “yes” response to an action undertaken in the last year is relatively recent, but cannot be considered to be “frequent” on that basis alone. The sum of the resulting adjusted variables composes the variable hereafter referred to as the

*environmental stewardship score.*
CHAPTER 4.

METHODS

4.1. Clustering

4.1.1. Conceptual basis

Cluster analysis is the process of sorting observations that share similar characteristics into clusters. There are different methods that can be used for clustering, depending on the type of observations, the number of observations, and the number of variables employed. In a simple two variable model, clustering can be done visually by graphing the observations using their Cartesian coordinates. From there, clusters of observations can be isolated and identified. This method is also feasible with three variables, although it would likely be necessary to employ graphical software to generate three-dimensional figures that can be precisely constructed and manipulated to distinguish the specific clusters.

Although graphical approaches can be effectively used for clusters involving one or two variables, these methods are unusable when handling $n$-variables, such that $n$ is greater than three. For this level of cluster analysis, analytical methods must be employed. There have been a number of different algorithms developed that can perform the necessary computations, with each one best situated to a specific type of data. At the most basic level, these algorithms take one of two different approaches: agglomerative
and disagglomerative. Agglomerative algorithms essentially build the clusters from the single observations. In this way, each observation is treated initially as its own cluster, and clusters are then combined with like clusters to form larger groups (Han & Kamber, 2006). Disagglomerative clustering methods start with all of the observations as one large cluster, from which distinct groups are derived and broken out (Han & Kamber, 2006). Each new group is formed from the break-up of a larger group. Agglomerative and disagglomerative methods may be thought of through the following example:

Suppose there was a large box containing all the pieces of several jigsaw puzzles. The goal is to reconstruct each individual puzzle. An individual may begin this process by separating out all the pieces that were of landscapes into one box, and all the pieces that were still-lifes into another. The landscape box may then be sorted into seascapes and mountain views, and so on. This approach would be disagglomerative in nature. However, suppose the individual began by separating out each individual piece; then, he or she would start to match like-pieces together into separate piles. This approach is agglomerative.

Both sides present some large computational hurdles. Agglomerative algorithms are generally less complex in nature, given the constructive task that they perform. It is conceptually easier to match and gather observations than to take a group of such observations and determine the breaking points. Almost all agglomerative methods revolve around the use of means and variances to distinguish clusters. It is essentially a maxi-min problem: minimize the distance and/or variance within the cluster while maximizing the distance and/or variance between clusters. The exact method of
clustering depends on the specific type of data employed, as certain algorithms are designed to better manage particular data quirks.

It is important to note the power that variances can have within these algorithms. If the algorithm is minimizing the variance within the cluster, then the variable with the largest variance is going to have the most sway in determining the cluster’s configuration. A good example of this is the variable *average income*. The nature of the variable could easily lead to a variance whose absolute value is in the thousands and be perfectly correct and within the bounds of the normal distribution. In contrast, the variance of *environmental stewardship* is likely to be less than five. Although both variables are important in the analysis, the clustering algorithm would essentially look at *average income* alone, leaving *environmental stewardship* out of the analysis. For this reason, the variables need to be standardized before being clustered. The standardization was accomplished using SAS’s [proc standard] function, which standardizes the variable using a normal distribution and an inputted mean and variance. For this work, the mean and variance employed were zero and one, respectively.

4.1.2. Clustering methods

There are many different methods within agglomerative clustering, but this project will focus on two in particular. Agglomerative hierarchical clustering is a process by which individual observations are joined with like observations into simple clusters. Subclusters are joined to create larger clusters in a process that is repeated until all observations are joined in a single cluster composed of the multiple subclusters at many levels (Tan, Steinbach, & Kumar, 2005). In contrast, partitional clustering divides the
observations into unique, non-overlapping clusters, such that each observation is a member of only one cluster (Tan, Steinbach, & Kumar, 2005).

4.1.2.a. Agglomerative hierarchical clustering

Agglomerative hierarchical clustering, henceforth referred to hierarchical clustering, is designed to sort the observations into a well-defined “tree” of observations. The general algorithm for this work is fairly simple. Each observation is placed in its own cluster to start, and then the two closest clusters are joined to create a larger cluster, with the process repeating itself until there is only one remaining cluster (Han & Kamber, 2006; Tan, Steinbach, & Kumar, 2005). The determination of the distance between clusters generally depends on the type of clusters being developed (Tan, Steinbach, & Kumar, 2005). It could include a minimum measurement, between the two closest observations in the two clusters, a maximum measurement, between the two farthest observations in the two clusters, or some group average (Han & Kamber, 2006; Tan, Steinbach, & Kumar, 2005). Hierarchical clustering is not ideal for all applications, but works well when taxonomy is needed (Tan, Steinbach, & Kumar, 2005). There are also some studies that indicate that this method provides better clusters (Tan, Steinbach, & Kumar, 2005). However, since all clustering decisions are made at a “local” level, there is no global optimization (Tan, Steinbach, & Kumar, 2005).

4.1.2.b. Partitional clustering

Partitional clustering has a number of different particular methods, depending on the application, but for this project, the focus is on prototype-based methods, specifically on the $K$-means method. Prototype-based methods center on the use of a prototype, or
semi-ideal observation, around which the cluster is formed (Han & Kamber, 2006; Tan, Steinbach, & Kumar, 2005). For clustering work that uses continuous variables, such as this one, the initial prototype, or seed, is the mean of the variables in the cluster; this mean is updated with each new observation that is added to the cluster (Han & Kamber, 2006; Tan, Steinbach, & Kumar, 2005).

The basic algorithm for this work is straightforward. \( K \) centroids are specified by the researcher, and observations are assigned to the nearest centroid. The centroids are recalculated, and the process is repeated until the centroids do not change (Aldenderfer & Blashfield, 1984; Han & Kamber, 2006; Tan, Steinbach, & Kumar, 2005). The distance used to determine a point’s inclusion can vary, depending on the type of data, but this project uses Euclidian distances. These distances are used to calculate an observation’s “error” or distance from the mean. The optimal cluster minimizes the sum of the squared errors of the cluster, as calculated by:

\[
SSE = \sum_{i=1}^{K} \sum_{x \in C_i} \text{dist}(c_i, x)^2
\]  

where \( K \) is the specified number of clusters, \( x \) is an object, \( C_i \) is the \( i^{th} \) cluster, \( c_i \) is the centroid of the \( i^{th} \) cluster, and \( \text{dist} \) is the normal Euclidian distance between two objects in Euclidian space (Tan, Steinbach, & Kumar, 2005).

4.1.3. Data formatting

4.1.3.a. Standardizing variables

The first step in making the data suitable for clustering was to standardize the variables involved. The other set is adjusted to normal distribution with a mean of zero.
and a standard distribution of one. This transformation is done largely to prevent one variable from dominating the others. Given the large nominal magnitude differences that exist between average income and the other variables, standardization is necessary to prevent the clusters from being decided wholly on income.

4.1.3.b. Outliers

Given the method used to develop clusters, outliers are one of the most important concerns of the researcher. Within the context of this analysis, outliers have the ability to significantly shift the center of the clusters (Han & Kamber, 2006; Tan, Steinbach, & Kumar, 2005). Although outliers can impact any statistical analysis, the centroid shift in cluster analysis potentially results in the cluster “stealing” or “forfeiting” points from or to other clusters, further shifting the center. Although a cascading effect of movement could be envisioned here, the outliers will not cause the cluster to “walk” around the n-space of the cluster. However, outliers could cause distortions in the clusters that are formed.

Given the trouble that outliers can cause in cluster analysis, they need to be carefully examined to determine their effect in the analysis. There is a clear incentive to removing the outliers from the data set. Their removal would provide tighter, more clearly defined clusters that possess better fit characteristics. However, lacking an a priori reason for their removal, it is difficult to justify trimming the data set simply to produce a tighter fit. In the context of cluster analysis, the important point of concern is examining potential outliers in clusters to determine if they are actually a micro-cluster within the larger cluster.
This project’s examination of the outliers is derived from the particular manner of the clustering analysis. Within the partitional clustering method, a distance from the center of the cluster can be determined for each member observation. This new variable was used to identify observations whose distance from the center was more than three units. Because the data was standardized to a normal distribution with mean of zero and a standard deviation of one for all variables, it would be expected that a distance of three units would encompass 99.76% of the data points (Studenmund, 2006). Observations with distances greater than three units were sorted into new data sets, which were then run through the clustering procedure on their own to examine for unique, small clusters.

The clusters that were developed were essentially random groupings of observations, nearly all of which possessed extreme values for two or more variables. There was no indication of a homogenous group that distinguished itself from the others. Lacking evidence of unique micro-clusters or procedural problems, there is no justification for the removal of outliers. Although there is the potential that these outliers distort their parent clusters, they must remain in the analysis.

4.1.3.c. Missing values

Missing values for some variables is a second source of distortion within the clusters. These observations get sorted into clusters on the basis of the variables that they do have, influencing the cluster’s mean values for only a portion of the variables. Whereas outliers can pull a cluster off of its true means, missing values hide some portion of what the cluster really contains. To deal with this, all observations that did not include a value for every variable included in the analysis were removed from the data set for that
analysis. For the cluster analysis of willingness to pay, the data sets employed had around 1250 points, depending on the willingness to pay variable in question. For the cluster analysis of reasons to support renewable energy, the data set without missing values had 993 observations for all the variables. The size of the data is considerably lower due to the relatively large number of individuals who indicated that they would not buy renewable energy for any reason.

4.1.4. Clustering procedure

The process of developing the clusters for this project involved a number of sequential steps. To start, the data were clustered using a hierarchical clustering method at the start as a means of determining the optimal number of clusters. For each node of cluster agglomeration, a pseudo- t-score can be calculated. Large increases in the pseudo- t-scores can indicate optimal cluster numbers. Often, there is more than one optimal level, leading the researcher to choose the one that would provide the most insight into the data. If, for instance, hierarchical clustering indicated good cluster fits at fourteen, six, and three clusters, the researcher might choose six clusters as an optimal level. Fourteen clusters may be too differentiated for identifying key trends, while three clusters may be too broad to make any distinguishing points.

Once the optimal number of clusters was determined, the partitional clustering developed the initial clusters. It was from these clusters that the observations with distances greater than three were removed and examined as described above. The final clusters were developed by performing partitional clustering on the data sets that had the missing values removed. Because each analysis was treated separately, not every
willingness to pay or reasons variable was run to the same number of partitioned clusters, but rather to the number of clusters that were determined to be ideal for that variable. The smallest number of clusters developed was four, and the largest number developed was six.

4.1.5. SAS clustering

The clustering for this project was performed using SAS 9.1. The SAS system essentially offers two different methods for clustering: [proc cluster] and [proc fastclus]. The [proc cluster] method is a hierarchical clustering method that uses agglomerative hierarchical clustering, while the partitional clustering is accomplished through [proc fastclus]. Each method offers a number of different options for algorithms, data display, and the like. For this project, [proc fastclus] used the default *k-means* algorithm, while [proc cluster] was set to use Ward’s method, which also works to minimize the sum of the squared errors.

4.1.5.a. Fit statistics

There are three primary fit statistics that are provided in the partitional analysis. The first is an approximate expected overall $R^2$, which is very similar to the $R^2$ values seen commonly in regression analysis. Somewhat different from what is normally seen is the pseudo F statistic. The pseudo F statistics is essentially a ratio of the sum of squares between the clusters to the sum of squares within the clusters. Computationally, it is calculated as:
**Pseudo F statistic**

\[
Pseudo F statistic = \frac{R^2/(c - 1)}{(1 - R^2)/[(n - c)]}
\]

where \( R^2 \) is the observed \( R^2 \), \( c \) is the number of clusters, and \( n \) is the number of observations (SAS Institute, 2008).

The third fit statistic is the cubic clustering criterion (CCC). This statistic was empirically developed to provide some means of measuring goodness of fit relating to the different number of clusters developed. The CCC examines the cluster’s difference from points drawn from a uniform distribution. Computationally, it is calculated as:

\[
CCC = \ln \left[ \frac{1 - E(R^2)}{1 - R^2} \right] \left( \frac{\sqrt{np^*}}{\sqrt{2}} \right) \left( 0.001 + E(R^2) \right)^{1.2}
\]

where \( E(R^2) \) is the expected \( R^2 \), \( R^2 \) is the observed \( R^2 \), \( n \) is the number of observations, and \( p^* \) is a measure of dimensionality between cluster variation (SAS Institute, 1983).

### 4.2. Regression Analysis

#### 4.2.1. Theoretical basis

Linear regression analysis is the tool used to analyze the willingness to pay data. Linear regression is a statistical means of describing the relationship between two or more variables (Kutner, Nachtsheim, & Neter, 2004). The most common form of regression analysis is that of least-squares regression. This method essentially identifies parameters by fitting a model which minimizes the squared differences between the fitted and observed values of the dependent variable. In its simplest form, the regression generally takes the form:
\[ Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i \] (4.2)

such that the expected value of \( Y \) is:

\[ E\{Y\} = \beta_0 + \beta_1 X \] (4.3)

where \( Y_i \) is the \( i^{th} \) observation of the dependent variable, \( \beta_0 \) and \( \beta_1 \) are the true parameters, \( X_i \) is the \( i^{th} \) observation of the dependent variable, and \( \varepsilon_i \) is an error term. Estimates of \( \beta_0 \) and \( \beta_1 \), generally denoted as \( \hat{\beta}_0 \) and \( \hat{\beta}_0 \) or \( b_0 \) and \( b_1 \) to distinguish them from the true but unknown parameters, are developed by taking the sum of the squared differences:

\[ Q = \sum_{i} (Y_i - \beta_0 - \beta_1 X_i)^2 \] (4.4)

setting the first derivatives \( \frac{\delta Q}{\delta b_0} \) and \( \frac{\delta Q}{\delta b_1} \) equal to zero and solving for \( b_0 \) and \( b_1 \). The resulting estimators are:

\[ b_1 = \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sum (X_i - \bar{X})^2} \] (4.5)

\[ b_0 = \bar{Y} - b_1 \bar{X} \] (4.6)

where \( \bar{Y} \) and \( \bar{X} \) are the averages of the \( Y \) and \( X \) observations. These estimators are unbiased estimates of \( \beta_0 \) and \( \beta_1 \). The estimation of parameters for models with multiple predictor variables follows an analogous method.

Interpretation of these estimated parameters is fairly straightforward. The \( b_0 \) term is an estimate of the linear regression’s intercept. This term can have varying interpretations, but in a theoretical sense, it is the expected value of dependent variable when all of the predictor variables are zero. For \( b_1 \), it is the marginal change in the dependent variable with a change in the predictor variable, i.e., for each one unit change
in $X$, there is a $b_1$ unit change in $Y$, holding all else constant. This interpretation continues for regressions with multiple predictor terms, although it should be clear that the *ceteris paribus* restriction remains in place and is important to identifying exactly what the estimates do, and perhaps more importantly do not, explain.

### 4.2.2. Willingness to pay regressions

The specific model for the willingness to pay data is:

$$
E\{\text{willingness to pay}\} = \beta_0 + \beta_1 X_{\text{age}} + \beta_2 X_{\text{education}} + \beta_3 X_{\text{political views}} + \beta_4 X_{\text{average income}} + \beta_5 X_{\text{environmental stewardship score}}
$$

(4.7)

The regression method was ordinary least-squares (OLS) regression. OLS is the default regression method, and is generally employed unless there are justifiable reasons, such as non-constant variance or non-linearity, that would require the use of a different model. The residuals were plotted against the regression’s fits, as well as against the predictor variables, as a means of examining for non-normality within the residuals, as well as checking the shape of the regression. There were no indications of heteroskedasticity, which is non-constant variance of the residuals, within the plots. The residuals had every appearance of falling within parallel bands, centered on the mean. The variables were then plotted in scatter plots to look for outliers and unexpected trends. Again, there was no visual evidence of any problems with the data.

The variables that were selected for this model were *age, education, political views, average income, and environmental stewardship*. The variables were first set into a correlation matrix to examine them for any signs of multicollinearity. Many times,
variables such as education and average income are positively correlated. Studies have demonstrated a consistent positive correlation between education and income that persists even when ability and family’s socioeconomic status are taken into account (Ashenfelter & Rouse, 1999). There are no firm rules as to how much correlation is “too much”, and each researcher is left to make that determination on their own. The presence of multicollinearity in a regression will still allow for unbiased estimators, but will increase the standard errors (Studenmund, 2006). Within the context of these variables, the largest simple correlation coefficient was 0.40, between education and average income. Multicollinearity was not judged to be a problem.

There were also no conclusive indications that the variables, when plotted, had a shape that was not linear. Of particular concern was education, as it could be argued that education has diminishing margin returns. That is to say, the difference between fifteen and sixteen years of education is not the same as the difference between twelve and thirteen years. As a result, it would be expected that education is curvilinear. The regression was performed both with and without education as a variable, and the residuals from both runs were plotted against education. From these plots, there was no clear evidence that it should be nonlinear.

Given the perspective of the overall sample, it was important to get an accurate measurement of rural Ohio consumers’ attitudes. To accomplish this, respondents in rural areas were oversampled. As a result, they were disproportionally represented in the data set. To adjust the sample back to representative of the population, the observations were assigned corrective weights. These corrective weights were based on the response
rate, and were assigned after collection was completed. The adjustment was made using the [weight] command within SAS to adjust the regression; this command weights all the variables according by the specified variable, in this case adjustedweight.

4.3. Logistic Regression

4.3.1. Theoretical basis

Different techniques for data analysis must be used when ordinal data is used. For the Likert-style analysis of the statements relating to the anaerobic digestion, logistic regression must be employed. Specifically, this analysis employs a proportional odds model, which is a form of cumulative logit models.

Logistic distributions, which are very similar to normal distributions, have a density of:

\[
 f_L(k) = \frac{\exp(k)}{(1 + \exp(k))^2} \quad (4.8)
\]

where \( k \) is a logistic variable (Kutner, Nachtsheim, & Neter, 2004). The cumulative distribution function is:

\[
 F_L(k) = \frac{\exp(k)}{1 + \exp(k)} \quad (4.9)
\]

(Kutner, Nachtsheim, & Neter, 2004). Given this distribution, the logistic mean response function follows:

\[
 E\{Y_i\} = \pi_i = \frac{\exp(X\beta)}{1 + \exp(X\beta)} \quad (4.10)
\]

where \( \pi_i \) is the probability of the right side, and \( X \) and \( \beta \) are matrixes of the predictor variables and the regression coefficients, respectively (Kutner, Nachtsheim, & Neter,
Through application of the inverse of the cumulative distribution function:

\[ F_L^{-1}(\pi_i) = X\beta = \pi'_i = \ln \left( \frac{\pi_i}{1 - \pi_i} \right) \]  

(4.11)

(Kutner, Nachtsheim, & Neter, 2004; Woolridge, 2003). The cumulative logit model harnesses these equations to develop a model that describes the increasing proportion of response explained by the predictor variable. In a model with \( J \) levels of responses, setting the following:

\[ L_j(X) = \text{logit}[F_j(X)], \quad j = 1, \ldots, J - 1 \]  

(4.12)

where:

\[ F_j(X) = P(Y \leq j|X) \]  

(4.13)

is the cumulative response probability for level \( j \) allows for the model:

\[ L_j(X) = \alpha_j - X\beta, \quad j = 1, \ldots, J - 1 \]  

(4.14)

(Agresti, 1990). Here, \( \alpha_j \) are the cutpoint parameters; similar to the intercepts in ordinary least squares regression, these parameters describe the increase in the cumulative probability of each successful level increase absent changes in the predictor variables (Agresti, 1990). The beta coefficients are negative in this case as the response variables are hypothesized to increase with increasing values of the predictor variables. A simpler explanation can be seen by illustrating the probability of predicting the response variable to the \( i^{th} \) observation, given \( J \) response levels (Agresti, 1990):

\[ P(Y_i = j|X_i) = \begin{cases} 
G(\alpha_j - X\beta) & j = 1 \\
G(\alpha_j - X\beta) - G(\alpha_{j-1} - X\beta) & 1 < j \leq J - 1 \\
1 - G(\alpha_{J-1} - X\beta) & j = J 
\end{cases} \]  

(4.15)
4.3.2. *Interpreting Logistic Coefficients*

Interpreting the estimated parameters in logistic regression does not follow the same method as seen in least squares regression. The difference is due to the equal-marginality condition missing in logistic regression, such that the equal increases in the variable from different starting points, holding all else constant, do not yield equal increases in the predicted probability. For the interpretation, odds ratios are employed, and are constructed as follows. Working with just one predictor variable for simplicity, where \( X = X_k \) we start with:

\[
\hat{\pi}'(X_k) = \alpha_1 - b_1 X_k \quad \text{and} \quad \hat{\pi}'(X_k + 1) = \alpha_1 - b_1 (X_k + 1) \quad (4.16)
\]

(Kutner, Nachtsheim, & Neter, 2004). The difference between the two is:

\[
\hat{\pi}'(X_k + 1) - \hat{\pi}'(X_k) = -b_1 \quad (4.17)
\]

(Kutner, Nachtsheim, & Neter, 2004). From equation 4.11, it can be seen that \( \hat{\pi}'(X_k) \) is the logarithm of the estimated odds when \( X = X_k \), which could be thought of as

\[
\ln[\text{odds}(X_k)].
\]

Analogously, \( \hat{\pi}'(X_k + 1) \) can be thought of as \( \ln[\text{odds}(X_k + 1)] \) (Kutner, Nachtsheim, & Neter, 2004). As a result:

\[
\ln[\text{odds}(X_k + 1)] - \ln[\text{odds}(X_k)] = \ln \left[ \frac{\text{odds}(X_k + 1)}{\text{odds}(X_k)} \right] = -b_1 \quad (4.18)
\]

Resultantly:

\[
\text{Odds Ratio} = \left[ \frac{\text{odds}(X_k + 1)}{\text{odds}(X_k)} \right] = \exp(-b_1) \quad (4.19)
\]

(Kutner, Nachtsheim, & Neter, 2004). As an example, suppose that the estimated parameter for variable \( x \) was -0.15. The resulting odds ratio would be \( \exp(-(-0.15)) = \)
1.162, which would be interpreted a one unit increase in x having 16.2% odds of moving the response variable to the next level.

4.3.3. Logistic models

There are two models used for this project. The first was used for respondents’ current knowledge of emerging renewable energy sources. These responses were rated on a seven point scale. The model employs the same five variables used in the least-squares regression and in the cluster analysis. The model for knowledge of renewable energy is:

\[
\text{likelihood of knowledge level}_j = \alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 + \alpha_5 + \alpha_6 - \beta_1 X_{\text{age}} - \beta_2 X_{\text{education}} - \beta_3 X_{\text{political views}} - \beta_4 X_{\text{average income}} - \beta_5 X_{\text{environmental stewardship score}}
\]

(4.20)

The second model was used for analyzing respondents’ attitudes towards anaerobic digestion specifically. These attitudes were gauged through their measurement of agreement or disagreement on a five point scale with four statements relating to anaerobic digestion. The model again employed the five basic predictor variables. This model was:

\[
\text{likelihood of agreement level}_j = \alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 - \beta_1 X_{\text{age}} - \beta_2 X_{\text{education}} - \beta_3 X_{\text{political views}} - \beta_4 X_{\text{average income}} - \beta_5 X_{\text{environmental stewardship score}}
\]

(4.21)
4.4. T-Test

The t-test is a two-sample pooled-variance t-test; this test is used to determine whether the means of two different populations are significantly different, assuming equal variances for the samples and normal distributions (Levine, et al., 2002; Witte & Witte, 2004). The test takes the form:

\[
    t = \frac{\bar{X}_1 - \bar{X}_2 - (\mu_1 - \mu_2)}{\sqrt{S_p^2 \left( \frac{1}{n_1} + \frac{1}{n_2} \right)}}
\]

(4.22)

where:

\[
    S_p^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 - 1) + (n_2 - 2)}
\]

(4.23)

and \(S_p^2\) is the pooled variance, \(n_i\) is the size of the sample from the \(i\)-th population, \(S_i^2\) is the variance of the sample from the \(i\)-th population, \(\bar{X}_i\) is the mean of the sample from the \(i\)-th population, and \(\mu_i\) is the mean of the \(i\)-th population (Levine, et al., 2002; Witte & Witte, 2004). The null hypothesis is that the population means are, in fact, identical, and that there is no significant difference between the populations.

For this project the t-test will be used to examine those individuals who responded that they would not buy renewable energy for any reason. The main body of analysis on the reasons section will use cluster analysis. The non-buyers will be presented as essentially an additional cluster. However, because they were not specifically sorted out in the clustering process, it will be difficult to know if they are actually different from the presented clusters. The use of the t-test will for testing to determine if they are genuinely statistically different.
CHAPTER 5

RESULTS

This chapter contains the analysis outputs and descriptors. The intent is to provide the critical pieces of output, such that it is essentially an accounting of the different outputs for each section. The complete tables of regression estimates, clusters, and other statistics are located in Appendix A. A broader and more intuitive description of the results is provided in the next chapter.

5.1. Knowledge of emerging renewable energy sources

One of the first questions put to respondents was to ask about their current level of knowledge regarding emerging renewable energy sources. Overall, a near majority of respondents indicated that they had less than the median level of knowledge, with another third possessing median level knowledge. These respondents were analyzed using both a t-test and logistic regression.

5.1.1. T-test

The t-test for knowledge of emerging renewable energy sources split respondents into two groups. The “less than median knowledge” group, hereafter referred to as Group\(_0\), consisted of individuals who marked a score of three or less. Conversely, the “more than median knowledge” group, hereafter referred to as Group\(_1\), consisted of
individuals who marked a score of five or more. Individuals who indicated a knowledge level of four were not included in the analysis.

There are some distinctive differences between the two groups. For the variables *education, average income*, and *environmental stewardship*, the difference is significant with p-values of less than 0.0001. Group$_1$ has 1.5 more years of education, with 15.1 years compared to Group$_0$’s 13.6 years. Group$_1$ earns nearly twenty thousand dollars more per year than Group$_0$, the difference between $80,124$ and $60,218$. Further, Group$_1$’s environmental activism score is 5.98, compared to Group$_0$’s score of 4.91. Group$_1$ is younger by just over two years, at 52.31 and 54.32 years, respectively, although this difference is just outside significance with a p-value of 0.0599. The difference politically is quite small and very insignificant, with a p-value of 0.5155.

Taken in a broad sweep, those individuals who think that they possess more than a median level knowledge of renewable energy are significantly better educated, have higher incomes, and are more environmentally proactive. They are also younger and slightly more politically liberal, although the differences here cannot be considered significant. The complete test is provided in Table A.1.

5.1.2. Logistic regression

The specified logistic regression for the respondents’ level of knowledge is:

$$\text{likelihood of knowledge level}_j = 1.31691 + 2.08872 + 2.80813 + 4.3314 + 5.57775 + 6.76346$$

$$+ 0.00169 X_{age} - 0.1021 X_{education} - 0.0729 X_{political \ views}$$

$$- 0.00000381 X_{average \ income} - 0.1638 X_{env \ score}$$
where ** denotes significance at the $\alpha = 0.01$ level and *** denotes significance at the $\alpha = 0.001$ level. The likelihood ratio score was 123.1210, with a p-value of less than 0.0001. The Wald statistic was 122.2818, with a p-value of less than 0.0001.

There are a few key trends that show up in this analysis. The first is the importance of education, which is expected, as more education should lead to an increase in both knowledge and the desire and ability to obtain it. The odds ratio on education is 1.1075, indicating a 10.75% likelihood of moving up a knowledge level with a one year increase in education. Similarly, the odds ratio on environmental stewardship is 1.1780, such that a one unit increase in a respondent’s environmental stewardship score increases the likelihood of he or she having a knowledge level one unit higher by 17.80%. The other significant variable in this analysis is average income, which has an odds ratio of 1.00000381. With each $1000 increase in an individual’s income, there is a 0.38% increase in the likelihood of that individual’s knowledge increasing one level. The variables age and political views were insignificant. The complete logistic regression analysis and odds ratio tables can be seen in Tables A.2 and A.3.

5.2. Reasons for purchasing renewable energy

A second portion of the consumer response data dealt with the reasons why consumers would or would not purchase renewable energy. There were two broad categories of respondents, those who would and those who would not. Those who would purchase renewable energy were further clustered by each individual reason to understand where the support for certain reasons was concentrated.
Examination of the eight reasons revealed four broad clusters that consistently appeared in nearly every cluster analysis. The clusters shifted somewhat within each analysis, but the essential core of each cluster can be distinguished in each case. These four groups will be discussed in their entirety in the next chapter, covering all of the reasons, as well as the relationship to the willingness to pay variables. The basic points of each reason-centered cluster will be presented here.

5.2.1. Cluster analysis

5.2.1.a. Would not purchase renewable energy for any reason

The group of respondents who indicated that they would not purchase renewable energy for any reason have some distinctive characteristics. The group’s mean age is 59.7 years, and they have a mean education of 12.9 years. Politically, they have a score of 4.69. Their average income is $51,705, and their environmental stewardship score is 4.49.

Although these numbers are not distinguished in and of themselves, a t-test comparing them to those people who would buy renewable energy makes some very strong distinctions. Those who would not buy renewable energy are 7.47 years older, have 1.40 fewer years of education, are more conservative by 0.49 points, earn $16,900 less per year, and have an environmental stewardship score that is 1.24 points lower. Further, all of these differences are highly significant with p-values of less than 0.0001.

5.2.1.b. Reason to purchase renewable energy: to reduce greenhouse gases

The first listed reason for purchasing renewable energy was to reduce greenhouse gas emissions. This variable will hereafter be referred to as reason$_{GHG}$. The clusters
developed for $reason_{GHG}$ followed the procedures outlined in the cluster analysis section in Chapter 4. The fitted number of clusters was four. The data set, with missing values in the employed variables removed, had 933 observations. The resulting cluster set had a pseudo F-statistic of 190.49 and an approximate expected over-all $R^2$ value of 0.31778. The cubic clustering criterion was 14.31.

Given the reverse scoring used for the reasons, as described in section 3.3 of chapter 3, larger values for the variable $reason_{GHG}$ can be interpreted as more support. Again, the ordinal nature of the ranking procedure comes into play here as well. Examining the clusters, the strongest supporting cluster has a $reason_{GHG}$ score of 2.72, while the lowest value is 1.78. The youngest cluster has an average age of 40.3 years and the oldest an age of 58.81 years. The most and least educated clusters had 16.8 and 13.1 years of education, respectively, while the clusters at the extremes politically had scores of 2.94 and 5.12. The cluster with the lowest income earned $46,800, while the highest income cluster earned $130,538. The most environmentally active cluster had a score of 8.55, while the least environmentally active cluster only scored 4.61. The entire set of clusters is presented in Table A.4.

5.2.1.c. *Reason to purchase renewable energy: to reduce coal mining*

The second listed reason for purchasing renewable energy was to reduce coal mining. This variable will hereafter be referred to as $reason_{coal}$. The clusters developed for $reason_{coal}$ followed the procedures outlined in the cluster analysis section in Chapter 4. The fitted number of clusters was four. The data set, with missing values in the employed variables removed, had 933 observations. The resulting cluster set had a
pseudo F-statistic of 202.25 and an approximate expected over-all $R^2$ value of 0.31851. The cubic clustering criterion was 17.53.

The strength of support for $reason_{coal}$ is not as strong as is seen for some of the other reasons. The strongest supporting cluster had a value of 1.86, while the weakest support was 1.36. The youngest cluster had a mean age of 40.0 years, while the oldest cluster had an age of 63.2 years. The most educated cluster had 16.9 years of education, contrasted against the least educated cluster’s 13.2 years. The most politically liberal group had a score of 2.68, while the most politically conservative group averaged a score of 4.76. The extreme clusters in income earned $142,509 and $43,733, while the environmental activism ranged from 8.23 to 4.53. The entire set of clusters is presented in Table A.5.

5.2.1.d. Reason to purchase renewable energy: to reduce foreign oil dependence

The third listed reason for purchasing renewable energy was to reduce foreign oil dependence. This variable will hereafter be referred to as $reason_{oil}$. The clusters developed for $reason_{oil}$ followed the procedures outlined in the cluster analysis section in Chapter 4. The fitted number of clusters was four. The data set, with missing values in the employed variables removed, had 933 observations. The resulting cluster set had a pseudo F-statistic of 185.87 and an approximate expected over-all $R^2$ value of 0.31664. The cubic clustering criterion was 13.24.

$Reason_{oil}$ was the strongest reason of any of the eight presented. It was included in the most respondents’ rankings and had the greatest number of first place rankings. This popularity is reflected in the strength of the support for $reason_{oil}$. The top three
clusters had scores of 2.89, 2.75, and 2.72, with the singular low score of 1.65 for the fourth cluster. This somewhat anomalous cluster will be explained in more depth in Chapter 6. In regards to age, the lowest cluster age was 37.7 years, while the highest cluster age was 59.56 years. The education extremes were 16.9 and 13.1 years, while the political scores ranged from 3.09 to 5.01. The highest earning group had an income of $141,823, in contrast to the lowest earning group, which made $46,601. The most environmentally active cluster had a score of 8.08, while the least environmentally active cluster scored 4.52. The entire set of clusters is presented in Table A.6.

5.2.1.e. Reason to purchase renewable energy: to improve water quality

The fourth listed reason for purchasing renewable energy was to improve water quality. This variable will hereafter be referred to as reason\textsubscript{water}. The clusters developed for reason\textsubscript{water} followed the procedures outlined in the cluster analysis section in Chapter 4. The fitting number of clusters was four. The data set, with missing values in the employed variables removed, had 933 observations. The resulting cluster set had a pseudo F-statistic of 178.74 and an approximate expected over-all $R^2$ value of 0.31757. The cubic clustering criterion was 10.859.

The clusters for reason\textsubscript{water} fall essentially into two groups. There are two clusters that are relatively supportive, with scores of 2.11 and 2.10, and two clusters that are relatively less supportive, with scores of 1.49 and 1.48. There are younger clusters, at 36.04 and 43.37 years, one on each side of the support line, and two older clusters, at 56.98 and 54.02 years, again split over support. Education has a lesser pair with 13.41 and 13.55 years of education and a greater pair with 14.52 and 17.62 years of education;
there are lesser and greater pairs on both sides of the support divide. Both of the more politically liberal clusters are on the more supportive side, while the two more politically conservative clusters are on the less supportive side. There is a pair of clusters with near mean incomes, at $61,175 and $62,109; one of these is on the more supportive side with the lowest income group, while the other shares the less supportive side with the highest income cluster. The two environmentally active clusters, with scores 7.70 and 7.06, are split over support, as are the less active clusters, with scores of 4.58 and 4.56. The entire set of clusters is presented in Table A.7.

5.2.1.f. Reason to purchase renewable energy: to reduce acid rain

The fifth listed reason for purchasing renewable energy was to reduce acid rain. This variable will hereafter be referred to as $\text{reason}_{\text{acid}}$. The clusters developed for $\text{reason}_{\text{acid}}$ followed the procedures outlined in the cluster analysis section in the methods chapter. The fitted number of clusters was six. The data set, with missing values in the employed variables removed, had 933 observations. The resulting cluster set had a pseudo F-statistic of 172.24 and an approximate expected over-all $R^2$ value of 0.44215. The cubic clustering criterion was 9.407.

The range over which the different variables vary is wider than seen for most of the other variables. The greater number of clusters allows for groups with more uniformly high or low characteristics to form. The support for $\text{reason}_{\text{acid}}$ ranges from a high of 2.26 to a low of 1.04. The youngest cluster has a mean age of 33.6 years, while the oldest cluster is 62.3 years old. The most educated cluster has 17.03 years of education, while the least educated cluster has only 12.88 years of education. Politically,
the most liberal group has a score of 2.96, compared to the score of 6.09 held by the most conservative cluster. The clusters at the extremes of average income are $144,570 and $39,696, while the environmental stewardship scores range from 9.05 to 3.66. The entire set of clusters is presented in Table A.8.

5.2.1.g. Reason to purchase renewable energy: to improve air quality

The sixth listed reason for purchasing renewable energy was to improve air quality. This variable will hereafter be referred to as \( reason_{\text{air}} \). The clusters developed for \( reason_{\text{air}} \) followed the procedures outlined in the cluster analysis section in the methods chapter. The fitted number of clusters was five. The data set, with missing values in the employed variables removed, had 933 observations. The resulting cluster set had a pseudo F-statistic of 162.54 and an approximate expected over-all \( R^2 \) value of 0.38482. The cubic clustering criterion was 6.116.

There were two clusters that had the most support for \( reason_{\text{air}} \), at 2.24 and 2.19. These two clusters were also at the extremes in age as the oldest and youngest clusters with mean ages of 62.7 and 36.6 years. The lowest support for \( reason_{\text{air}} \) was a tie at 1.25 between two clusters that were both at the conservative end of the political range, with scores of 4.68 and 5.08. In contrast, the lowest political score was 2.99. The most educated cluster had 17.8 years of education, while the least educated cluster has 12.37 years of education. At the ends of the income spectrum are clusters with average incomes of $143,934 and $39,469. The lowest environmental activism score is 4.08, and the highest score is 8.36. The complete set of clusters is available in Table A.9.
5.2.1.h. *Reason to purchase renewable energy: to support Ohio farmers*

The seventh listed reason for purchasing renewable energy was to support Ohio farmers. This variable will hereafter be referred to as \( \text{reason}_{\text{farm}} \). The clusters developed for \( \text{reason}_{\text{farm}} \) followed the procedures outlined in the cluster analysis section in the methods chapter. The fitted number of clusters was four. The data set, with missing values in the employed variables removed, had 933 observations. The resulting cluster set had a pseudo F statistic of 192.00 and an approximate expected over-all \( R^2 \) value of 0.31686. The cubic clustering criterion was 15.006.

The strongest support for \( \text{reason}_{\text{farm}} \) is from a cluster with a value of 2.22, then drops off to the remaining three clusters, the lowest of which is 1.31. The clusters’ age ranges from a top mean age of 63.01 to a bottom mean age of 39.8. The most educated group has 17.54 years of education, while the least educated group has 13.07 years of education. The most politically liberal group has a score of 3.08, in contrast to the most politically conservative cluster at 4.88. The highest income cluster earns $140,171, as opposed to the lowest income cluster, which earns $43,796. The most environmentally motivated cluster has a score of 7.99, and the least environmentally motivated cluster has a score of 4.06. The complete set of clusters is available in Table A.10.

5.2.1.i. *Reason to purchase renewable energy: to benefit Ohio’s economy*

The eighth and final reason for purchasing renewable energy was to benefit Ohio’s economy. This variable will hereafter be referred to as \( \text{reason}_{\text{econ}} \). The clusters developed for \( \text{reason}_{\text{econ}} \) followed the procedures outlined in the cluster analysis section in the methods chapter. The fitted number of clusters was five. The data set, with
missing values in the employed variables removed, had 933 observations. The resulting cluster set had a pseudo F statistic of 172.36 and an approximate expected over-all $R^2$ value of 0.38495. The cubic clustering criterion was 9.412.

There is one cluster that shows relatively strong support for $\text{reason}_{\text{econ}}$, with a score of 2.46. The remaining four clusters are all congregated around 1.40, with the lowest at 1.12. The youngest cluster has a mean age of 34.8 years, and the oldest cluster has a mean age of 64.3 years. The most educated cluster has 17.17 years of education, while the lowest educated cluster has just 13.21 years of education. The political spectrum ranges from the liberal cluster at 3.15 to the conservative cluster at 4.93. Average income spans between a cluster earning $149,007 and a cluster earning $43,642. The environmental stewardship variable has a maximum value at 9.12 in one cluster and a minimum value at 4.72 in another cluster. The entire group of clusters is presented in Table A.11.

5.3. Support for anaerobic digestion

Most of the questions in the data set dealt with renewable energy in general. This section employed Likert-style data points to identify attitudes regarding anaerobic digestion specifically. The logistic regression analysis then allows for specific important variables to be highlighted.

5.3.1. Logistic regression

5.3.1.a. Statement: I would be comfortable with an anaerobic digester being constructed near my home.

The specified logistic regression for the first statement is:
\[ likelihood \text{ of agreement level}, \]
\[ = -2.0375_1 - 0.8297_2 + 1.3114_3 + 3.359_4 + 0.0143 X_{age}^{***} \]
\[ + 0.00669 X_{education} + 0.04 X_{political \; views} \]
\[ + 0.00000274 X_{average \; income}^{*} - 0.1437 X_{env\;score}^{***} \]

where * denotes significance at the \( \alpha = 0.05 \) level and *** denotes significance at the \( \alpha = 0.001 \) level. The likelihood ratio score was 62.4071, with a p-value of less than 0.0001. The Wald statistic was 61.5208, with a p-value of less than 0.0001.

This statement is the most penetrating of the four statements, as it directly asks about a nearby digester. Although there are many environmentally friendly technologies, many of them appeal to people in the abstract. Comfort with these facilities in the immediate vicinity is often a different matter altogether. As was discussed in section 4.3.2. of chapter 4, interpretation of the logistic coefficients on the predictor variables requires some manipulation to produce odds ratios. The odds ratio on \( age \) is 0.9858, indicating that with each additional year of age, the respondent is 1.42\% less likely to move up a level of agreement. The odds ratio on \( average \; income \) is 0.999997265; with each additional $1000 of income earned per year, the respondent is 0.27\% less likely to move up a level of agreement. In contrast, the odds ratio on \( environmental \; stewardship \) is 1.1545, such that a one unit increase in the respondent’s environmental stewardship score increases the likelihood that they will move up a level of agreement by 15.45\%. The variables \( education \) and \( political \; views \) are insignificant. The complete logistic regression analysis and odds ratio tables can be seen in Tables A.12 and A.13.
5.3.1.b. Statement: An anaerobic digester would be a welcome addition to my local municipality’s waste treatment system.

The specified logistic regression for the second statement is:

\[
\text{likelihood of agreement level}_j = -1.48191 - 0.47662 + 1.91623 + 4.01754 + 0.0101 X_{\text{age}}^{**} \\
- 0.1067 X_{\text{education}}^{***} + 0.0843 X_{\text{political views}}^{*} \\
+ 0.00000158 X_{\text{average income}} - 0.1632 X_{\text{env score}}^{***}
\]

where * denotes significance at the \( \alpha = 0.05 \) level, ** denotes significance at the \( \alpha = 0.01 \) level, and *** denotes significance at the \( \alpha = 0.001 \) level. The likelihood ratio score was 112.6895, with a p-value of less than 0.0001. The Wald statistic was 108.8542, with a p-value of less than 0.0001.

This statement is the only one that explicitly ties anaerobic digestion to a local municipal system, rather than a dairy or livestock facility. However, that does not imply that it is any more or less popular. Here we see the greatest number of significant predictor variables. The odds ratio on age is 0.9899, which indicates that for each additional year of age, the likelihood of increase one level of knowledge is -1.00%. The odds ratio on education is 1.1126, such that with an additional year of education, the respondent is 11.26% more likely to move up one level of agreement. In contrast, the odds ratio on political views is 0.9191, so that as a respondent’s political score increases by one unit, they are 8.08% less likely to move up one level. The odds ratio on environmental stewardship is 1.1773, indicating that with each one unit increase in the respondent’s environmental stewardship score, the individual is 17.73% more likely to
move up one level. For this analysis, *average income* is insignificant. The complete logistic regression analysis and odds ratio tables can be seen in Tables A.14 and A.15.

5.3.1.c. **Statement:** Potential problems, such as odor or accidental leakages, outweigh the benefits of an anaerobic digester.

The specified logistic regression for the third statement is:

\[
\text{likelihood of agreement level}_j = -2.54621 - 1.06922 + 0.98333 + 2.69194 + 0.00288 X_{\text{age}} \\
+ 0.0361 X_{\text{education}} - 0.0985 X_{\text{political views}} \\
- 0.0000019 X_{\text{average income}} - 0.006 X_{\text{env.score}}
\]

where * denotes significance at the \( \alpha = 0.05 \) level. The likelihood ratio score was 11.142, with a p-value of 0.0486. The Wald statistic was 11.412, with a p-value of less than 0.0438. The fit statistics for this regression are much less impressive than for any of the other three.

This statement was negative in its tone, in contrast to the other three. Negative statements serve to keep respondents alert and to make sure that there is balance in the statements. In this case the poor fit of the model suggests that some respondents may have been confused by the statement. The only significant variable was *political views*. The odds ratio on this variable is 1.1035, indicating that for each one unit increase in a respondent’s political score, her or she is 10.35% more likely to move up one level of agreement. The complete logistic regression analysis and odds ratio tables can be seen in Tables A.16 and A.17.
5.3.1.d. Statement: An anaerobic digester can be an important tool in managing the waste from large livestock operations.

The specified logistic regression for the fourth statement is:

\[
\text{likelihood of agreement level}_j = -1.94041 - 1.23422 + 1.39443 + 3.6634 + 0.00749 \times_{\text{age}} \\
- 0.0687 \times_{\text{education}}^{**} - 0.0359 \times_{\text{political views}} \\
+ 0.000000154 \times_{\text{average income}} - 0.1475 \times_{\text{env. score}}^{***}
\]

where * denotes significance at the \( \alpha = 0.05 \) level and *** denotes significance at the \( \alpha = 0.001 \) level. The likelihood ratio score was 62.1691, with a p-value of less than 0.0001. The Wald statistic was 61.6382, with a p-value of less than 0.0001.

The final statement matches some of the same characteristics seen in the earlier logistic regressions, namely the importance of education and environmental stewardship. The odds ratio on education is 1.0711, such that an additional year of education increases the likelihood of the respondent moving up a level by 7.11%. Similarly, the odds ratio on environmental stewardship is 1.1589, indicating that with a one unit increase in the environmental stewardship score the likelihood of moving up one level of agreement is 15.89%. The other significant variable is age, which has an odds ratio of 0.9925; an additional year of age decreases the likelihood of moving up one level of agreement by 0.75%. The variables political views and average income are insignificant. The complete logistic regression analysis and odds ratio tables can be seen in Tables A.18 and A.19.
5.4. Willingness to pay

One of the most discussed means of assisting farmers with the cost of the construction and operation of the farm based digester is the use of consumer premiums. These premiums are paid by willing consumers to support the digester. These consumers perceive some benefits to the operation of the digester, usually either environmentally or socially related. Social motivations often include those that relate to the preservation of the dairy industry and/or support for small or environmentally proactive dairy farms.

These premiums are paid as additions to the consumer’s monthly utility bill for either electricity or natural gas, depending on the type of energy produced from the digester. Generally, consumers do not pay a per-unit premium, such as 0.5¢/kWh; rather, they purchase a “block” of energy so that the monthly premium that they pay remains the same each month and does not fluctuate with use. Further, consumers who choose to pay these premiums must sign agreements with the companies, preventing at-will movement into and out of the program. If such an option were available, it would seem likely that there would be few consumers paying an electricity premium in the summer and few natural gas premium supporters in the winter. The premiums paid are collected by the utility company in question, which then distributes them to the participating farmers.\(^5\)

For electricity, the mean value selected was 12.93, with a median value of 5, and a standard deviation of 18.99; 40.9% of all respondents selected that they would pay no

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\(^5\) It should be noted that the physical electricity received by the consumer is whatever is flowing through that particular line. Thus, individuals may actually be purchasing electricity generated from a coal-burning plant or some other means; the commoditized nature of electricity makes differentiation impossible. However, the consumers recognize that their ‘purchase’ enables the grid to move toward more renewable sources.
additional amount of money, while 13.1% and 15.5% marked that they would pay 5 and 10 dollars extra per month, respectively.

Nearly half of all respondents indicated that they would not pay any additional amount for natural gas generated from renewable anaerobic digesters; specifically, 47.5% indicated a $0 premium, while 11.8% and 13.0% indicated a willingness to pay $5 and $10, respectively. In this fashion, the respondents can be broken into essentially three groups, with roughly half not willing to pay any premium, nearly a quarter willing to pay $5 or $10, and another quarter willing to pay $15 or more. The mean willingness to pay was $11.815, with a median value of $5 and a standard deviation of $18.785.

5.4.1. Regression analysis

5.4.1.a. Willingness to pay for electricity from anaerobic digesters

The analysis for respondents’ willingness to pay for electricity generated from anaerobic digesters began with ordinary least-squares regression. The specified regression is as follows:

\[
\text{wtp}_{\text{electricity}} = 8.4745 - 0.0777 X^*_{\text{age}} - 0.1607 X_{\text{education}} - 0.3073 X_{\text{politics}} \\
+ 0.00006187 X^{**}_{\text{income}} + 1.6541 X^{***}_{\text{environmentalism}}
\]

Variables marked with * or ** are significant at the 5% and 1% level, respectively. The F-value for the regression is 17.82, with significance at the 0.0001 level. The adjusted \( R^2 \) value is 0.0626.

The signs on the variables are all in line with empirical expectations. Willingness to pay is positively correlated with \textit{average income} and the \textit{environmental stewardship} score. Individuals with higher income have more money to spend on supporting causes.
that they believe in; here, average income is measured in dollars, so the coefficient could be interpreted as a 6.187 cent increase in willingness to pay per month for each $1000 increase in income. A more practical interpretation may be state that individuals from the high-income cluster that will be illustrated later, earning around $130,000 a year, would pay about $4 more per month than an individual with the mean income of about $64,000.

The environmental stewardship score coefficient is more difficult to interpret, given that the score is an artificially created means of extracting an individual’s past participation in environmentally-friendly activities. The comparatively large coefficient does, however, demonstrate that increasing participation in environmental activities can quickly influence monthly willingness to pay premiums in an appreciable manner. Willingness to pay declines with age, such that for each year older the respondent is, he or she is willing to pay 7.777 cents per month less for renewable energy. This decline is more than likely less of a reflection on older respondents being less willing to pay, and more of an indicator that younger respondents, given their greater exposure to the environmental movement, are more willing to pay.

The variables for education and politics are both negative and both insignificant. The negative value on education is somewhat more surprising, as the more educated individual is posited to possess more information about renewable energy and the benefits; however, the variable is insignificant, so the conundrum of the willingness to pay is irrelevant. The negative sign on politics is less surprising, given that it indicates that the more politically conservative the individual is, the less likely they are to pay a premium for renewable energy.
5.4.1.b. Willingness to pay for natural gas generated from renewable source

The analysis for respondents’ willingness to pay for natural gas produced from anaerobic digesters began with ordinary least-squares regression. The specified equation is as follows:

\[
\text{wtp}_{\text{gas}} = 6.9794 - 0.0510 X_{\text{age}} - 0.1238 X_{\text{education}} - 0.3785 X_{\text{politics}} \\
+ 0.00005585 X_{\text{income}}^{**} + 1.4919 X_{\text{environmentalism}}^{**}
\]

Variables marked with an \( ** \) are significant at the 1% level. The F-value for the regression is 13.91, with significance at the 0.0001 level. The adjusted \( R^2 \) value is a much weaker 0.0498.

The signs on the variables for willingness to pay for natural gas are the same as the signs on the variables for willingness to pay for electricity from the same source. Here, the two variables of significance are average income and environmental stewardship. The coefficient on average income would indicate that a $1000 increase in annual income would increase the monthly willingness to pay by 5.585 cents. A similar interpretation for environmental stewardship is more difficult, given the constructed nature of the variable; however, given the variable’s large coefficient relative to the other variables, it shows the strong impact that a history of environmental activism can have on willingness to pay. Again, it is still unclear as to the explanation of the negative sign on education, but given the variable’s clear insignificance, any interpretation would be fruitless. Similarly, age and politics are also insignificant, although these signs make more intuitive sense, as willingness to pay decreases with age and political conservatism.
5.4.1.c. Willingness to pay for odor elimination due to renewable anaerobic digesters

A third potential source of consumer premiums is potentially from those individuals who would be willing to eliminate the odor of the manure on dairy farmers. As the process of anaerobic digestion destroys the odorous compounds in the manure, the installation and use of an anaerobic digester can significantly reduce the amount of odor generated by a dairy farm.

The mean value of the responses, calculated using midpoints for each category, was $51.776, with a median value of $13, i.e. $1-$25, and a standard deviation of $132.69. 42.2% of respondents would not be willing to pay any premium at all, while another 26.8% would be willing to pay $1-$25. The next two categories, $25-$50 and $50-$100 each received nearly ten percent apiece. To put the odor willingness to pay in the same terms as the other values, the mean per-month premium is $4.31. Remembering the mean willingness to pay values for electricity and gas as $12.93 and $11.82, respectively, it can be seen that the premium for odor elimination could add approximately one-third more to the available premium.

The specified equation is as follows:

\[
wt_{p_{odor}} = -77.6343 - 0.2283 X_{age} + 5.0232 X_{education}^* - 1.8269 X_{politics}^* \\
+ 0.00043497 X_{income}^* + 10.6192 X_{environmentalism}^*
\]

Variables marked with an ** are significant at the 1% level. The F-value for the regression is 21.41, which is significant at the 1% level, with an adjusted R-squared value of 0.0756.
On initial examination, the coefficients on these variables are clearly different than those on the first two willingness to pay regressions. It should be noted immediately that the question asked about a yearly premium, which would certainly increase the magnitude of the premiums. In this regression, education is both positive and significant, in contrast to the first two regressions examined. Here, it can be interpreted that with each additional year of formal education completed, the respondent is willing to pay an additional $5.02 per year to eliminate odor, or 41.8 cents per month. Similarly, for each additional $1000 of average income earned by individual, he or she is willing to pay an additional 43.50 cents per year to eliminate odor, or 3.625 cents per month. The magnitude of the premium for odor elimination associated with average income is approximately half of that available for electricity or gas from renewable sources. Again, there is a relatively large coefficient on environmental stewardship, although it is somewhat diminished by the yearly-premium foundation. If this premium is broken down into a monthly basis, the coefficient is 0.8849, again roughly half that seen in the other regressions. Age and politics are not significant; from the signs on the coefficients, the theme of willingness to pay negatively correlated with age and political conservatism is continued.

5.4.2. Cluster analysis

The cluster analysis of the willingness to pay was done in three separate pieces, one for each willingness to pay variable. Reflecting what was seen in the regression analysis, the electricity and the natural gas clusters were similar in nature, while the odor reduction willingness to pay differs somewhat. As discussed in Section 5.2.2. of this
chapter, there are four distinctive clusters that tend to appear in the cluster analyses. These clusters will be discussed in a more complete fashion in the next chapter.

5.4.2.a. Willingness to pay for electricity clusters

The clusters developed for willingness to pay for electricity followed the procedures outlined in the cluster analysis section in the methods chapter. The fitted number of clusters was six. The data set that was used had 1266 observations, with no missing values for any of the variables used. The resulting cluster set had a pseudo F-statistic of 206.55 and an approximate expected over-all $R^2$ value of 0.43411. The cubic clustering criterion was 4.471. The largest willingness to pay for any cluster was $69.59, and the lowest willingness to pay value was $5.72. The youngest cluster had a mean age of 40.6 years of age, while the oldest had a mean age of 66.0. The most educated cluster had 16.27 years of education, on average, while the least educated cluster had 12.69 years of education. The extreme clusters politically had scores of 3.06 and 5.26, respectively, while the top and bottom clusters with regards to average income made $127,390 and $38,404 per year. The most environmentally active cluster scored a 7.88, while the least active cluster scored a 4.13. The complete set of clusters is provided in Table A.20.

5.4.2.b. Willingness to pay for natural gas clusters

The clusters developed for willingness to pay for natural gas followed the procedures outlined in the cluster analysis section in the methods chapter. The fitted number of clusters was six. The data set, with missing values in the employed variables trimmed out, had 1238 observations. The resulting cluster set had a pseudo F-statistic of 224.48 and an approximate expected over-all $R^2$ value of 0.43420. The cubic clustering
criterion was 11.795. The highest willingness to pay cluster had a mean value of $63.98, while the lowest willingness to pay had a value of only $5.28. The youngest and oldest clusters have mean ages of 37.9 years and 66.18 years, respectively, while the extremes of the education variable had a cluster with 12.3 years of education and another with 16.4 years of education. The most politically liberal group had a score of 3.81, while the most politically conservative cluster had a score of 6.15. The extreme clusters in terms of average income earned $142,871 and $35,069 per year, while the environmental scores ranged from 4.30 to 8.18. The complete set of clusters is provided in Table A.21.

5.4.2.c. Willingness to pay for odor elimination clusters

The clusters developed for willingness to pay for odor elimination followed the procedures outlined in the cluster analysis section in the methods chapter. The fitted number of clusters was six. The data set, with missing values in the employed variables removed, had 1255 observations. The resulting cluster set had a pseudo F-statistic of 224.48 and an approximate expected over-all R² value of 0.43420. The cubic clustering criterion was 11.795. The group with the highest willingness to pay had a value of $1573.08, while the lowest willingness to pay value was $22.72. The youngest and oldest clusters were 42.9 and 65.9 years of age, respectively, while the most and least educated clusters had 18.40 and 12.67 years of education. The most politically liberal and politically conservative groups scored 3.19 and 5.23, respectively, while the highest and lowest income groups earned $132,765 and $38,301. The most environmentally

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6 This value, which is greater than the true value of $1500, is the result of the extreme values in the cluster and the large standard deviation used as part of the z-score calculations used to convert the standardized variables back into recognizable groups.
active group scored 7.86, while the least environmentally active cluster scored only 4.00. The complete set of clusters is provided in Table A.22.

Although the intuition behind the four core clusters will be discussed in Chapter 6, there is one cluster in the odor elimination section worth examining at this juncture. Cluster 3 is the cluster with the $1573 per year willingness to pay, and has only three observations. This cluster was initially populated largely with observations that had missing values for one or more variables. When the missing variables were removed, there was an expectation that the best-fit number of clusters would decrease by one, and that the three lone very high willingness to pay individuals would be absorbed into other clusters. However, the best fitting number of clusters remained at six, and the three observations remained in a single cluster. An examination of the cluster reveals something about the reasons these individuals would be unique. The mean education is 18.40 years, suggesting graduate or professional degrees. Their political score is 3.64, as they are close to the most liberal cluster, however, their mean environmental activism score is only 4.49. Their mean income is $94,000 a year. These three observations are well-educated, highly paid individuals who would willingly pay what is truly an extraordinary amount of money to have dairy odor eliminated. The most likely explanation would be that the respondents live in close proximity to an odorous livestock facility.
6.1. Clusters

There are four core groups that show up repeatedly throughout the cluster analysis. These four clusters appear in the electricity and natural gas willingness to pay clusters, as well as in most of the clusters regarding the reasons to purchase renewable energy. These clusters are not absolutely constant in their formation, in the sense that their mean values can shift somewhat from cluster to cluster. However, the core of the cluster can be distinguished, especially relative to the other clusters in the group.

6.1.1. The Elders

One of the first clusters to distinguish itself as a recurring group is a cluster of older respondents with low incomes and less education. This group will hereafter be referred to as the “Elders”. The cluster ranges in age from 56 to 66 years of age, with most clusters centered around 62 years of age. In these ranges, the Elders are the oldest cluster in every collection of clusters in which they appear. They are always the least educated group as well. The mean years of education range from 12.2 years on the low end to 13.2 years on the high end. The Elders are also at the bottom end of the income scale, with mean cluster incomes ranging from $35,000 to $46,000, centered about $39,000. The cluster also has a tendency to be one of the most politically conservative
clusters, although there is more variation for this variable. Similarly, the Elders generally have one of the lowest environmental stewardship scores in each group, although there is more fluctuation here as well.

The Elders encompass the earliest of the Baby Boom generation, as well as the World War II and Pre-War generations. This cluster came of age in 1950’s, a time of both economic prosperity and rising Cold War tension. Too old for the Vietnam Conflict, and too young for the Korean Conflict, this group is innately aware of the potential dangers posed by the world as a whole. This group also entered an economy still strong with manufacturing, a time when an individual could support a family in the newly emerging suburbs with a high school education and a factory job. The environmental movement was only beginning to emerge as the Elders entered middle age. These events would have likely influenced the Elders’ perspective.

The Elders distinguish themselves beyond their demographic characteristics in their attitudes towards anaerobic digestion and their willingness to pay for its attributes. This group has the lowest willingness to pay of all unique clusters for electricity, natural gas, or odor reduction produced from anaerobic digestion. In each case, the group’s willingness to pay was less than half of the average willingness to pay of the sample as a whole. It is possible, and indeed likely, that this reluctance is due in some part to their relatively low incomes. However, as will be demonstrated later on in this chapter, the highest willingness to pay generally does not come from the highest income cluster, lending credence to the notion that willingness to pay and income, while positively correlated, are not slaved to one another.
The possibility of a generally negative view on anaerobic digesters can be seen through the responses to reasons for purchasing renewable energy. The respondents who indicated that they would not purchase renewable energy for any reason were, as a whole, older, less educated, and had lower incomes than those who would purchase renewable energy. The orientation of this group reflects the disproportionate weighting of the Elders. Among those individuals who would purchase renewable energy, the Elders remain distinctive. As with the sample as a whole, reducing the country’s foreign oil independence is the highest scoring reason for this cluster, well ahead of any other reason. Although one could make an argument about the potentially lax environmental regulations of foreign energy production, this reason is really not environmental in nature. Rather, it is a reflection of price and security concerns. Consumers might expect that a reduction in foreign oil imports could stabilize prices at the fuel pump, as well as the removal of the economic sword of Damocles that hangs over the country in the form of potential oil embargoes. The second and third place reasons are much closer to each other, namely, improving air quality and reducing greenhouse gas emissions. The remaining reasons, in descending popularity, are reducing acid rain, supporting Ohio farmers, reducing coal mining, and benefiting Ohio’s economy. It is worth noting the Elders did not appear among the clusters for improving water quality. The difference in scores between the first and fourth reason is nearly four times the difference between the fourth reason and the last one. This pattern of a clear preference followed a close pair and then the rest of the pack, with large gaps between each grouping, is repeated in the other clusters.
6.1.2. *The Educated Wealthy*

A second prevalent group that emerges in the cluster analysis is the high income-high education cluster, hereafter referred to as the “Educated Wealthy”. This cluster is consistently either the most educated cluster or is within one-tenth of a year from being the most educated, with the notable exception of the uniquely high willingness to pay cluster in odor that was mentioned in Chapter 5. The cluster’s mean education ranges from 16.3 to 17.8 years of education; on the whole, the group could be thought of as being composed of respondents with bachelor’s degrees, with a significant proportion of graduate degrees in addition. The group has a very high average income, nearly twice that of the sample as a whole. The average income for the cluster ranges from $127,600 to $142,800. Although these are the unique characteristics of the cluster, it has a few tendencies as well. The clusters trend toward being somewhat younger than the norm, ranging in age from 43 to 47 years of age, and are generally somewhat more conservative than other clusters. Their environmental stewardship scores are, by and large, in the middle of the range of scores represented.

The Educated Wealthy were born in the middle of the 1960’s as children of the early Baby Boomers. This generation is sometimes referred to as Generation Jones, bridging the divide between the Baby Boomers and Generation X. The Educated Wealthy came of age in the 1970’s and early 1980’s. Along the way, these individuals saw the emergence of the environmental movement and the power of OPEC. Memories of Vietnam and Watergate would have likely left permanent memories of cynicism and disappointment with the government. At the same time, these individuals were the
creators of the foundations of the digital age that we have today. Home computers and cellular communication were the intellectual property of this generation, a generation that entered an economy showing the emerging power of today’s so-called “tech” companies.

The potential cynicism of this group of individuals is reflected somewhat in their willingness to pay values. The willingness to pay values for the Educated Wealthy are below the mean values for the sample as the third or fourth highest value, depending on the cluster. Potentially, these individuals could just be premium-weary, in the sense that they pay or are asked to pay premiums for numerous other items.

The Educated Wealthy have a different perspective on the motivations for anaerobic digestion and renewable energy as well. The standout first reason for renewable energy purchases was foreign independence, as seen for the Elders. However, the second reason was reducing acid rain, the highest place that that particular reason placed for any of the four clusters. Continuing the trend set by the Elders, the third place reason, reducing greenhouse gases, followed the second fairly closely, while the remaining reasons were more distantly placed. These reasons were, in descending order, reduce coal mining, improve water quality, benefit Ohio’s economy, improve air quality, and support Ohio farmers. This ranking for Ohio farmers was the lowest of any of the four clusters. The Educated Wealthy also have very low scores for air quality, similar to the Liberal Environmentalists, but in direct contrast to the Elders and the Youth, which rank air quality fairly high.
6.1.3. Liberal Environmentalists

A third group that emerges the cluster analysis, which is largely defined by its political views and environmental activism. As a result, this group becomes known as the “Liberal Environmentalists”. This group is the most interesting group in composition, and is likely the most important group for providing support for anaerobic digestion. The cluster is somewhat less homogeneous than some of the other clusters. Regarding willingness to pay, there tend to be two similar subgroups of the Liberal Environmentalists that appear, one of which is slightly more conservative, better paid, and less environmentally active. Regarding reasons to purchase renewable energy, the difference tends to show itself through the appearance of an older, less educated cluster or its converse. The ages for the cluster range from 44 to 57 years of age, with a mean age of 48. The group is relatively well educated and fairly well paid. They tend to be the most or nearly the most politically liberal cluster, with scores ranging as low as 2.68. They also have higher environmental stewardship scores, with values reaching as high as 9.12.

Demographically, the Liberal Environmentalists are very similar to the Educated Wealthy. As fellow Generation Jones members, they would have seen the same shaping world events. However, it is likely that the emerging environmental movement affected much more radically than those individuals in the Educated Wealthy cluster. In the way that the former cluster brought us the beginnings of the digital age, the Liberal Environmentalists provided the foundations of the environmentally-friendly economy. This is the group that would have read Carson’s Silent Spring growing up, and
remembers the Exxon Valdez disaster vividly. This is the group that forms the core of support for renewable energy.

The willingness to pay clusters for Liberal Environmentalists show a divergence within the group. As a whole, the Liberal Environmentalists have higher willingness to pay values than the other clusters. However, within the Liberal Environmentalists, there is a group with somewhat higher than the norm willingness to pay and a group with markedly high willingness to pay. The lower value group could be thought of as the less committed side, being more politically conservative, better paid, and less environmentally active than the more radical, very high value group. For electricity and natural gas, the lower value group has a willingness to pay of just less than $14, while the high value group has a willingness to pay of $63 to $69. For odor elimination, the two values are $47 and $525. In all cases, the higher willingness to pay group has fewer members, often starkly fewer members. From a digester support perspective, this is the cluster which would be most efficient to target for premiums.

The Liberal Environmentalists stand out from a renewable energy support reasons as well. Whereas every other cluster had foreign oil independence the most important reason to support renewable energy by a fairly wide margin, this particular reason barely ranked fifth. For the Liberal Environmentalists, the standout reason is the reduction of greenhouse gases. Also somewhat surprising is the second place reason, supporting Ohio farmers. This rank is the highest for this reason in any of the clusters. The remaining reasons, in order, are improving water quality, reducing coal mining, reducing foreign oil dependence, benefiting Ohio’s economy, improving air quality, and reducing acid rain.
Of interest is acid rain’s residency at the bottom of the list. Although once a major problem in Rust Belt states such as Ohio, acid rain has been largely reduced by improved coal plant scrubber technology. People who have an interest in environmental matters would be more likely to know about and understand this decrease, and value combating other problems more.

6.1.4. The Youths

The fourth cluster that distinguishes itself as being unique is a group of young respondents that trend toward the middle of the road in many of the other variables. This cluster of respondents will be referred to as the “Youths”. The Youths are consistently the youngest cluster developed, with mean ages in their late thirties. They trend to the more liberal end of the political scale, with scores as low as 2.99, but more often occupy a place just to the left of center. They earn less than the sample mean income at around $50,000 a year. Their mean education pivots around fourteen years, which could be thought of as a fairly balanced mix of high school diplomas, associate’s degrees, and bachelor’s degrees. The only other points of uniqueness for this group are its environmental stewardship scores. The Youths consistently have the lowest or nearly the lowest environmental stewardship score of any of the other clusters, regardless of the variable at hand.

The Youths sit fairly squarely in Generation X. These individuals grew up in the 1980’s, witnessing the implosion of Communism, the Reagan legacy, and the First Persian Gulf War. This group also grew up with the booming technology of the day, where video games and cable television were now the norm, and the Internet was just
starting to show the power that it would come to have. Technology and consumption were part of the way of life, and the influence the nascent environmental movement had on the previous generation may have become commonplace, lacking the sudden urgency it had possessed in the 1970’s.

The Youths tend to trend closer to the center regarding willingness to pay. They never have the highest willingness to pay nor the lowest. The Youths’ willingness to pay for electricity is $7.97, with a similar willingness to pay for natural gas at $7.14. Their odor reduction willingness to pay is just above that of the Elders, at $23.33. As a result, this group is not currently an attractive cluster to target for premiums to support anaerobic digestion. However, it is worth considering that as these individuals age, the willingness to pay might increase for some. The better educated members of the group might advance into the Educated Wealthy cluster, while some of the more passionate but lifestyle-constrained members might be able to move into the Liberal Environmentalists cluster as time passes.

The Youths’ reasons for purchasing renewable electricity reflect some of the environmental scores. The first place reason is reducing foreign oil independence, similar to every other group other than the Liberal Environmentalists. However, the second and third place reasons are to improve air and water quality, respectively. Although these are real concerns, they have also become clichéd to a certain point. Nearly every news story regarding general pollution will mention either air or water problems. They are omnipresent, understandable, and affect virtually everyone. Further evidence of this is seen in the examining the rest of the reasons; in descending order, they
were reducing coal mining, reducing greenhouse gas emissions, reducing acid rain,
supporting Ohio farmers, and benefiting Ohio’s economy. The difference from the fourth
placed reason to the seventh placed reason was a mere 0.24 points, indicating a fairly
even spread over these reasons. In a sense, the group would seem to agree that the
foreign oil problem was the most important, with air and water quality following close
behind. After that, however, there is much less consensus on the order of priorities. The
exception here is the Ohio economy, which is last by a clear margin. It is possible that
the group is skeptical about the ability of renewable energy to bolster the economy, and is
instead focusing on the attainable environmental benefits.

6.2. Knowledge of emerging renewable energy sources

The examination of respondents’ current knowledge of emerging renewable
energy sources revealed a general dearth of understanding among the sample as a whole.
Overall, the number of people who felt that they possessed relatively less knowledge was
greater than the number of people with relatively more knowledge by a ratio of more than
two to one. Those who did have more knowledge were, somewhat unsurprisingly,
younger, better educated, and have more income.

At first look, the relatively low number of individuals who consider themselves to
be knowledgeable regarding renewable energy can seem somewhat discouraging.
However, this level of understanding seems to have improved from past crises (Farhar, et
al., 1980). A review of the studies conducted during the energy crises of the 1970’s
reveal that solar appears to be one of the only renewable energy forms understood,
although nuclear power retained fair amount of popularity at that point (Farhar, et al.,
1980). Among the possible replacements for foreign oil, coal is particularly popular (Farhar, et al., 1980). This idea seems somewhat unusual today, given the clear differences between liquid fuels and electricity generation, as well as a general appreciation in understanding regarding coal’s polluting nature.

Knowledge of emerging renewable energy sources is somewhat low, but it is clearly well above zero. There is room for a cautious optimism that renewable energy understanding could be on the upswing, and that more people are making an effort to seek out information about the future of energy consumption and production. It would only seem reasonable that more knowledge would lead to better decisions regarding energy consumption.

6.3. Statements regarding anaerobic digestion

Although there is a considerable amount of information regarding renewable energy in general, anaerobic digestion is somewhat less well known. The statements asking the respondents about anaerobic digestion bear this out. The overall response to these statements could be considered somewhat positive in some instances, and somewhat negative in others. The best characterization of consumers’ reactions might be: “Not sure.” Essentially, respondents give the impression that they just do not know enough about anaerobic digestion to make an informed decision.

This information gap is problematic from the perspective of establishing anaerobic digestion through consumer premiums. It would seem unlikely that people would be willing to financially support that which they do not understand. However, the evidence from the willingness to pay analysis seems to indicate that there is a pool of
premiums that exists. Logically, it would follow that consumers do not seem to have much information about digesters, but their initial indications are that it seems to be positive technology. Therefore, going forward, the goal of anaerobic digestion could be better described as cementing a positive impression, rather than an attempting to win over consumers. In other words, try to not to mess up the momentum. As a result, this fledgling industry needs to concentrate on maintaining a positive image as a safe, green, clean energy source.

6.4. Willingness to pay

Determining consumers’ willingness to pay for green energy from any source is a subject that has been a research subject for many years. As with many willingness to pay studies of different types, the results of this work do not come to a conclusive dollar figure. There is no authoritative study that states with relative certainty a value with defined confidence intervals. There is also some amount of uncertainty relating to adoption as well, as stated willingness to pay and follow through to premiums paid can only be said to be related, not the same.

However, these studies, including this one, show that there is some real interest in paying premiums to support renewable energy production development. These premiums cannot be construed as large or widespread by any metric, but they must be acknowledged as available. In this sense, they reflect anaerobic digesters themselves. At this point, the technology’s adoption is relatively small, but real nonetheless. The pool of available premiums and the number of producers these premiums would support are of a similar scale. There is clearly room to grow in the adoption of anaerobic digester
technology. Similarly, given the low follow-through rates and lack of information regarding anaerobic digestion in the community at large, there is room for growth in the willingness to pay premiums as well. As anaerobic digesters become more commonplace, the consumer premiums to support this technology should begin to dry up, but the increased infrastructure developed to construct and maintain digester should lower the costs of construction, decreasing the need for consumer premiums. The available premiums could then have the real effect of significantly assisting in jumpstarting the anaerobic digestion adoption process.
CHAPTER 7

CONCLUSIONS

7.1. There exists some pool of premiums for anaerobic digestion

The renewable energy production potential and drastic odor reduction achievable through anaerobic digestion combine to make this technology conceptually attractive to dairy producers. The benefits offered through this manure-management tool could provide some producers, especially those producers in sensitive areas or with larger operations, with the means to better integrate into their environment and community. Anaerobic digestion is a logical fit with today’s changing dairy industry.

The cost barrier to the installation of anaerobic digesters is one of the largest obstacles to the widespread adoption of this technology. One potential means of minimizing this cost problem would be to solicit premiums from consumers for the renewable energy produced from this technology. These voluntary premiums could then be transmitted back to the farmers to assist in subsidizing some portion of the cost involved in constructing a digester.

The concept of consumer premiums is certainly not a new one. Consumers have long been paying premiums for desired attributes. With the increasing consciousness of the environmental, developmental, and social concerns faced by this planet, there have been a number of products that have arisen to offer “responsible” consumption.
Consumers pay premiums for organic food, fair trade coffee, and biodegradable materials. Similarly, there has been some development of premiums for energy from emerging renewable sources.

The willingness to pay portion of the survey work for this project clearly indicates that a pool of premiums does exist. Although there are a number of respondents who would be unwilling to pay any additional premium, the majority of respondents indicate that they would be willing to pay some premium each month. Granted, most of the premiums that were indicated were fairly small, on the order of five to ten dollars each month. However, if even one million households in Ohio, less than a quarter of all households, were willing to pay a five dollar monthly premium on their utility bill, that would amount to a sixty million dollar revenue stream each year with which to promote digester construction. Clearly, even the small premiums can make a large difference in the affordability of anaerobic digesters.

7.2. There is a specific group of consumers who should be targeted

The potential premiums to support renewable energy from anaerobic digesters will not appear in a spontaneous outpouring. These premiums will have to be sought out from willing consumers, who will first need to be made aware of the opportunities that are available. Although it is likely that blanket coverage of the market area will reach the interested consumers, it is likely that much of the effort and expense to perform such a broad marketing campaign will be wasted on those individuals who are not interested in purchasing renewable energy. The highest return to the marketing effort will come from
specifically targeting those individuals who value the renewable energy potential of anaerobic digesters the most.

The group of people who are most interested in supporting anaerobic digesters through premiums are those individuals who occupy the cluster that was earlier labeled as the Liberal Environmentalists. These individuals are the most environmentally proactive in their daily lives, concerned with recycling, contributing to environmental causes, and being informed and outspoken about environmental issues in their own communities. These individuals are generally more politically liberal than the rest. There is room for debate about the direction of causality in this arrangement, if any exists, but for whatever reason, these individuals tend toward the politically liberal end of the scale. The Liberal Environmentalists also tend to be better educated than is the norm for the sample.

Targeting this group of individuals would be more productive than mass market efforts. These individuals have significantly higher willingness to pay values than the other respondent groups, by factors of four or more. Furthermore, these individuals have stronger environmental motivations for these premium support programs. The willingness to pay section showed strong significant positive correlations between willingness to pay and income and environmental activism. However, income-centric motivations can disappear as real incomes decrease, such as in the current economic crisis. As a result, these commitments to premiums could be considered unstable. However, ideological commitments tend to be fairly strong in the face of incentives to revoke a commitment, making for a more favorable long-term platform on which to build a premium program.
BIBLIOGRAPHY


APPENDIX A

TABLES

Notes on the tables:

1. For those tables that detail cluster analysis, the cluster types that are defined as:
   A – The Liberal Environmentalists
   B – The Educated Wealthy
   C – The Elders
   D – The Youth

2. The corresponding caption for each table follows the table.
### Table A.1:

<table>
<thead>
<tr>
<th>Variable*</th>
<th>N</th>
<th>Lower CL Mean</th>
<th>Lower CL Std. Dev.</th>
<th>Age 0 - Age1</th>
<th>Upper CL Mean</th>
<th>Upper CL Std. Dev.</th>
<th>Std. Err.</th>
</tr>
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<td>15.667</td>
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<tr>
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<td>44664</td>
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<td>2.3745</td>
<td>0.1568</td>
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* Variable 0 = knowledge of emerging renewable energy sources <4
* Variable 1 = knowledge of emerging renewable energy sources >4

### Fit Statistics

<table>
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<th>Method</th>
<th>Variances</th>
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<th>Pr &gt;</th>
<th>t</th>
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Table A.1. T-test results for analysis for respondents’ knowledge of emerging renewable energy sources.
<table>
<thead>
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<th>Variable</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Wald Chi-Square</th>
<th>P-value</th>
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Table A.2. Logistical regression parameter estimates and fit statistics for knowledge of emerging renewable energy sources.

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<tr>
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<th>Odds Ratio</th>
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<th>Odds Ratio</th>
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Table A.3. Odds ratios for the logistical regression analysis of knowledge of emerging renewable energy sources.
<table>
<thead>
<tr>
<th>Cluster Number</th>
<th>Reason: Reduce greenhouse gases</th>
<th>Age (years)</th>
<th>Education (years)</th>
<th>Political Attitudes</th>
<th>Income ($/year)</th>
<th>Environ. Steward.</th>
<th>Cluster Size (if app.)</th>
<th>Cluster Type</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>2.72</td>
<td>44.94</td>
<td>16.62</td>
<td>2.94</td>
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<td>188</td>
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<td>2</td>
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</table>

**Fit Statistics:**
- Pseudo F Statistic: 190.49
- Approximate Expected Over-All R-Squared: 0.31778
- Cubic Clustering Criterion: 14.31

Table A.4. Cluster analysis results and fit statistics for respondents’ reasons to purchase renewable energy sources: reduce greenhouse gases.

<table>
<thead>
<tr>
<th>Cluster Number</th>
<th>Reason: Reduce coal mining</th>
<th>Age (years)</th>
<th>Education (years)</th>
<th>Political Attitudes</th>
<th>Income ($/year)</th>
<th>Environ. Steward.</th>
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**Fit Statistics:**
- Pseudo F Statistic: 202.25
- Approximate Expected Over-All R-Squared: 0.31851
- Cubic Clustering Criterion: 17.533

Table A.5. Cluster analysis results and fit statistics for respondents’ reasons to purchase renewable energy sources: reduce coal mining.
<table>
<thead>
<tr>
<th>Cluster Number</th>
<th>Reason: Reduce foreign oil depend.</th>
<th>Age (years)</th>
<th>Education (years)</th>
<th>Political Attitudes</th>
<th>Income ($/year)</th>
<th>Environ. Steward.</th>
<th>Cluster Size</th>
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Fit Statistics:

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Table A.6. Cluster analysis results and fit statistics for respondents’ reasons to purchase renewable energy sources: reduce foreign oil dependence.

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<tr>
<th>Cluster Number</th>
<th>Reason: Improve water quality</th>
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<th>Education (years)</th>
<th>Political Attitudes</th>
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<td>17.62</td>
<td>3.99</td>
<td>127,684</td>
<td>7.06</td>
<td>215</td>
</tr>
</tbody>
</table>

Fit Statistics:

<table>
<thead>
<tr>
<th>Pseudo F Statistic</th>
<th>178.74</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate Expected Over-All R-Squared</td>
<td>0.31757</td>
</tr>
<tr>
<td>Cubic Clustering Criterion</td>
<td>10.859</td>
</tr>
</tbody>
</table>

Table A.7. Cluster analysis results and fit statistics for respondents’ reasons to purchase renewable energy sources: improve water quality.
<table>
<thead>
<tr>
<th>Cluster Number</th>
<th>Reason: Reduce acid rain</th>
<th>Age (years)</th>
<th>Education (years)</th>
<th>Political Attitudes</th>
<th>Income ($/year)</th>
<th>Environ. Steward.</th>
<th>Cluster Size</th>
<th>Cluster Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>1.57</td>
<td>62.30</td>
<td>12.88</td>
<td>3.85</td>
<td>39,696</td>
<td>7.20</td>
<td>151</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>1.69</td>
<td>33.55</td>
<td>14.99</td>
<td>3.37</td>
<td>52,972</td>
<td>5.24</td>
<td>172</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1.13</td>
<td>45.85</td>
<td>17.03</td>
<td>2.96</td>
<td>92,837</td>
<td>9.05</td>
<td>141</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>1.63</td>
<td>53.77</td>
<td>13.77</td>
<td>6.09</td>
<td>52,710</td>
<td>5.32</td>
<td>168</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>1.04</td>
<td>50.01</td>
<td>12.90</td>
<td>3.93</td>
<td>66,206</td>
<td>3.66</td>
<td>159</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>2.26</td>
<td>43.02</td>
<td>17.00</td>
<td>4.94</td>
<td>144,570</td>
<td>5.39</td>
<td>142</td>
</tr>
</tbody>
</table>

**Fit Statistics:**
- Pseudo F Statistic: 172.24
- Approximate Expected Over-All R-Squared: 0.44215
- Cubic Clustering Criterion: 9.407

Table A.8. Cluster analysis results and fit statistics for respondents’ reasons to purchase renewable energy sources: reduce acid rain.

<table>
<thead>
<tr>
<th>Cluster Number</th>
<th>Reason: Improve air quality</th>
<th>Age (years)</th>
<th>Education (years)</th>
<th>Political Attitudes</th>
<th>Income ($/year)</th>
<th>Environ. Steward.</th>
<th>Cluster Size</th>
<th>Cluster Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>1.25</td>
<td>44.54</td>
<td>13.84</td>
<td>5.08</td>
<td>72,915</td>
<td>4.08</td>
<td>240</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>2.24</td>
<td>62.69</td>
<td>12.37</td>
<td>4.11</td>
<td>39,469</td>
<td>4.71</td>
<td>158</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1.42</td>
<td>43.43</td>
<td>17.82</td>
<td>4.10</td>
<td>143,934</td>
<td>6.44</td>
<td>165</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>2.19</td>
<td>36.59</td>
<td>15.09</td>
<td>2.99</td>
<td>55,195</td>
<td>6.54</td>
<td>205</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>1.25</td>
<td>57.42</td>
<td>14.49</td>
<td>4.68</td>
<td>56,404</td>
<td>8.36</td>
<td>165</td>
</tr>
</tbody>
</table>

**Fit Statistics:**
- Pseudo F Statistic: 162.54
- Approximate Expected Over-All R-Squared: 0.38482
- Cubic Clustering Criterion: 6.116

Table A.9. Cluster analysis results and fit statistics for respondents’ reasons to purchase renewable energy sources: improve air quality.

95
<table>
<thead>
<tr>
<th>Cluster Number</th>
<th>Reason: Support Ohio farmers</th>
<th>Age (years)</th>
<th>Education (years)</th>
<th>Political Attitudes</th>
<th>Income ($/year)</th>
<th>Environ. Steward.</th>
<th>Cluster Size</th>
<th>Cluster Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>1.62</td>
<td>39.81</td>
<td>13.81</td>
<td>4.50</td>
<td>65,529</td>
<td>4.06</td>
<td>272</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>1.31</td>
<td>43.97</td>
<td>17.54</td>
<td>4.22</td>
<td>140,171</td>
<td>6.34</td>
<td>190</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>2.22</td>
<td>44.18</td>
<td>15.15</td>
<td>3.08</td>
<td>57,595</td>
<td>7.99</td>
<td>219</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>1.54</td>
<td>63.01</td>
<td>13.07</td>
<td>4.88</td>
<td>43,796</td>
<td>5.75</td>
<td>252</td>
</tr>
</tbody>
</table>

**Fit Statistics:**
- Pseudo F Statistic: 192
- Approximate Expected Over-All R-Squared: 0.31686
- Cubic Clustering Criterion: 15.006

Table A.10. Cluster analysis results and fit statistics for respondents’ reasons to purchase renewable energy sources: support Ohio farmers.

<table>
<thead>
<tr>
<th>Cluster Number</th>
<th>Reason: Benefit Ohio’s economy</th>
<th>Age (years)</th>
<th>Education (years)</th>
<th>Political Attitudes</th>
<th>Income ($/year)</th>
<th>Environ. Steward.</th>
<th>Cluster Size</th>
<th>Cluster Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>1.23</td>
<td>64.33</td>
<td>13.21</td>
<td>4.79</td>
<td>43,642</td>
<td>5.53</td>
<td>216</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>1.47</td>
<td>43.34</td>
<td>17.17</td>
<td>4.45</td>
<td>149,007</td>
<td>5.99</td>
<td>165</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1.59</td>
<td>48.49</td>
<td>15.42</td>
<td>3.15</td>
<td>65,992</td>
<td>9.12</td>
<td>161</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>2.46</td>
<td>45.19</td>
<td>13.30</td>
<td>4.93</td>
<td>62,071</td>
<td>4.72</td>
<td>220</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>1.12</td>
<td>34.75</td>
<td>15.24</td>
<td>3.32</td>
<td>57,387</td>
<td>4.78</td>
<td>171</td>
</tr>
</tbody>
</table>

**Fit Statistics:**
- Pseudo F Statistic: 172.36
- Approximate Expected Over-All R-Squared: 0.38495
- Cubic Clustering Criterion: 9.412

Table A.11. Cluster analysis results and fit statistics for respondents’ reasons to purchase renewable energy sources: benefit Ohio’s economy.
### Table A.12. Logistical regression parameter estimates and fit statistics for statements regarding anaerobic digestion: I would be comfortable with an anaerobic digester being constructed near my home.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Wald Chi-Square</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept 1</td>
<td>-2.0375</td>
<td>0.3987</td>
<td>26.1116</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Intercept 2</td>
<td>-0.8297</td>
<td>0.3946</td>
<td>4.4224</td>
<td>0.0355</td>
</tr>
<tr>
<td>Intercept 3</td>
<td>1.3114</td>
<td>0.396</td>
<td>10.9663</td>
<td>0.0009</td>
</tr>
<tr>
<td>Intercept 4</td>
<td>3.359</td>
<td>0.4241</td>
<td>62.7195</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Age</td>
<td>0.0143</td>
<td>0.00362</td>
<td>15.6946</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Education</td>
<td>-0.00669</td>
<td>0.0203</td>
<td>0.109</td>
<td>0.7412</td>
</tr>
<tr>
<td>Pol. Attit.</td>
<td>0.04</td>
<td>0.0396</td>
<td>1.0193</td>
<td>0.3127</td>
</tr>
<tr>
<td>Income</td>
<td>2.735E-06</td>
<td>1.276E-06</td>
<td>4.5921</td>
<td>0.0321</td>
</tr>
<tr>
<td>Env. Stew.</td>
<td>-0.1437</td>
<td>0.0238</td>
<td>36.5411</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

### Fit Statistics

<table>
<thead>
<tr>
<th>Test</th>
<th>DF</th>
<th>Chi-Square</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood Ratio</td>
<td>5</td>
<td>62.4071</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Score</td>
<td>5</td>
<td>60.6312</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Wald</td>
<td>5</td>
<td>61.5208</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

Table A.13. Odds ratios for the logistical regression analysis for statements regarding anaerobic digestion: I would be comfortable with an anaerobic digester being constructed near my home.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>Relative Percentage</th>
<th>Odds Ratio</th>
<th>Relative Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.986</td>
<td>-1.42%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>1.007</td>
<td>0.67%</td>
<td>For income only</td>
<td></td>
</tr>
<tr>
<td>Pol. Attit.</td>
<td>0.961</td>
<td>-3.92%</td>
<td>Per $1,000</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>1.000</td>
<td>0.00%</td>
<td>0.997</td>
<td>-0.27%</td>
</tr>
<tr>
<td>Env. Stew.</td>
<td>1.155</td>
<td>15.45%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable</td>
<td>Estimate</td>
<td>Standard Error</td>
<td>Wald Chi-Square</td>
<td>P-value</td>
</tr>
<tr>
<td>------------</td>
<td>----------</td>
<td>----------------</td>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Intercept 1</td>
<td>-1.4819</td>
<td>0.4111</td>
<td>12.9932</td>
<td>0.0003</td>
</tr>
<tr>
<td>Intercept 2</td>
<td>-0.4766</td>
<td>0.4029</td>
<td>1.3994</td>
<td>0.2368</td>
</tr>
<tr>
<td>Intercept 3</td>
<td>1.9162</td>
<td>0.4056</td>
<td>22.3226</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Intercept 4</td>
<td>4.0175</td>
<td>0.4209</td>
<td>91.1065</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Age</td>
<td>0.0101</td>
<td>0.00368</td>
<td>7.5893</td>
<td>0.0059</td>
</tr>
<tr>
<td>Education</td>
<td>-0.1067</td>
<td>0.0208</td>
<td>26.3197</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Pol. Attit.</td>
<td>0.0843</td>
<td>0.0200</td>
<td>4.3269</td>
<td>0.0375</td>
</tr>
<tr>
<td>Income</td>
<td>0.00000158</td>
<td>1.295E-06</td>
<td>1.4883</td>
<td>0.2225</td>
</tr>
<tr>
<td>Env. Stew.</td>
<td>-0.1632</td>
<td>0.0242</td>
<td>45.3072</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

Table A.14. Logistical regression parameter estimates and fit statistics for statements regarding anaerobic digestion: An anaerobic digester would be a welcome addition to my local municipality’s waste treatment system.

<table>
<thead>
<tr>
<th>Test</th>
<th>DF</th>
<th>Chi-Square</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Likelihood Ratio</td>
<td>5</td>
<td>112.6895</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Score</td>
<td>5</td>
<td>107.5435</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Wald</td>
<td>5</td>
<td>108.8542</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>Relative Percentage</th>
<th>Odds Ratio</th>
<th>Relative Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.990</td>
<td>-1.00%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>1.113</td>
<td>11.26%</td>
<td>For income only</td>
<td></td>
</tr>
<tr>
<td>Pol. Attit.</td>
<td>0.919</td>
<td>-8.08%</td>
<td>Per $1,000</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>1.000</td>
<td>0.00%</td>
<td>0.998</td>
<td>-0.16%</td>
</tr>
<tr>
<td>Env. Stew.</td>
<td>1.177</td>
<td>17.73%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table A.15. Odds ratios for the logistical regression analysis for statements regarding anaerobic digestion: An anaerobic digester would be a welcome addition to my local municipality’s waste treatment system.
Table A.16. Logistical regression parameter estimates and fit statistics for statements regarding anaerobic digestion: Potential problems, such as odor or accidental leakages, outweigh the benefits of an anaerobic digester.

Table A.17. Odds ratios for the logistical regression analysis for statements regarding anaerobic digestion: Potential problems, such as odor or accidental leakages, outweigh the benefits of an anaerobic digester.
Table A.18. Logistical regression parameter estimates and fit statistics for statements regarding anaerobic digestion: An anaerobic digester can be an important tool in managing the waste from large livestock operations.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Wald Chi-Square</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept 1</td>
<td>-1.9404</td>
<td>0.425</td>
<td>20.8413</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Intercept 2</td>
<td>-1.2342</td>
<td>0.4116</td>
<td>8.9915</td>
<td>0.0027</td>
</tr>
<tr>
<td>Intercept 3</td>
<td>1.3944</td>
<td>0.4054</td>
<td>11.8304</td>
<td>0.0006</td>
</tr>
<tr>
<td>Intercept 4</td>
<td>3.663</td>
<td>0.4184</td>
<td>76.6527</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Age</td>
<td>0.00749</td>
<td>0.00368</td>
<td>4.1448</td>
<td>0.0418</td>
</tr>
<tr>
<td>Education</td>
<td>-0.0687</td>
<td>0.0209</td>
<td>10.8282</td>
<td>0.001</td>
</tr>
<tr>
<td>Pol. Attit.</td>
<td>-0.0359</td>
<td>0.0407</td>
<td>0.7748</td>
<td>0.3787</td>
</tr>
<tr>
<td>Income</td>
<td>1.537E-07</td>
<td>1.304E-06</td>
<td>0.0139</td>
<td>0.9062</td>
</tr>
<tr>
<td>Env. Stew.</td>
<td>-0.1475</td>
<td>0.0243</td>
<td>36.8998</td>
<td>&lt;.0001</td>
</tr>
</tbody>
</table>

| Fit Statistics |
|-----------------|-----------------|-----------------|-----------------|
| Test            | DF              | Chi-Square      | P-value         |
| Likelihood Ratio| 5               | 62.1691         | <.0001          |
| Score           | 5               | 59.6489         | <.0001          |
| Wald            | 5               | 61.6382         | <.0001          |

Table A.19. Odds ratios for the logistical regression analysis for statements regarding anaerobic digestion: An anaerobic digester can be an important tool in managing the waste from large livestock operations.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio</th>
<th>Relative Percentage</th>
<th>Odds Ratio</th>
<th>Relative Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.993</td>
<td>-0.75%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>1.071</td>
<td>7.11%</td>
<td>For income only</td>
<td></td>
</tr>
<tr>
<td>Pol. Attit.</td>
<td>1.037</td>
<td>3.66%</td>
<td>Per $1,000</td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>1.000</td>
<td>0.00%</td>
<td>0.9998</td>
<td>-0.02%</td>
</tr>
<tr>
<td>Env. Stew.</td>
<td>1.159</td>
<td>15.89%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cluster Number</td>
<td>Willingness-to-pay: electricity</td>
<td>Age (years)</td>
<td>Education (years)</td>
<td>Political Attitudes</td>
</tr>
<tr>
<td>----------------</td>
<td>--------------------------------</td>
<td>-------------</td>
<td>-------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>1</td>
<td>7.97</td>
<td>40.59</td>
<td>13.08</td>
<td>4.00</td>
</tr>
<tr>
<td>2</td>
<td>8.25</td>
<td>47.25</td>
<td>16.27</td>
<td>5.26</td>
</tr>
<tr>
<td>3</td>
<td>13.78</td>
<td>47.60</td>
<td>16.15</td>
<td>3.06</td>
</tr>
<tr>
<td>4</td>
<td>55.54</td>
<td>51.23</td>
<td>12.76</td>
<td>4.91</td>
</tr>
<tr>
<td>5</td>
<td>5.72</td>
<td>66.01</td>
<td>12.69</td>
<td>5.01</td>
</tr>
<tr>
<td>6</td>
<td>69.59</td>
<td>45.16</td>
<td>16.19</td>
<td>3.83</td>
</tr>
</tbody>
</table>

Fit Statistics:  
- Pseudo F Statistic: 206.55  
- Approximate Expected Over-All R-Squared: 0.43411  
- Cubic Clustering Criterion: 4.471

Table A.20. Cluster analysis results and fit statistics for respondents’ willingness to pay for electricity generated from anaerobic digesters.

<table>
<thead>
<tr>
<th>Cluster Number</th>
<th>Willingness-to-pay: natural gas</th>
<th>Age (years)</th>
<th>Education (years)</th>
<th>Political Attitudes</th>
<th>Income ($/year)</th>
<th>Environ. Steward.</th>
<th>Cluster Size</th>
<th>Cluster Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7.14</td>
<td>37.85</td>
<td>13.60</td>
<td>3.81</td>
<td>50,072</td>
<td>4.30</td>
<td>287</td>
<td>D</td>
</tr>
<tr>
<td>2</td>
<td>63.98</td>
<td>49.61</td>
<td>13.91</td>
<td>4.53</td>
<td>71,053</td>
<td>5.87</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>13.79</td>
<td>47.93</td>
<td>16.07</td>
<td>2.96</td>
<td>70,247</td>
<td>8.18</td>
<td>151</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>5.82</td>
<td>57.48</td>
<td>13.63</td>
<td>6.15</td>
<td>56,018</td>
<td>4.51</td>
<td>239</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>9.04</td>
<td>45.41</td>
<td>16.36</td>
<td>4.73</td>
<td>142,871</td>
<td>5.03</td>
<td>174</td>
<td>B</td>
</tr>
<tr>
<td>6</td>
<td>5.28</td>
<td>66.18</td>
<td>12.26</td>
<td>3.99</td>
<td>35,069</td>
<td>5.11</td>
<td>274</td>
<td>C</td>
</tr>
</tbody>
</table>

Fit Statistics:  
- Pseudo F Statistic: 224.48  
- Approximate Expected Over-All R-Squared: 0.43420  
- Cubic Clustering Criterion: 11.795

Table A.21. Cluster analysis results and fit statistics for respondents’ willingness to pay for natural gas generated from anaerobic digesters.
<table>
<thead>
<tr>
<th>Cluster Number</th>
<th>Willingness-to-pay: odor reduction</th>
<th>Age (years)</th>
<th>Education (years)</th>
<th>Political Attitudes</th>
<th>Income ($/year)</th>
<th>Environ. Steward.</th>
<th>Cluster Size</th>
<th>Cluster Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>50.29</td>
<td>46.62</td>
<td>16.32</td>
<td>4.95</td>
<td>132,765</td>
<td>4.78</td>
<td>212</td>
<td>B</td>
</tr>
<tr>
<td>2</td>
<td>525.22</td>
<td>46.51</td>
<td>14.70</td>
<td>4.12</td>
<td>87,148</td>
<td>7.46</td>
<td>60</td>
<td>A</td>
</tr>
<tr>
<td>3</td>
<td>1573.08</td>
<td>47.22</td>
<td>18.40</td>
<td>3.64</td>
<td>94,227</td>
<td>4.49</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>47.07</td>
<td>48.32</td>
<td>15.63</td>
<td>3.19</td>
<td>65,264</td>
<td>7.86</td>
<td>217</td>
<td>A</td>
</tr>
<tr>
<td>5</td>
<td>22.72</td>
<td>65.92</td>
<td>12.67</td>
<td>5.23</td>
<td>38,301</td>
<td>5.06</td>
<td>384</td>
<td>C</td>
</tr>
<tr>
<td>6</td>
<td>23.33</td>
<td>42.85</td>
<td>12.99</td>
<td>4.02</td>
<td>49,115</td>
<td>4.00</td>
<td>379</td>
<td>D</td>
</tr>
</tbody>
</table>

**Fit Statistics:**

<table>
<thead>
<tr>
<th>Pseudo F Statistic</th>
<th>214.53</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate Expected Over-All R-Squared</td>
<td>0.43628</td>
</tr>
<tr>
<td>Cubic Clustering Criterion</td>
<td>7.061</td>
</tr>
</tbody>
</table>

Table A.22. Cluster analysis results and fit statistics for respondents’ willingness to pay for odor reduction from anaerobic digesters.
Ohio Survey of Food, Agriculture, and Environmental Issues

The Ohio State University
Columbus, Ohio
May 2008

104
Ohio Survey of Food, Agriculture, and Environmental Issues

I. Your Place of Residence & Community

A. Please describe the kind of place in which you currently live. (Circle your answer)
   1. City
   2. Suburb
   3. Small Town
   4. Countryside (but not on a farm)
   5. Farm

B. How long have you lived in your current community? ______ years (enter 1 if less than one year)

C. In what kind of place did you spend most of your childhood? (Circle your answer)
   1. City
   2. Suburb
   3. Small Town
   4. Countryside (but not on a farm)
   5. Farm

D. Please indicate your level of agreement with the following questions related to life, leadership, and opportunities in your community by circling the appropriate numbered response.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

a. The leaders of my community have a good vision and sense of direction for the future

b. Local officials in my community understand how to develop the area’s economy

c. My local community is actively involved in local community improvement/economic development efforts

d. Local officials are doing the best they can with the resources they have

e. When something needs to be done in my community, the whole community usually gets behind it

f. When important community issues arise most people in my community are willing to express their opinions publicly

g. The involvement of youth in community projects is encouraged in my community

h. Clubs and organizations in my community are interested in what is best for all residents

i. Residents in my community are receptive to new residents taking leadership positions

j. People in my community trust their local officials

k. Overall, Ohio is a good state in which to work and live...
E. How satisfied are you with the following aspects of your life or community? Please indicate not applicable where appropriate (for instance, job security might not be applicable if you are retired).

<table>
<thead>
<tr>
<th></th>
<th>Very Dissatisfied</th>
<th>Neutral</th>
<th>Very Satisfied</th>
<th>Not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Your housing</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>b. Your education</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>c. Your job</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>d. Your job security</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>e. Your job opportunities</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>f. Your community</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>g. Your current income level</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>h. Your current financial security</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>i. Your anticipated financial security</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>during retirement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

II. Farming and Food Behaviors

A. How often do you engage in the following activities associated with food, agriculture, or the environment?

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Seldom</th>
<th>Occasionally</th>
<th>Frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Buy foods that are locally grown or produced?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>b. Take a recreational drive through the countryside?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>c. Visit a pick-your-own fruit or vegetable farm?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>d. Tote or visit a working farm?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>e. Purchase farm produce or other food items at a farmer’s market or roadside stand?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>f. Use your own tote bags when shopping?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>g. Recycle waste (paper, cans, glass, bottles, plastic, etc.)?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>h. Buy foods labeled as certified organic?</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

B. About how much would you estimate your household spent buying farm products or food items directly from a farmer in 2007? (For example, at a farmers’ market, roadside stand, CSA, etc.) (Please write "$0" if you bought nothing directly from a farmer in 2007) $________

C. How much of the food that you eat is processed, packaged and not locally grown (from more than 200 miles away)?

1. Most of the food I eat is processed, packaged and from far away
2. Three quarters
3. Half
4. One quarter
5. Very little. Most of the food I eat is unprocessed, unpackaged and locally grown
D. There is growing interest in creating more opportunities for Ohioans to purchase foods that have been grown or processed closer to where they live. How important do you think it is that state and local governments work to develop stronger local food systems throughout the state?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>Somewhat</td>
<td>Very</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Important</td>
<td>Important</td>
<td>Important</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

E. How often do you eat animal based products? (beef, pork, chicken, fish, eggs or dairy products)?
1. Almost always (meat and eggs/dairy in almost every meal)
2. Very often (meat daily)
3. Often (meat once or twice a week)
4. Occasionally (no meat or occasional meat, but eggs/dairy almost daily)
5. Infrequently (no meat, and eggs/dairy a few times a week; strict vegetarian)
6. Never (vegan)

F. Do you or does anyone in your household engage in the following gardening or food preservation activities?

<table>
<thead>
<tr>
<th>Activity</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Maintain a fruit or vegetable garden?</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b. Canned or froze fresh vegetables or fruit that you grew or purchased?</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c. Compost yard, garden, or kitchen waste?</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

G. If you or someone in your household grew fruits and vegetables for home consumption last year, how much would you estimate its value was if you had bought the same food at a grocery store or farmer’s market? (Please write “0” if no fruits or vegetables were grown)

<table>
<thead>
<tr>
<th>Value</th>
<th>$</th>
</tr>
</thead>
</table>

H. There are several possible obstacles to getting started in fruit and vegetable gardening. Which of the following are obstacles for your household? If someone in your household already grows fruits and vegetables, which are obstacles for increasing the amount of fruits or vegetables grown?

<table>
<thead>
<tr>
<th>Obstacle</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. No interest in fruit or vegetable gardening</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b. Not enough time to garden</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c. Don’t have the space or access to a place to grow fruits or vegetables</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d. Don’t know how to grow fruits or vegetables</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e. Mobility or physical impairments limit ability to garden</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>f. It costs too much to get started growing fruits or vegetables</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

I. Recently, public television stations around the state have been airing a television show about Ohio food and agriculture titled “Our Ohio.” This show is sponsored by the Ohio Farm Bureau Federation. Have you seen that show, and if so, what is your opinion of it?
1. I have never seen the show
2. Yes, I have seen the show and enjoyed it
3. Yes, I have seen the show, but did not like it
III. Food, Agriculture and Environmental Views

A. Several issues, including many related to food, agriculture or the environment have been in the news in the past year. We would like to know how concerned you are about the following issues:

<table>
<thead>
<tr>
<th>Issue</th>
<th>Not Concerned</th>
<th>Somewhat Concerned</th>
<th>Very Concerned</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Global warming or the “greenhouse effect”</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>b. Pollution of Ohio’s rivers, streams or groundwater</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>c. The rising cost of gasoline and heating fuel</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>d. Loss of farmland as a result of urban growth</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>e. The high debt levels of some Americans</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>f. Development of large-scale poultry and livestock production facilities in Ohio</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>g. The loss of family farmers</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>h. The rising cost of food</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>i. Rising obesity among Americans</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>j. Air pollution in Ohio cities, villages and towns</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>k. The great distance many foods travel to get to Ohio</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>l. Loss of Ohio jobs due to “globalization”</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>m. The amount of taxes Ohioans must currently pay</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>n. The declining value of the U.S. dollar</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

B. Please indicate your level of agreement with the following statements related to food, agriculture or the environment by circling the appropriate numbered responses.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Undecided</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Ohio's economy will suffer if the state continues to lose farmers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>b. I trust Ohio farmers to protect the environment</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>c. Environmental protection laws regulating farming practices are too strict</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>d. Overall, farming positively contributes to the quality of life in Ohio</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>e. Food is not as safe as it was 10 years ago</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>f. In general, increased regulation of the treatment of animals in farming is needed</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>g. In a couple years, the cost of gasoline will probably be about the same or even less than it is today</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>h. More should be done to encourage energy conservation</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
IV. Home Energy and Conservation
A. Which housing type describes your home?
   1. Free standing home
   2. Multi-story apartment building
   3. Row house or building with 2-4 housing units
B. Does your home or apartment have any significant green design elements built into it that improve its energy efficiency, heating or cooling performance?
   1. Yes  2. No
C. What is the size of your home or apartment (in square feet)? ________ square feet
D. Do you use energy conservation or efficiency measures throughout your home?
   1. Yes  2. No
E. Do you use high efficiency light bulbs in your home?
   1. Yes  2. No
F. Do you own or rent your current residence?
   1. Own
   2. Rent (Skip to item 1 below)
   3. Have some other arrangement (Skip to question 1 below)
G. If you own your current residence, what is its current estimated market value?
   1. Less than $49,999
   2. $50,000 to 99,999
   3. $100,000 to 149,999
   4. $150,000 to 199,999
   5. $200,000 to 299,999
   6. $300,000 or more
H. If you own your current residence, have you done the following in the last two years to improve energy efficiency or reduce energy costs?
   In the last two years, have you...
   a. Replaced existing windows with more energy efficient windows? ......................... 1  2
   b. Added or increased insulation in the walls or attic of your house? ....................... 1  2
   c. Sealed your house’s windows, doors, or ductwork to reduce air leaks ................ 1  2
   d. Claimed a Home Energy Efficiency Improvement Tax Credit on your Federal Tax Return .......................................................... 1  2
I. How often do you engage in the following energy saving behaviors? (Circle your answer)
<table>
<thead>
<tr>
<th>Never</th>
<th>Seldom</th>
<th>Occasionally</th>
<th>Frequently</th>
</tr>
</thead>
</table>
   a. Reduce heat in unused rooms? ...................... 1  2  3  4
   b. Reduce temperature on hot water heater? .......... 1  2  3  4
   c. Keep heating low to save energy? .................... 1  2  3  4
   d. Wear more clothes instead of increase the heat? 1  2  3  4
   e. Turn lights off in unused rooms? .................... 1  2  3  4
V. Energy and Transportation

A. How much electricity, natural gas or liquid heating fuel has your household consumed in the last year? Also, which companies serve your energy needs? Information concerning your annual usage is printed on your monthly bill. If you do not know, are unable to locate the information, or the cost of a particular utility is bundled in your rent or other similar payment, please check the “don’t know” box.

<table>
<thead>
<tr>
<th>Energy Type</th>
<th>Utility Company</th>
<th>Usage</th>
<th>&quot;Don't Know&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td></td>
<td>kWh</td>
<td>&quot;Don't Know&quot;</td>
</tr>
</tbody>
</table>

Please check and answer for the heating fuel source for your household. If heat is not generated from natural gas or a liquid heating fuel, please write N/A to the left of the table and move on to Question B.

<table>
<thead>
<tr>
<th>Natural Gas</th>
<th>CCF</th>
<th>&quot;Don't Know&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Heating Fuel</td>
<td>Gallons</td>
<td>&quot;Don't Know&quot;</td>
</tr>
</tbody>
</table>

B. How knowledgeable are you with emerging renewable energy sources, such as the sun, wind, water, or plants? Please indicate on a scale of 1 to 7, your level of knowledge. (Circle the number that comes closest to your level of knowledge)

Not at all | Somewhat | Very
Knowledgeable | Knowledgeable | Knowledgeable

C. Does your electricity provider permit you the option to purchase renewable energy?

☐ Yes  ☐ No  ☐ Don't Know

D. There are a number of reasons why someone might purchase electricity from renewable sources. Please rank the top three reasons why you would purchase electricity produced from renewable sources. Indicate 1 for the top reason, “2” for the second most important reason and “3” for the third most important reason. If you have no interest in purchasing energy from renewable sources, please indicate this by checking the “no interest” box.

☐ I have no interest in purchasing energy from renewable sources
☐ To reduce greenhouse gas emissions  ☐ To reduce acid rain
☐ To reduce coal mining  ☐ To improve air quality
☐ To reduce dependence on foreign oil  ☐ To support Ohio farmers
☐ To improve water quality  ☐ To benefit Ohio’s economy

Please read the following paragraph before continuing.

Anaerobic digesters are processors in which waste materials such as livestock manure, municipal sludge, and food processing waste are broken down by bacteria in a sealed environment. The resulting products are compost and biogas, the biogas contains methane, and can be burned to produce electricity, or refined into natural gas.

E. How much more per month would you be willing to pay for electricity generated from renewable anaerobic digesters? (Check one please)

☐ $0  ☐ $5  ☐ $10  ☐ $15  ☐ $20  ☐ $25  ☐ $30  ☐ more than $50
F. How much more per month would you be willing to pay for natural gas generated from renewable anaerobic digesters? (Check one please)

- $0
- $5
- $10
- $15
- $25
- $35
- $50
- more than $50

G. Please indicate your level of agreement with the following statements related to different renewable energy generation methods by circling the appropriate numbered response.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I would be comfortable with an anaerobic digester being constructed near my home.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>b. An anaerobic digester would be a welcome addition to my local municipality's waste treatment system.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>c. Potential problems, such as odor or accidental leakages, outweigh the benefits of an anaerobic digester.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>d. An anaerobic digester can be an important tool in managing the waste from large livestock operations.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

H. Below are some renewable sources of electricity. Please indicate your support for each as a source of electricity.

<table>
<thead>
<tr>
<th>Strongly Oppose</th>
<th>Neutral</th>
<th>Strongly Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Wind</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b. Solar</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c. Hydroelectric</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d. Nuclear</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e. Anaerobic digestion</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>f. Geothermal</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

I. Odor can be a nuisance and a potential health risk for individuals living in close proximity to animal feeding operations. Anaerobic digestion can eliminate this odor almost entirely when used to generate power and manage manure. How much would you be willing to pay each year, as an amount added to your electricity or gas bill, for energy produced from anaerobic digestion which effectively eliminates odor? (Check one please)

- $0
- $1 - $25
- $25 - $50
- $50 - $100
- $100 - $250
- $250 - $500
- $500 - $1000
- more than $1000

J. How much would you be willing to pay each year to help make the United States independent of foreign oil by the year 2020? (Check one please)

- $0
- $1 - $25
- $25 - $50
- $50 - $100
- $100 - $250
- $250 - $500
- $500 - $1000
- more than $1000
K. Have you engaged in any of the following environmental activities in the last year? 

<table>
<thead>
<tr>
<th>In the last year, have you</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Stopped buying a product that is associated with an environmental problem?</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>b. Attended a public hearing on an environmental issue?</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>c. Contributed money to or volunteered for an environmental group?</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>d. Watched a television special about the environment?</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>e. Purchased an energy star rated appliance (such as a dishwasher, TV, etc.)</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

L. If the cost of gasoline continues to steadily increase, how likely are you to take the following actions to reduce your transportation costs? 

<table>
<thead>
<tr>
<th>Very unlikely</th>
<th>Somewhat unlikely</th>
<th>Somewhat likely</th>
<th>Very likely</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Use mass transit (like the bus) more often to get where you need to go</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>b. Walk or bicycle more often to get where you need to go</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>c. Carpool or share rides more often to get where you need to go</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>d. Buy a more energy efficient car</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>e. Change jobs to work closer to your home</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>f. Move to a new house or apartment to be closer to the places you or others in your household need to travel to</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>g. Work from home more often</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

M. Which of the following are obstacles to your more frequent use of alternative transportation to get where you need to go? 

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I have no access to mass transit, such as the bus (if yes, skip the next question)</td>
<td>1</td>
</tr>
<tr>
<td>b. Mass transit is too expensive</td>
<td>1</td>
</tr>
<tr>
<td>c. The places I need to go are too far away to walk or bike to</td>
<td>1</td>
</tr>
<tr>
<td>d. I have health/physical impairments that prevent me walking, biking or using mass transit</td>
<td>1</td>
</tr>
<tr>
<td>e. Carpooling or sharing rides is not possible</td>
<td>1</td>
</tr>
<tr>
<td>f. It is generally inconvenient to use alternative transportation such as the bus or walking</td>
<td>1</td>
</tr>
</tbody>
</table>

VI. Current well-being

A. Some Ohio families have recently needed to make financial adjustments to family living. In the past year, have you or any family members made the following adjustments? (Circle your answer) 

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Used savings to meet expenses</td>
<td>1</td>
</tr>
<tr>
<td>b. Changed transportation patterns to save money</td>
<td>1</td>
</tr>
<tr>
<td>c. Eaten at home more or changed the types of food eaten to save money</td>
<td>1</td>
</tr>
<tr>
<td>d. Postponed obtaining prescription drugs in order to save money</td>
<td>1</td>
</tr>
<tr>
<td>e. Used public/charitable assistance (such as food banks) to meet needs</td>
<td>1</td>
</tr>
</tbody>
</table>
B. All things considered, do you think you are better or worse off than you were two years ago?
   1. Worse off  2. About the same  3. Better off

C. Overall, have increased gasoline, home heating or food costs been a financial hardship for your household during the last six months? (Circle your answer)

<table>
<thead>
<tr>
<th></th>
<th>Not a Financial Hardship</th>
<th>Modest Financial Hardship</th>
<th>Serious Financial Hardship</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Increased gasoline costs</td>
<td>1 2 3 4 5</td>
<td>6 7</td>
<td></td>
</tr>
<tr>
<td>b. Increased home heating costs</td>
<td>1 2 3 4 5</td>
<td>6 7</td>
<td></td>
</tr>
<tr>
<td>c. Increased food costs</td>
<td>1 2 3 4 5</td>
<td>6 7</td>
<td></td>
</tr>
</tbody>
</table>

D. There is increasing concern about the amount of debt Ohioans currently have. How much stress does the total debt you (and your spouse/partner) currently have cause you?
   1. I (and my spouse/partner) have no debt (skip to Section VII, Question A below)
   2. No stress at all
   3. Not very much stress
   4. Quite a bit of stress
   5. A great deal of stress

E. How concerned are you that you will never be able to pay off your debts?
   1. Not at all concerned
   2. Somewhat concerned
   3. Quite concerned
   4. Very concerned

VII. Background Questions

A. What is your age (as of your last birthday)? ________ years

B. Your sex?  1. Male  2. Female

C. How many years of education have you completed? ________ years
   (for example, high school diploma or GED is equivalent to 12 years)

D. What is your current marital status?
   1. Now married
   2. Living together
   3. Never married
   4. Divorced/Separated
   5. Widowed/Widower

E. Which best describes you?
   1. African American
   2. Asian
   3. Hispanic/Latino
   4. Native American/American Indian
   5. White
   6. Other: (please specify) ________

F. How many people live in your household? ________ people

G. How many persons in your household are the following ages (including yourself):
   a. Under 5 years of age ______
   b. 5 to 18 years of age ______
   c. 19 years of age or older ______
H. How would you generally describe your political views on a scale of 1 to 7 (1=extremely liberal, 7=extremely conservative)? (Circle your answer)

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely Liberal</td>
<td>Middle of the Road</td>
<td>Extremely Conservative</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

I. What is your present employment status? (Circle one answer)

1. Employed on a full-time basis
2. Employed on a part-time basis
3. Self-employed on full-time basis
4. Self-employed on a part-time basis
5. Retired
6. Full-time homemaker
7. Student
8. Unemployed

J. If you are employed in paid work, what is your major occupation in which you work most of the time?

1. Professional or technical (teacher, engineer, etc.)
2. Manager/administrator
3. Sales, office support
4. Production, transportation
5. Construction, mining, repair
6. General service work
7. Farm operator or manager
8. Non-farm, self-employed
9. Other—please specify________________________

K. If you are employed or self-employed on a full or part-time basis, how many miles do you travel, one way, to work from home? ____________ miles

L. On average, how far do you travel on public transportation each week? Please indicate “0” if you do not use public transportation. ____________ miles

M. On average, how far do you travel by car each week (as driver or passenger)? Please indicate “0” if you do never travel by car. ____________ miles

N. How often do you drive a car with someone else, rather than alone?

1. Almost never
2. Occasionally (about 25% of the time)
3. Often (about 50% of the time)
4. Very often (about 75% of the time)
5. Almost always

O. How many miles per gallon does the car you drive or most frequently ride in get? ____________ miles per gallon

P. Approximately how many hours do you spend flying each year, that is hours the plane is in the air? ____________ Hours/year

Q. What was your approximate gross household income from all sources, before taxes, for 2007?

1. Less than $9,999
2. $10,000 to 19,999
3. $20,000 to 34,999
4. $35,000 to 49,999
5. $50,000 to 74,999
6. $75,000 to 99,999
7. $100,000 or more

Thank you for your cooperation!!! If you have additional comments, please provide them on the back cover.