Three Essays on Adoption of Practices Related to the Environment

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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled:

THREE ESSAYS ON ADOPTION OF PRACTICES RELATED TO THE ENVIRONMENT

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A candidate for the degree of

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And hereby certify that, in their opinion, it is worthy of acceptance.

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ABSTRACT

This dissertation consists of three essays related to the adoption of technology. The first essay is about the adoption of manure best management practices (BMPs) such as manure testing. A data set from 2006 of U.S. farmers from the states of Missouri and Iowa was used to ask farmers questions about farming practices and other environmental practices. The innovation was that this paper examined factors that affect manure testing for manure transported off the farm. Factors that increased the probability of manure testing were: individuals with less than high school education compared to those who had high school education, having a contract for the manure transfer, distance manure was transferred, receiving payment for the manure, and soil testing. Also, those whose off-farm income levels ranged from $0-$9,999, or $25,000-$49,000, versus having no off-farm income, and who had solid or both solid and liquid manure compared to liquid manure were less likely to adopt manure testing.

The second essay dealt with farmers in the district of Mardan in the Northwest Frontier Province of Pakistan, who were asked questions in the fall of 2009 about their use of fertilizer and manure and how they applied it to their crops. The purpose of the essay was to analyze the factors that affect the adoption of phosphorous fertilizer. The results show that farm size, land tenure, distance to the central market, obtaining information about prices, supply, and demand for inputs from other farmers, and obtaining information about agricultural practices from other farmers and from personal contacts with businesses positively affect the adoption of phosphorous

fertilizer among farmers living in the district of Mardan. Those farmers who borrowed from the agricultural bank for agricultural purposes were less likely to adopt phosphorous fertilizer than those who did not.

Finally, the third essay used 2007 data from a CBS News/New York Times Monthly Poll to analyze the factors that affect U.S. consumers' adoption of environmental practices such as recycling, mass transit, and the purchase of compact florescent light bulbs. The study found that those who belonged to the Democratic party were more likely to recycle than those in neither party. Furthermore, those who drove SUVs were more likely to recycle than those who drove cars. Individuals living in the central city were more likely to recycle while those living in a rural area were less likely to recycle than those who lived in the suburbs. Furthermore, individuals living in the northeast, north central and western parts of the U.S. were more likely to recycle than those living in the southern part of the U.S.

The use of mass transit was more likely to be adopted by individuals with post graduate education compared to those who had some college education. Individuals with income levels of under \$15,000, \$15,000 to \$30,000, and above \$100,000 were more likely to use mass transit than those whose income was between \$50,000 and \$75,000. Respondents with no cars were more likely to use mass transit than those with cars, since it served as their mode of transportation. Individuals who lived in large central cities were more likely to use mass transit while those in rural areas were less likely than the base category of living in the suburbs. Those living in the northeastern and western parts of the U.S. were more likely to use mass transit than those individuals living in the southern part of the U.S. Furthermore, belonging to the Republican Party was found to negatively affect the adoption of mass transit compared to those of neither party. Those who drove trucks were less likely to use mass transit than those who drove cars.

The purchase of compact florescent light bulbs was more likely for those who drove a minivan compared to those who drove cars, as well as for those who lived in the western part of the U.S. versus the south. Those who were not high school graduates, college graduates, and high school graduates were all less likely to buy fluorescent light bulbs compared to those who had some college education. Finally, individuals with an income from $15,000 to $30,000 were less likely to buy fluorescent light bulbs compared to those with an income of $50,000 to $75,000.

The analysis of these three environmental practices has helped to show the characteristics of different agents in terms of their adoption choices. Livestock producers in the U.S., Pakistan, and consumers in the U.S. are all driven by a unique set of factors within their environment that influence their decisions.

CHAPTER 1: INTRODUCTION

Technological innovation plays an important role in the overall improvement of the quality of life. Such technological change leads to economic improvement which can be measured by economic growth and productivity. The different technologies which are adopted, while they may serve different purposes, share a common factor: those who adopt the technologies derive utility from the innovation, and each adoption practice has a unique set of attributes that attract different types of adopters. This dissertation will attempt to explore the concepts of innovation, the diffusion and adoption of such innovations, and the factors which influence the individual adopters in the context of three different innovations.

Numerous empirical and theoretical studies have shown that resource conservation practices are beneficial and necessary for the sustainability of natural resources, therefore the study of adoption can help policymakers and others design effective policies or programs that give economic agents incentives to conserve the natural resources being depleted. This dissertation will discuss the factors which affect the adoption of best management practices (BMPs) such as manure testing, fertilizer use in developing countries such as Pakistan, and environmental practices among U.S. consumers. It will identify the relevant literature and methodology to examine each practice. Together, these papers compare and contrast producers and consumers who would like to maximize utility in different environments. Farmers in the U.S. have had access to inputs such as fertilizer for many years, while farmers in Pakistan have had many problems obtaining such inputs. The lessons learned from the adoption of BMPs such as manure testing among U.S. farmers, could be implemented in developing countries such as Pakistan. The papers on manure testing and fertilizer adoption are from a producer’s perspective, while the paper on the adoption of environmental practices is from a consumer perspective.

CHAPTER 2: GENERAL LITERATURE REVIEW

2.1. Innovation

The literature on innovation is divided into several categories and focuses on the generation and adoption of innovations (Sunding and Zilberman 2001). An innovation as defined by Rogers (1983) is "….an idea, practice, or object that is perceived as new by an individual or another unit of adoption." Two ways by which innovations can be classified are embodied innovations, which are associated with capital goods, and disembodied innovations, which can be practices such as integrated pest management (Sunding and Zilberman 2001). The innovation process is divided into the following steps: discovery, registration, development, production, and marketing (Sunding and Zilberman 2001). These steps are interconnected and are not discrete stages in time due to the environment in which innovation takes place. The adoption of an innovation can be characterized by a discrete or continuous decision by the user (Sunding and Zilberman 2001).

Technological change as defined by Ruttan and Hayami (1985) is "…any change in production coefficients resulting from purposeful resource-using activity directed to the development of new knowledge embodied in designs, materials, or organizations." Ruttan and Hayami (1985) have indicated that new technology can develop as a result of changing economic conditions in the environment (Sunding and Zilberman 2001); this is referred to as induced innovation. For example, in the case of developing countries, the Green Revolution helped to meet a growing population's demand for food by the introduction of high yielding varieties (HYVs) (Feder et al. 1985). The HYVs increased yields, thus increasing food production for consumers in developing countries, and allowing them to sell extra food as earned income.

Research has been conducted on the factors that result in induced innovation in the private and public sectors. Induced innovation in the public sector is driven by research which in turn is driven by changes in resource endowments and economic growth (Ruttan and Hayami 1985). Research innovation is driven by many factors, however if budget constraints were not present, decisions to invest in research would be determined by marginal analysis (Binswanger 1974). When factor prices of key inputs increase, this prompts scientists and researchers to develop cost-saving technologies that are designed to minimize the use of those inputs (Binswanger 1974; Ruttan and Hayami 1985). Research can be motivated by rising factor prices, thus prompting many firms to invest in cost-saving technologies developed by scientists, researchers, and other innovators outside the firm. The diffusion of innovation, according to the induced innovation model, can only take place if the proper institutions exist, and if the resource endowment of a country can effectively utilize these institutions (Ruttan and Hayami 1985).

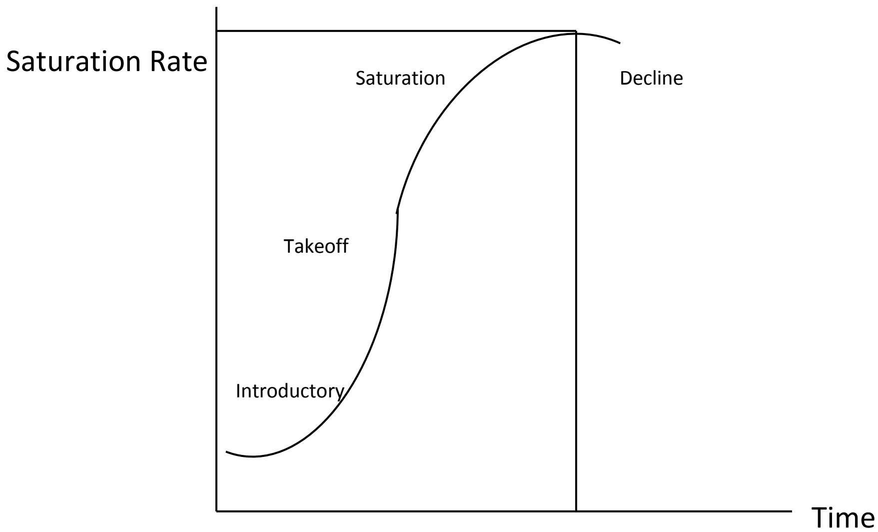
In addition to the establishment of effective institutions, the generation of innovations also requires competent, scientific research organizations (Ruttan and Hayami (1985). For example, the post-World War II establishment of agricultural research organizations in many developing countries shows how important these research organizations were in developing human capital, as well as utilizing existing resources for economic activities (Sunding and Zilberman 2001).

2.2. Diffusion

Diffusion, as defined by economists, is the aggregate adoption of an innovation (Sunding and Zilberman 2001) or as defined by a sociologist, Rogers (1983), an "…innovation is communicated through certain channels over time among the members of a social system." The diffusion of new technologies is quite slow, but Mansfield (1961) found that technologies which were more profitable and had lower investment costs, had a faster rate of imitation among users.

The literature has shown that diffusion takes the form of an S-curve (Griliches 1957; Rogers 1958; Sunding and Zilberman 2001). This aggregate adoption of innovation has been represented by the following equation $Y_t = K\ [1+ e^{(-a+bt)]}]^{-1}$ where diffusion at time t is represented by Y_t, K is the long-run upper limit of diffusion, a is the beginning of the estimation period, and b is the measure of diffusion (Sunding and Zilberman 2001). The x-axis represents time, and the y-axis represents the saturation rate. The S-shaped curve starts with early adoption, takeoff, saturation, and finally a decline in the adoption of the technology (Sunding and Zilberman 2001). The marginal rate of diffusion depicted in Figure 1 initially increases when the innovation is first introduced into the market, then levels off as it saturates the market, and finally declines as it completely penetrates the market (Sunding and Zilberman 2001).

Figure 1: S-Shaped Diffusion Curve (Sunding and Zilberman, 2001)



The diffusion of innovations has also been quantified by the process of imitation and the threshold model (Sunding and Zilberman 2001). Diffusion as the process of imitation, according to Mansfield (1963), is a result of contacting others and imitating their use of an innovation (Sunding and Zilberman 2001). Mansfield (1963) used a logistic diffusion formula that examined marginal diffusion within a multiple identical producer framework, where he assumed that technological diffusion is a process of imitation. However in the threshold model, there are multiple heterogeneous producers that maximize profit or utility (Sunding and Zilberman 2001).

Related to the S-curve, the types of adopters are classified as: innovators, early adopters, early majority, majority, and non-adopters (Bohlen et al. 1957). The characteristics of early and late adopters differ (Rodgers 1983), since over time late adopters can observe whether the innovation successfully enhanced an activity undertaken by the early adopters. Furthermore, an innovation is subject to change over time, thus the innovation may alter from its original form to a new innovation with different features that appeal to a different type of user. According to Rogers (1983), the rate of adoption of an innovation is based on five categories: perceived attributes of the innovation, type of innovation-decision, communication channels, nature of the social system, and extent of change agents' promotion efforts.

The diffusion of these technologies over time has been widely studied in the economics literature, indicating that the S-shaped curve best represents the concept of aggregate adoption over time. This next section will focus adoption as a decision process by an individual agent.

2.3. Adoption

The adoption of technology in agriculture has gone through many phases from the introduction of electricity, to mechanization, HYVs, and genetically modified organisms (GMOs). In order to illustrate some of the issues that will be examined in the literature review, a historical example can be analyzed. In the case of developing countries, HYVs were introduced during the Green Revolution. The global demand for food, especially in developing countries, motivated scientists and biotechnology firms to produce this technology.

Economists define adoption as discrete choices as to whether an individual uses an innovation (Sunding and Zilberman 2001). The adoption of technology is undertaken by all economic agents including consumers and producers for different goods and services depending on individual preferences and market demand. The adoption of a technology goes through many stages, depending on factors such as institutions and temporal dimensions (Copp et al. 1958).

Rural sociologists have observed that there are many stages in the adoption process, and adopters utilize different resources at each stage (Beal et al. 1957; Copp et al. 1958; Rodgers 1958). The adoption of farm practices were observed in the following five stages: awareness, information, application, trial, and adoption (Beal et al. 1957). In the awareness stage, the individual is initially exposed to the new practice. The highest level of informational asymmetry exists in this stage, since the practice is considered relatively new to the user. The information stage is characterized by general curiosity and interest in the practice (Beal et al. 1957), however this stage is influenced by many exogenous factors such as the farmer's exposure to their neighbors, extension agencies, and other institutions that promote the adoption of agricultural practices (Copp et al. 1958). In the application stage, the farmer decides whether the agricultural practice can be used in their production process and uses some type of subjective utility analysis in the adoption assessment (Beal et al. 1957). The trial stage occurs when the farmer applies the agricultural practice and is concerned with the specifics of the practice. Finally, in the adoption stage, the agricultural practice is used by the farmer after evaluation and continued use of the practice (Beal et al. 1957).

Each individual will make adoption decisions based on a number of variables. Rogers (1983) classifies the characteristics of adopters into three categories: socioeconomic characteristics, personality variables, and communication variables. The socioeconomic characteristics have shown that early adopters vary in age, tend to have more income, are more highly educated, and are moving up the social ladder (Rogers 1983). In terms of personality variables, early adopters are more open towards change, less dogmatic, more rational, and are less risk averse (Rogers 1983). Finally, early adopters tend to participate in more social networks, and are more cosmopolite than later adopters (Rogers 1983). According to the works of rural sociologist Rogers (1957), the awareness and experimentation gap of early adopters is quite short.

Economists suggest that adopters will use a marginal analysis framework in order to determine whether they should adopt or disadopt (Feder et al. 1985). The adoption will continue as long as marginal benefits are greater than their marginal costs, and will stop when marginal benefits are less than marginal costs. Technological improvement can decrease marginal costs or increase marginal benefits of one practice, or even generate substitute technology that is superior to the original technology. Furthermore, the use of Bayesian learning rules and equations of motion represent the change over the time with regards to the use of a new technology versus a traditional technology (Feder et al. 1985).

Researchers have tried to identify the factors that influence the adoption of certain technologies over others. According to the adoption literature in economics, those who adopt technologies are classified by factors such as age, education, farm size, income, and risk aversion (Sunding and Zilberman 2001; Feder et al. 1985). There have been a number of studies as cited by Feder et al. (1985) on the adoption behavior of individual farmers (Just and Zilberman 1983; Feder 1982; Roumasset 1976; Hiebert 1974).

The literature indicates that age and increased risk aversion are negatively associated with the adoption of technology, whereas increases in education, farm size, and use of other complementary practices increase the adoption of technology. For example, in the case of HYVs, older farmers and more risk averse farmers were less likely to adopt HYVs, whereas those who were more educated, had larger farms, and used other technologies were more likely to adopt HYVs (Sunding and Zilberman 2001; Feder et al. 1985). There are also constraints to adoption that Feder et al. (1985) identified such as: lack of credit, limited access to information, lack of human capital, lack of transportation infrastructure, and input supply constraints.

2.3.1 Profitability

Agricultural producers are influenced by profit maximization when deciding which technologies to adopt (Useche et al. 2009). The type of production technology used by an agricultural producer will affect profits (Feder et al. 1985), consequently affecting the individual's utility. Each individual will make decisions based on characteristics of the individual and the farm.

The adoption of technology is also based on the belief that it will increase crop yield. The adoption of a technology is more likely as argued by Just and Zilberman (1983), when it can demonstrate that it will provide higher yields than an old or existing technology (Feder et al. 1985). Application of any type of technology has to be in the optimal environment. An environment with favorable soil conditions, and access to water will likely cause farmers to adopt a technology (Feder et al. 1985).

Furthermore, incentives play a key role in people's decisions. Policies that are designed to motivate producers in implementing BMPs have increased adoption (Hall et al. 2007). Often times, incentives can be viewed as short-term, therefore long-term incentives are needed to keep agricultural producers motivated. If a technology is also viewed in an industry as one that complements an existing good or service, it will also be quickly adopted (Katz and Shapiro 1986). In addition to profitability, there are other factors that affect the adoption of technology, which include, aversion to risk, farm size, yield uncertainty, human capital and off-farm work (Sunding and Zilberman 2001).

2.3.2. Risk

The adoption of technology by farmers also depends on the individual's attitude regarding risk. Risk-averse agents with concave utility functions tend to adopt less than those who are risk-loving agents with a convex utility function. In a study done by Hiebert (1974), it was assumed that farmers were risk-averse agents, and if there was less information asymmetry, then farmers would be more likely to adopt technology through means of extension (Feder et al. 1985). Other variable inputs such as capital and land can be uncertain to farmers. Depending on the weather conditions, farmers cannot be certain to use all available acreage or to obtain the full benefits of a technology.

Furthermore, different technologies exhibit various levels of risk. It has been shown in several empirical studies that risk aversion increases along with an input that shows increasing risk (Feder et al. 1985). In the case of new technologies that have not been thoroughly tested, risk aversion should decrease as more people use it. In the case of agricultural technology, the tractor has been widely accepted since its use has been observed worldwide and has contributed to increased agricultural yields. Initially, the adoption of tractors was risky since it was a large fixed cost that farmers incurred, and had to be used at the proper time given weather variability in agriculture (Lew and Cater 2008). Furthermore, the adoption of tractors among U.S. farmers gave them more time to engage in activities that increased off-farm income, tend to livestock, and improve farm infrastructure, which thus would lower their respective risk aversion (Martini and Silberberg 2006).

There are ways to address risk aversion faced by farmers by the use of contracts, rental technology, and money back guarantees (Sunding and Zilberman 2001). Contracts between buyers and sellers of technology vary according to the degree of risk. The ability to innovate among buyers of technology can be slower if they are more risk averse than sellers of technology (Larson and Anderson 1994). Another empirical study of the adoption of integrated pest management (IPM) technology showed that farmers were more likely to adopt IPM technology if they used forward contracting (McNamara 1991). Furthermore, the use of contracts by agricultural producers and various other entities can also be explained by Williamson's (1979) theoretical framework in which he specified the three dimensions of contracts: specificity, frequency of the transaction, and complexity or uncertainty. These dimensions can be analyzed and applied to transactions between buyers and sellers in all markets where there are institutions that allow and enforce contracts.

Other ways of reducing risk include farmers renting technology instead of purchasing it since credit constraints are an obstacle, and many technologies require an investment of high fixed costs (Sunding and Zilberman 2001). Furthermore, many products have money back guarantees which allow farmers to use technology up to a certain point that would also reduce risk (Sunding and Zilberman 2001). In the case of developed versus developing countries, rental contracts and money-back guarantees are easier to enforce, given that effective legal institutions enforce contracts.

Finally, the introduction of new technology may also bring about new forms of risk for agricultural producers (Sunding and Zilberman 2001). The introduction of new HYVs during the Green Revolution resulted in yield uncertainty, whereas the traditional varieties had less yield uncertainty (Sunding and Zilberman 2001). Farmers who were more risk averse, and constrained by credit were less likely to adopt HYVs (Feder 1980; Sunding and Zilberman 2001). New technology introduces an element of uncertainty to the potential user. Depending on the number of constraints the rational, economic agent faces, they would prefer to minimize the level of uncertainty they face.

2.3.3. Perceived Characteristics

Perception of technology affects whether an individual will adopt a particular technology, which can be influenced by physical location, age, education, income, and other factors. Furthermore, the adoption of technology can also be a function of perceived characteristics, the consumer's beliefs and attitudes regarding this technology, and their social environment (Karahanna et al. 1999). The application of technology in agriculture has different results that each participant is measuring. An example of perception shows what researchers, farmers, extension workers, and policy makers think about certain topics related to agriculture (Rao et al. 1995). Researchers believe that farmers are ignorant, while farmers believe the technology is not relevant, extension workers take the researchers and farmers point of view, while policy makers believe farmers do not have access to technology (Rao et al. 1995). It maybe that all four cases are happening, but these different point of views can create conflict, and lead to more inefficient and inequitable outcomes.

Perceptions are formed by each individual's own experience and are unique. Overlapping perceptions can often benefit principal-agent relationships. For example, if a researcher wants to see the effect of an agricultural practice that will reduce environmental costs, and the farmer wants to maximize profits while taking into account the environment, then an efficient outcome can result. Unfortunately, due to informational asymmetries, perceptions can also differ by greater magnitudes resulting in negative externalities such as pollution.

2.3.4. Education

The literature indicates that educated farmers are more likely to utilize the latest technologies on their farms (Huffman 1974; Wozniak 1984). One study used a multinomial probit model to examine factors that influence the choice of technology bundles selected by U.S. apple growers (Dorfman 1996). Although higher education levels among U.S. apple farmers help them realize the potential for higher profits and sustainability, due to low marginal probabilities, Dorfman concluded that for policy purposes, less educated farmers were more likely to adopt technology than their more educated counterparts. Since less educated farmers are less likely to engage in off-farm activity, more of their efforts are concentrated on the daily activities of their farm. The constant awareness of their environment enables them to be more likely to adopt technology. However, education results in positive externalities, and society expects that people who are more educated are better informed about all possible alternatives before making a decision. Higher levels of education also have lead to the adoption of other BMPs such as soil testing, conservation tillage, and integrated pest management (Fuglie and Kascak 2001). The literature indicates a mix of empirical evidence that suggests higher levels of education can either increase or decrease technology adoption.

CHAPTER 3: MANURE TESTING

3.1. Introduction

Non-point source water pollution is any type of pollution that cannot be traced back to a particular source and ends up in ground and surface water. Agricultural runoff contributes a high percentage of non-point source pollution in the U.S. (Hanley et al. 1997). Best management practices (BMPs), such as manure testing, help to improve water quality by reducing non-point source pollution. The objective of this paper will be to analyze the factors which influence those farmers who transported manure off the farm to conduct manure testing.

It is imperative to address the problem of non-point source pollution, since the emission of pollutants is also a loss for the individual farmer in terms of resources (Griffin and Bromley 1982). Oftentimes the overuse of some inputs and under use of other inputs results in allocative inefficiency, thus resulting in more environmental externalities (Asche et al. 2009). The contamination of ground and surface water affects water quality, and poor water quality can even affect a farmer's productivity under some circumstances (Asche et al. 2009). Non-point source pollution is caused by a variety of agricultural practices. Non-point source water pollution can come from confined animal feeding operations (CAFOs) that can also affect the air quality and have possible health effects on humans (Abdallah and Lawton 2006). It could be reduced if the appropriate BMPs, such as manure testing, were utilized by livestock and crop producers.

Furthermore, the use of manure as an input substitute for commercial fertilizer is another viable option to reduce the amount of nonpoint source pollution. If crop farmers replace some fertilizer with manure from livestock farmers who might otherwise overapply it due to limited land area, it may result in fewer excess nutrients being applied. From a profit view, agricultural producers may also prefer manure to commercial fertilizers due to the recent increase in energy prices, and thus fertilizer prices. There are however, disadvantages of using manure, such as the transportation costs of manure, its odor, as well as the heterogeneous nature of manure due to differing dry matter content and volatilization of nitrogen compounds. The composition of manure varies due to digestive processes, at excretion point, and even after excretion with respect to nitrogen, since it is a mobile component of animal waste (Van Horn 1998).

Since manure is a heterogeneous product, farmers need to test it for its nutrient contents frequently (Halstead et al. 1990). Given the heterogeneous composition of animal manure, the level of uncertainty using manure as an input rather than commercial fertilizer is higher, therefore using manure testing will reduce the level of uncertainty when using manure as an input.

The use of soil testing is widespread among agricultural producers it has been widely studied. Manure and soil testing are complementary BMPs that when practiced together result in more efficient yields, and can decrease overapplication of nutrients and thus levels of nonpoint source pollution. Crops require a certain amount of nutrients such as nitrogen or phosphorous. The soil has to be tested in order to determine, for example, the current level of phosphorous relative to plant requirements. If the farmer applies manure, the amount of phosphorous in it needs to be determined by means of manure testing (Sharpley et al. 2004). The joint adoption of BMPs such as soil and manure testing increases the likelihood of optimal nutrient balance for crop production.

This paper will analyze data collected from a survey of 3,000 Iowa and Missouri farmers with animal feeding operations who were asked questions about their manure management practices, including manure testing. Factors that affected the testing of manure transported off the farm will be examined. Manure testing will decrease the amount of uncertainty typically associated with this heterogeneous input in the theoretical model explained later.

3.2. Literature Review

This analysis will focus on manure testing that has been done on manure transported off the farm. Since no research has been done on this specific issue, the literature review will address the variety of factors that affect whether or not farmers adopt manure testing more generally. These factors are discussed below, with the more common factors presented first. Finally, this will add to the more general literature on adoption that was presented in Chapter 2.

3.2.1. Characteristics of Adopters

The use of agricultural technology varies by socioeconomic characteristics such as age and education. Farmers in Iowa are more likely to use manure than in Missouri (Nunez and McCann 2004), and farms located in Illinois, Indiana, or Iowa are more likely to use precision technologies (Daberkow and McBride 1998) due to the intensity of crop production, especially corn production in these states.

3.2.2. Age

The literature indicates that age negatively affects technology adoption (Rogers 1983). The adoption of agricultural BMPs (Prokopy et al. 2008; Knowler and Bradshaw 2007) and the adoption of nutrient management BMPs (Weaver 1996) decreases for older farmers. The use of manure among younger farmers was more likely than older farmers in a survey of Missouri and Iowa farmers (Nunez and McCann 2004). Agricultural producers who are older will be less likely to test their manure given that older farmers are generally less innovative. In this analysis, the variable age is expected to be a negative influence on manure testing (Walton et al. 2008, Nunez and McCann 2008, Halstead et al. 1990).

3.2.3. Education

The literature suggests higher levels of education increase technology adoption. Higher levels of education lead to the adoption of BMPs such as soil testing, conservation tillage, integrated pest management, and insect management technology (Prokopy et al. 2008; Fuglie and Kascak 2001). For example, in two studies of the beef cattle production industry, the adoption of nutrient management BMPs increased as the level of the farmer’s education increased (Kim et al. 2005; Weaver 1996). However, Halstead et al. 1990 examined the adoption of manure testing, but did not find the variable education to be significant. Conservation practices can be underutilized due to the lack of knowledge pertaining to the effects of particular practices. Individuals with higher education are better able to understand the benefits of using manure nutrients more precisely (Walton et al. 2008; Ribaudo and Johansson 2006). The implementation of extension programs could increase knowledge (Walton et al. 2008; Ribaudo and Johansson 2006) regarding the benefits associated with BMPs such as manure testing. Higher education levels are expected to result in higher rates of adoption.

3.2.4. Off-farm Income

The literature indicates that off-farm income affects whether agricultural producers will adopt technology. The types of technologies that farmers adopt vary according to off-farm income levels. For example, Gedikoglu and McCann (2007) found that livestock farmers with off-farm income between $10,000 and $24,999 are more likely to inject manure and use grass filters than those farmers with off-farm income levels between $25,000 to $49,999, while there was no significant finding related to the adoption of soil testing. Those with low off-farm incomes spend more time on the farm, and are more familiar with agricultural issues than those farmers who are employed off the farm, thus making them more likely to adopt technologies (e.g. Dorfman 1996). An increasing off-farm income shows that the agricultural producer is spending less time on their farm, and less likely to spend time testing manure since the opportunity cost of their time is high.

3.2.5. Farm Size

The literature indicates that farm size positively affects the adoption of technology (Daberkow and McBride 2003). The adoption of BMPs was higher on farms with greater acreage (Prokopy et al. 2008). A study of dairy farmers showed that larger farms were more likely to adopt BMPs than smaller farms (Hall et al. 2007). Larger sized farms will adopt other particular manure management techniques such as comprehensive nutrient management plans, the use of phytase (Key et al. 2008; Cooper and Keim 1996), adoption of precision soil sampling (Walton et al. 2008), soil testing, integrated pest management, and conservation tillage (Fuglie and Kascak 2001). Manure use is more prevalent on livestock farms with a higher number of animal units (Key et al. 2008). An AU is calculated by multiplying the number of animals by an animal unit factor for the specific type of animal. Larger farms were more likely to adopt manure testing than smaller farms (Halstead et al. 1990). Larger sized farms have more incentive to use all possible testing procedures to ensure high quality products given the scale of business they are engaged in.

According to the literature, farms with more animal units will have excess manure which they may sell to others. Farmers who have more animal units and also have more acres can substitute it for fertilizer. Manure testing will thus be adopted by those farmers who have more animal units and larger farms (Cooper and Keim 1996). In this study, the variables farm size in acres and animal units are expected to be positive influences on manure testing.

3.2.6. Manure Type & Storage

Manure testing can depend on whether the agricultural producer is utilizing solid or liquid manure, and whether there are adequate storage facilities for the manure. Farmers who had adequate manure storage capacity (Nowak et al. 1998; Halstead et al.

1990), and who were in close proximity to a facility that tests the manure were likely to conduct manure testing (Halstead et al. 1990).

3.2.7. Complementary Practices

The adoption of a variety of BMPs such as soil and manure testing is likely to occur if an agricultural producer is using a comprehensive nutrient management plan (CNMP) to address issues such as water quality and soil health. The use of CNMPs has been shown to be a positive influence on manure testing (Halstead et al. 1990). The use of BMPs like soil testing increases the adoption of complementary BMPs such as manure testing (Halstead et al. 1990), and often times the value of the nutrients in manure have gone unnoticed until testing shows that there are high levels of nitrogen and phosphorous in the manure (Moore et al. 1995). The variables CNMP and soil testing are expected to have a positive influence on manure testing (Halstead et al. 1990).

The discussion of other BMPs that test nutrient content such as soil testing are widespread, however the current literature lacks a significant discussion on the testing of manure for nutrient content. For example, a survey conducted of dairy farms in Pennsylvania resulting in 994 respondents indicated that 77 percent checked the box “none” for manure testing of nutrients, while only 20 percent tested for nitrogen, phosphorous, and potassium (Dou et al. 2001). Furthermore, more respondents tested their soil than manure, and more also kept track of soil testing records than manure testing records (Dou et al. 2001). The testing of manure only accounted for 14 percent of dairy farm operations across the U.S. (Dou et al. 2001), which implies that manure testing is not practiced among many U.S. agricultural producers.

3.2.8. Institutional Constraints

The willingness-to-pay for manure depends on factors such as experience with manure applications, and concerns by crop producers on issues of odor, substitutability of manure with commercial fertilizers, transportation costs, and other uncertainties (Norwood et al. 2005). Contracts between buyers and sellers are formed under the presence of transaction costs, and are influenced by various factors including the level of uncertainty, frequency of trade, and the amount of transaction investment related to the trade (Williamson 1979). In the context of agriculture, if there is a contract between a buyer and seller of manure, both benefit from manure testing. The seller has an incentive to test the manure for nutrient value in order to ensure that the product has the proper nutrient value, and is in compliance with contractual obligations. An additional incentive is to sell a quality product in order to have repeated transactions in the future with the buyer. Similarly, the buyer has an incentive to purchase a product that has been tested for nutrient value in order to make better decisions about the use of other inputs such as fertilizer. Furthermore, a buyer may also purchase manure from the same seller, reducing their search costs of finding a new seller.

Contracts allow for less informational asymmetry which facilitates the exchange of quality goods and services (Hart and Moore 1988), which in this case is the testing of manure prior to its sale. The enforcement of informal contracts among agricultural producers is quite effective given that interaction between individuals is high, and a reputation effect can discourage any shirking since individuals are expected to interact in the future as well (Shelanski and Klein 1995). If there is a contract that can be enforced, the seller has more of an incentive to sell a quality product. In this study, the variable having a contract for the manure transfer is expected to be a positive influence on manure testing.

3.2.9. Distance

The physical distance between sellers and buyers affects the decision to use manure, since hauling costs rise as distance increases. Also, the decision to buy manure depends on the state of the manure, that is, whether it is liquid or solid. Dilution of nutrients in liquid manure means that the transportation cost is higher per unit of nutrient. The transportation of manure is thus limited to five or six miles according to the literature (Hoag et al. 2004). In this analysis, the distance manure was transferred is expected to positively affect manure testing, since buyers of manure have high incentives to purchase manure that has already been tested with known nutrient value, if they are incurring high transportation costs. The variable distance manure transferred is expected to be a positive influence on manure testing.

3.2.10. Payment for Manure

Often times, agricultural producers overlook the benefits associated with manure application. Manure and commercial fertilizers can be complements, or manure can be viewed as an imperfect substitute when fertilizer prices rise. Manure can also be a substitute for fertilizer if certain costs such as hauling distance, hauling cost, amortized equipment cost, nutrient treatment cost, and application costs (Hoag et al. 2004) are lower than using commercial fertilizer. The use of manure and commercial fertilizer was studied by Schnitkey and Miranda (1993) who concluded that separate increases in livestock profits, crop prices, fertilizer prices, and hauling costs would lead to an increased use of manure by farmers.

In order for manure to be a substitute, the agricultural producer must also associate some type of value which can be greater than the value of using commercial fertilizer, therefore relative factor prices matter. Factors which determine the value of manure include crop prices, treatment costs, and the total quantity of manure produced (Hoak and Roka 1995). Since there are other inputs in the production processes such as commercial fertilizers, pesticides, and insecticides, the amount of actual manure used is also contingent upon the usage of other inputs.

Furthermore, the over application of commercial fertilizers has also been observed (Sheriff 2005) due to risk and uncertainty, perceptions about fertilizer application rates, increasing expected profits, and the constraint of other inputs. The heterogeneity of manure raises the issue of uncertainty in whether to use manure as a substitute for commercial fertilizer. More specifically, the level of nitrogen in manure is not known (Wang and Sparling 1995), but manure testing should reduce that level of uncertainty. In this analysis, the variable payment for manure is expected to positively affect manure testing.

3.2.11. Environmental Awareness

Attitudes and awareness of the environment and conservation behavior among farmers indicate the likely adoption of agricultural BMPs (Prokopy et al. 2008; Knowler et al. 2007). Knowledge of the environment positively correlates with adoption of BMPs. For example, in a study of Oregon watersheds, informing other agricultural landowners about conservation practices positively affected the use of agricultural BMPs (Habron 2004). Other studies such as Lynne et al. (1988) have shown that those who have strong views on the use of non-renewables will spend more effort on conservation. The acknowledgment by farmers that there are problems, and possible technical solutions, increased adoption of waste management BMPs (Weaver 1996). The perception of manure on these various issues will affect whether these respondents will continue to use manure testing, as Contant and Korsching (1997) show that these factors also affect whether farmers continue to use a Nitrogen-Trak kit. Furthermore, issues such as the smell of manure could make it uncomfortable for farmers to test it, therefore those individuals who are bothered by the smell of the manure will be less likely to test it (Gedikoglu 2008). In this analysis, the Likert scale variable "This practice improves water quality" will increase adoption of manure testing. The variables "This practice is time consuming" and "This practice is complicated" will decrease adoption of manure testing.

3.2.12. Profitability

Agricultural producers maximize profits which are subject to a production function and other various constraints such as time. The adoption of BMPs increases with rising income and with the perception that the adoption of BMPs is profitable (Prokopy et al. 2008). For instance, larger sized farms' incomes can be higher and adoption of manure testing has also been observed in farms with higher net farm income (Cooper and Kein 1996). Profitability and low costs are the key determinants of whether or not farmers in a concentrated animal feeding operation (CAFO) use manure management techniques as cited by Fleming, Babcock, and Wang (1998) and Carrerira and Stoecker (2000). Manure testing will help to decrease input costs such as commercial fertilizer, since manure can substitute for the commercial fertilizer (Lory and Kallenbach 2008; O'Donoghue et al. 2005). Manure testing can also enable farmers to complement manure nutrients with specific amounts of fertilizer nutrients to meet crop nutrient requirements. The actual cost of manure testing is relatively low in the U.S., about $40 per sample.

The adoption of environmentally friendly practices is less of a concern for farmers faced with economic constraints and fixed market prices (Ahnstrom et al. 2008), since capital resources are being diverted elsewhere. To defray the costs of implementing manure management techniques, the USDA has offered assistance to producers under the Environmental Quality Incentives Program (EQIP) with aid up to $450,000 per farm from the period of 2002 to 2007 (Key et al. 2008). Large fixed costs incurred by small farms prevent the adoption of technology (Feder et al. 1985). Given these financial hurdles, government policies that subsidize pivotal technologies can help all producers utilize all available technology. The variable 'this practice is profitable' is expected to positively affect manure testing.

3.2.13. Risk

The adoption of technology by farmers also depends on the individual's attitude regarding risk. According to the literature, those farmers who are less risk averse will adopt BMPs (Prokopy et al. 2008). However, the levels of uncertainty regarding the use of manure as an input will decrease once testing is implemented, since actual levels of nutrients will be known (Zhang 2005), thus helping the farmer make accurate decisions regarding the purchase of inputs such as fertilizer (Reeves III 2007). Manure testing is a risk decreasing technology. It enables farmers to gather more information about the manure, and make informed decisions about buying other inputs such as fertilizer. Farmers who want to decrease the level of uncertainty when using manure as an input, will adopt manure testing. This will be further discussed in the theoretical model.

3.3. Conceptual Model

The conceptual model has been adapted from Isik and Khanna (2003) who expanded Meyer's (1987) work related to expected utility maximization in two-moment (mean and standard deviation of profit/payoff) decision models. The only decision in this model is whether to test the manure or not, represented by the indicator function I which takes the value of '1' if manure testing is adopted, and '0' if manure testing is not adopted. The Isik and Khanna (2003) model has been adapted by adding manure testing and a water quality component:

$$\text{Max } U\left(\pi^{N} + I(\pi^{MT} - \pi^{N} - C^{MT}),\ \sigma^{N} + I(\sigma^{MT} - \sigma^{N}),\ WQ^{N} + I(WQ^{MT} - WQ^{N}\right),$$

where U(.) is the utility for the manure user. The quasi rents associated with not testing manure are π^{N}, and the quasi rents using manure testing are π^{MT}. The actual cost of manure testing is denoted by C^{MT}. The standard deviation associated with not manure testing is denoted by σ^{N}, and that associated with manure testing by σ^{MT}. The water quality associated with not testing the manure is WQ^{N}, and the water quality associated with testing it denoted by WQ^{MT}. Manure testing will decrease the uncertainty of using manure as an input since the levels of dry matter, nitrogen, phosphorous, and other components in the manure will be known, thus mitigating one source of variation. Thus, the testing of manure implies that $\sigma^{MT} < \sigma^{N}$. Also, manure testing will lead to improved water quality given that non-point pollutants associated with manure will be less likely to end up in surface and ground water if the proper amounts are applied to fields, implying that $WQ^{MT} > W^{QN}$.

The empirical model for whether agricultural producers tested the manure transported off the farm for nutrient content will be in the theoretical context of utility maximization discussed above. The dependent variable TEST took on binary values, whether the manure was tested or not. The expected utility from testing manure will be denoted by $E\,[U_{MT}]$, while the expected utility from not testing manure will be denoted by $E[U_N]$.

$$\text{Test} = \begin{cases} 1 \ if \ E\,[U_{MT}] > \ E\,[U_N] \\ 0 \ if \ E\,[U_{MT}] \leq \ E\,[U_N] \end{cases}$$

According to the literature review, there are a number of variables that are predicted to affect adoption of manure testing for manure transported off the farm. The following variables, based on the literature presented earlier, were hypothesized to affect the adoption of manure testing:

Age (-), Education (+), Off-farm income (-), State (+), Aggregate Animal Units (+), Farm Size (+),Type of Manure (+), Manure Storage Capacity (+), Fertilizer Use (+), Smell Bothers Me (-), CNMP (+), Soil Testing (+), Contract (+), Distance (+), Payment for Manure (+), Perceived Profitability (+), Improves Water Quality (+),Time Consuming (-), and Complicated Practice (-).

3.4. Methodology

The data for this analysis was collected from a survey of 3,000 Iowa and Missouri farmers with animal feeding operations. The data came from Gedikoglu and McCann (2007), who designed a survey that used methodology developed by Dillman (2000), and asked farmers questions about their use of conservation practices and the factors that impacted their decisions. More specifically these farmers were asked questions about manure testing and other BMPs. The survey resulted in a response rate of 37.4 percent. Respondents answered various questions regarding manure management, with some questions using the Likert scale to gauge respondents' beliefs. Respondents were asked questions about manure testing and ranked their answer choices using a Likert scale, whereby 1 was strongly disagree, 3 was neutral, and 5 was strongly agree. In this analysis, answer choices 4 and 5 became agree, 3 was neutral, and answer choices 1 and 2 became disagree which served as the base category.

Respondents who answered yes to the question of whether they provided manure to other farm operations or individuals in the past two years comprised the subset for this study. The respondents were asked whether they or the farmer receiving the manure tested it for nutrient content before applying it, and this was used as the dependent variable. A number of cases were deleted, and resulted in a small subsample. It was because there were missing answers to some questions.

The use of maximum likelihood was used for this binary response model. The density of y_i given x is (Wooldridge 2002):

$$F(y|x_i; \beta) = [G(x_i; \beta)]y[1- G(x_i; \beta)]1-y , y = 0,1$$

The log-likelihood function takes the following form:

$\ell i(\beta) = y_i \log[G(x_i\beta)] + (1 - y_i)\log[1 - G(x_i\ \beta)]$ and the log likelihood for sample size N is denoted by $L(\beta) = \sum_{i=1}^{N} \ell_i(\beta)$ where G(◦) is the logistic cumulative distribution function, then $\hat{\beta}$ is the logit estimator.

3.5. Results and Discussion

The descriptive statistics for this analysis are listed in table 1. The average age of respondents from the subset was 47 years old, and 36 percent were high school educated, with the second highest category being 32 percent with some college or vocational college background. The portion of respondents who reported no off-farm income was about 28 percent, while 61 percent reported that they had prepared a CNMP.

The general awareness about the benefits which result from manure testing among agricultural producers is still low compared to the benefits associated with soil testing, since the dataset shows that only 53 percent tested the manure, whereas 82 percent of respondents conducted soil testing. Only 13 percent of respondents used a written contract for their manure transfer, but despite the low number of contracts written, 52 percent of respondents were paid for manure. The lack of contracts in this type of exchange could imply that the transaction costs associated with the construction and implementation of a contract are too high, thus causing buyers and sellers to exchange manure based on informal rules such as social norms or customs. Future research could examine the factors which determine whether farmers who utilize manure testing will also use contracts.

Table 1: Descriptive Statistics: Factors that Affect Adoption of Manure Testing n = 109

Variable	Description	N	Mean	St. Dev.	Min.	Max.
Farmer Characteristics						
Age	Age in Years	109	47.01	10.249	25	79
Education	Categorical Variable					
Less than High School	Category 1	109	.13	.336	0	1
High School	Base Category	----	-----	-----	---	---
Some College or Vocational School	Category 2	109	.32	.469	0	1
Bachelor's Degree	Category 3	109	.18	.389	0	1
Graduate Degree	Category 4	109	.01	.096	0	1
Off-Farm Income	Categorical					
None	Base Category	----	----	---	---	---
$0 to $9,999	Category 1	109	.17	.381	0	1
$10,000 to $24,999	Category 2	109	.18	.389	0	1
$25,000 to $49,999	Category 3	109	.26	.439	0	1
$50,000 to $99,000	Category 4	109	.08	.277	0	1
$100,000 or more	Category 5	109	.03	.164	0	1
Farm Characteristics						
Location	Iowa =1; Missouri = 0	109	.48	.501	0	1
Aggregate Animal Units		109	1117	1362	70	7662
Farm Size	Number of Acres owned + rented - rented out to others	109	444	558	10	3240
Type of Manure stored	Solid =1, Liquid =0	109	.54	.50	0	1
Type of Manure stored	Both Solid and Liquid =1, Liquid = 0	109	.27	.44	0	1
Manure Storage Capacity	1 = Greater than 6 months, 0 = Less than 6 months	109	.61	.48	0	1
Perceived Characteristics of Manure Application						
Fertilizer Use	Applied fertilizer to any manured fields =1; otherwise =0	109	.46	.501	0	1
Smell Bothers Me or My Family (Neutral)	Neutral=1; disagree= 0	109	.43	.498	0	1
Smell Bothers Me or My Family (Agree)	Agree that bothers me or my family=1; Disagree= 0	109	.11	.314	0	1
CNMP	Prepared a CNMP Plan=1; otherwise = 0	109	.61	.491	0	1
Soil Testing every 3 years	Yes, perform practice=1; Otherwise=0	109	.82	.389	0	1
Contract	Contract between you and other farmer=1; otherwise=0	109	.13	.336	0	1
Distance	Maximum distance manure was transported (miles)	109	8.71	18.36	0	100
Value of Manure	Were you paid for the manure=1; otherwise = 0	109	.52	.502	0	1
Perceptions about Manure Testing						
Profitability (Neutral)	Neutral=1, Disagree=0	109	.30	.462	0	1
Profitability (Agree)	Agree=1, Disagree=0	109	.61	.491	0	1
Improves water quality (Neutral)	Neutral=1, Disagree=0	109	.25	.438	0	1
Improves water quality (Agree)	Agree=1, Disagree=0	109	.61	.48	0	1
Time consuming (Neutral)	Neutral=1, Disagree=0	109	.39	.489	0	1
Time consuming (Agree)	Agree=1, Disagree=0	109	.33	.472	0	1
Complicated practice (Neutral)	Neutral=1, Disagree=0	109	.28	.449	0	1
Complicated practice (Agree)	Agree=1, Disagree=0	109	.18	.389	0	1
Dependent Variable: Did you or person you sold manure test it?	1=Yes 0=No	109	.53	.502	0	1

The mean distance between buyers and sellers was observed to be 8 miles. Hauling manure can be inconvenient for farmers given the costs of transporting liquid versus solid manure. Furthermore, the negative externalities which result from transporting manure include the odor associated with it. The application of commercial fertilizers to manured fields was done by 46 percent of respondents.

Soil testing is a nutrient management practice that may be preferred to manure testing due to the odor involved with manure testing, even though only 11 percent of respondents reported that the smell of manure bothered them or their family. Both tests are relatively inexpensive, however the utility associated with manure testing maybe less than that with soil testing, due to the nature of manure's physical properties. The smell of manure or physical form maybe two factors that will make manure testing an unpleasant experience for farmers.

Using the descriptive statistics, the perception of whether or not manure testing is regarded as a profitable and a time consuming practice was also examined. The proportion of respondents that agreed manure testing was profitable was 61 percent, and 33 percent thought it was a time consuming practice. Furthermore, 61 percent of respondents agreed that manure testing improved water quality, and only 18 percent of respondents reported that manure testing was a complicated practice.

Prior to running this regression, a multivariate logistic regression was used to account for responses to the question of "Did you or the person you sold manure test it?", however only nine observations were found for the response "I do not know", thus they were removed from the analysis, resulting in a sample size of 109 for the "yes" versus “no” response regression. Future analysis could examine whether people receiving the manure, or those providing it, actually test it. Other bivariate regressions were conducted, one included using the variable CAFO, but it resulted in multicollinearity. The goodness of fit for this logistic regression includes a number of tests. After conducting the Omnibus Tests of Model Coefficients, it was found that the model is statistically significant therefore the null hypothesis that $H_0 = \beta_1 \ldots \beta_k = 0$ can be rejected. The logit model in its fullest form predicted 88.9 percent of the cases correctly, and the pseudo r-square value using the Cox and Snell was 0.537 and the Nagelkerke was 0.717. Furthermore, the Hosmer and Lemeshow Test shows that there is no difference between the observed and predicted values of y, indicating that this model is appropriate for this data set. Finally, diagnostic tests such as the tolerance values and variance inflation factors (VIF) found that the model did not display multicollinearity. Regression results are shown in table 2.

Factors that were found to be significant at the ten percent level in the adoption of manure testing were the following: those with less than high school education, off-farm income levels from $0-$9,999, $25,000-$49,000, type of manure, soil testing, having a contract for the manure transfer, distance manure transferred, and payment for manure.

Livestock producers with off-farm income have less incentive to thoroughly test manure due to time constraints associated with this process (McCann et al. 2008). Those with off-farm income levels of $0-$9,999 and $25,000-$49,000 were less likely to test manure than the base category of no off-farm income. Since more time is being spent off the farm, the agricultural producer has less incentive to learn a new technology that will take away time from other profitable ventures off the farm. In this logistic regression, the off-farm income level variable can represent a proxy for the agricultural producer's time that is not accounted for when on the farm. Since two of the categories reported significant negative coefficients, this can imply that the agricultural producer was constrained by time, thus decreasing the probability of testing the manure for nutrient value.

Furthermore, the variable 'type of manure' was found to be negative and significant for manure that was solid, or both solid plus liquid compared to liquid. The negative sign on these variables could result from the difficulty of sampling solid manure or the fact that the liquid manure is more variable due to the dilution effect so testing is more advantageous.

Soil testing is one of the many conservation practices that help to maintain water quality and keep nonpoint pollution under control, and as expected it had a positive influence on the adoption of manure testing. It was also a factor which affected whether farmers would utilize manure testing if it was provided to them in Halstead et al. (1990). Individuals who conduct soil testing, are more likely to test the manure since they already realize the benefits of such practices, and are likely to adopt other BMPs that are beneficial. Manure and soil testing are complementary practices which result in more efficient yields and can decrease levels of non-point pollution. The adoption of both is critical to prevent non-point source pollution.

Table 2: Logit Regression Results: Factors that Affect Adoption of Manure Testing n=109

Variable	Description	B	S.E.	Wald	Sig.	Exp(B)	Marginal Effects (dy/dx)
Farmer Characteristics							
Age	Age in Years	.034	.057	.348	.555	1.034	.017
Education	Categorical Variable						
Less than High School	Category 1	2.802	1.517	3.413	.065	16.484	2.479
High School	Base Category	----	-----	----	-----	-----	
Some College or Vocational School	Category 2	.092	1.021	.008	.928	1.097	.004
Bachelor’s Degree	Category 3	.682	1.128	.365	.546	1.97	.222
Off-Farm Income	Categorical						
None	Base Category	----	----	----	----	----	
$0 to $9,999	Category 1	-3.492	1.555	5.049	.025	.030	3.289
$10,000 to $24,999	Category 2	-2.073	1.418	2.138	.144	.126	1.610
$25,000 to $49,999	Category 3	-2.624	1.269	4.273	.039	.073	2.267
$50,000 to $99,000	Category 4	-2.120	1.780	1.418	.234	.120	1.666
$100,000 or more	Category 5	-2.672	2.250	1.410	.235	.069	2.328
Farm Characteristics							
Location	Iowa =1; Missouri = 0	.221	1.180	.035	.852	1.247	.024
Aggregate Animal Units		.001	.001	2.394	.122	1.001	$2.49 * 10^{-7}$
Farm Size	Number of Acres owned +rented - rented out to others	.001	.001	.432	.511	1.001	$2.49 * 10^{-7}$
Type of Manure stored	Solid =1, Liquid =0	-4.404	1.736	6.438	.011	.012	4.303
Type of Manure stored	Both Solid and Liquid =1, Liquid = 0	-2.492	1.333	3.496	.062	.083	2.111
Manure Storage Capacity	1 = Greater than 6 months, 0 = Less than 6 months	-.969	1.035	.875	.350	.380	.435
Perceived Characteristics of Manure Application							
Fertilizer Use	Applied fertilizer to any manured fields =1; otherwise =0	1.092	.905	1.456	.228	2.980	.533
Smell Bothers Me or My Family (Neutral)	Neutral=1; strongly disagree= 0	.143	.935	.023	.878	1.154	.010
Smell Bothers Me or My Family (Agree)	Strongly agree that bothers me or my family=1; strongly disagree= 0	.413	1.241	.111	.740	1.511	.083
CNMP	Prepared a CNMP Plan=1; otherwise = 0	.805	1.009	.637	.425	2.237	.306
Soil Testing	Yes, perform practice=1; Otherwise=0	2.329	1.242	3.515	.061	10.271	1.912
Contract	Contract between you and other farmer=1; otherwise=0	3.440	1.623	4.496	.034	31.201	3.223
Distance	Maximum distance manure was transported	.207	.115	3.232	.072	1.230	.021
Value of Manure	Were you paid for the manure=1; otherwise = 0	2.037	1.205	2.857	.091	7.671	1.565
Perceptions about Manure							
Profitability (Neutral)	Neutral=1, Disagree=0	.759	1.781	.182	.670	2.136	.274
Profitability (Agree)	Agree=1, Disagree=0	1.295	1.847	.492	.483	3.653	.738
Improves water quality (Neutral)	Neutral=1, Disagree=0	.511	1.499	.116	.733	1.667	.125
Improves water quality (Agree)	Agree=1, Disagree=0	.901	1.510	.356	.551	2.461	.380
Time consuming (Neutral)	Neutral=1, Disagree=0	-.772	1.088	.504	.478	.462	.284
Time consuming (Agree)	Agree=1, Disagree=0	.245	1.319	.034	.853	1.277	.029
Complicated practice (Neutral)	Neutral=1, Disagree=0	-1.408	1.064	1.751	.186	.245	.854
Complicated practice (Agree)	Agree=1, Disagree=0	-1.92	1.276	.023	.881	.826	.183
Constant		-3.85	3.649	1.117	.291	.021	3.693

In this analysis, the variables distance manure was transferred and contract were both found to be significant. Larger distance could affect the buyers' expectations about the product, thus it is more valuable for the seller or buyer who transports the manure a greater distance to test the manure, ensuring a known quality of product. Manure, specifically liquid manure is a heterogeneous product, thus buyers and sellers may want to mitigate any uncertainty by means of a contract or use it to cover all possible contingencies that may arise during a transaction.

As indicated previously, the majority of the farmers who transferred manure off the farm were paid for it, this indicating the buyers placed a value on manure nutrients. The logit results show the variable 'payment for manure' was positive and significant. Similar to distance, if someone is paying for a product, they will want some assurance of its quality. Even though the regression did not find any significance related to whether manure testing is profitable, the economic significance of manure testing is partly reflected in the contracts, distance, and payment variables.

Since agriculture has been identified as one of the major causes of non-point source pollution (O'Donoghue et al 2005), it is imperative that inputs such as manure and commercial fertilizers be used with precision and accuracy, given that there can be detrimental environmental consequences. Given the rising concern about non-point pollutants entering water sources, it is interesting to note that agricultural producers may be led to more efficient use of manure, and thus improved environmental outcomes as the value of the nutrients increases.

3.6. Conclusion

Manure and soil testing are complementary practices that, when practiced together, result in more efficient nutrient applications and can also decrease levels of non-point pollution. As expected, soil testing was positively associated with the adoption of manure testing. Individuals who test soil are more likely to test manure since they already realize the benefits of more precise nutrient management. Furthermore, farmers may need assistance from extension agencies in order to understand the results of the manure and soil testing in order to make the best judgments about how to use inputs such as manure and fertilizer. Manure testing results are less well understood by farmers than soil testing results (Motavalli, personal communication).

The perceived effect of manure testing on water quality was not significant, indicating that manure testing is primarily related to the value of the nutrients for crop production, rather than to reducing non-point source pollution. Educational programs focused on the positive effects of manure testing regarding reduced uncertainty and increased profitability are likely to be more effective than those focused on the water quality impacts.

While the value of manure may result in more efficient use of this resource, normal markets are unlikely to fully internalize the externalities associated with nutrients. Other market induced mechanisms which involve coordination between government agencies and agricultural producers that internalize the externalities which arise from non-point source pollution have also been suggested (Abdalla and Lawton 2006).

Non-point source regulation is under the discretion of state and local governments, since the Clean Water Act does not require livestock producers who are not CAFOs to adopt BMPs such as manure testing and soil testing (Ribaudo and Johansson 2007). The lack of government stringency may not give agricultural producers an incentive to adopt BMPs, thus leading to behavior that may contribute to agricultural runoff.

CHAPTER 4: ADOPTION OF FERTILIZER IN NWFP, PAKISTAN

4.1. Introduction

Pakistan faces a rising population and has a scarce amount of arable land that requires better use of its resources and inputs such as chemical fertilizer to obtain higher agricultural yields (Chaudhry 2001). Since agriculture is a major part of Pakistan's economy (Ahmad et al. 2008), increased productivity of farmers will also bring about increased employment in the agricultural sector, thus an increase in real income (Mellor and Ranade 2006). Furthermore, other problems that poor farmers face include lack of access to formal sources of credit, lack of education, and owning less machinery relative to richer farmers (Ahmad 2003).

The Northwest Frontier Province (NWFP), recently changed to Khyber Pakhtoonkhwa province but which is referred to as NWFP for the purposes of this paper, is an area of Pakistan that is relatively difficult to access given its geographic location and its adherence to traditional tribal governance which has also differentiated it from the other three provinces of Pakistan. Economic development has been slow in this region due to factors such as lack of infrastructure, institutions, and political instability (Nelson 2008). The general economic development of this region relies on agricultural production, thus the adoption of technology such as fertilizer can help increase yields, thus increase incomes, and perhaps improve societal welfare.

This study examines the use of manure and fertilizer in the NWFP of Pakistan, more specifically, the factors that affect the adoption of fertilizers by these farmers.

The factors which affect fertilizer use in the NWFP of Pakistan will be examined in this study. The data collected will characterize fertilizer practices in Pakistan and give a better description of the markets for fertilizer and manure. Other barriers to the adoption of fertilizer are also examined.

Previous literature has focused on adoption studies pertaining to fertilizer in the Punjab province and Swat Valley of the NWFP. The contribution of this paper will examine both inputs, and hopefully shed insight into the behavior of farmers living in the district of Mardan, in the NWFP of Pakistan. Furthermore, previous research has focused on the demand for fertilizer in the Punjab province (Coady 1995) and other parts of the country (Quddus 2008; Fayaz et al. 2008; Ahmad 2000; Zia 2000), but it did not include animal units or other variables such as sources of information. This paper will attempt to fill a gap in the literature with the addition of these new variables in the understudied area of NWFP in the district of Mardan.

4.2. Literature Review

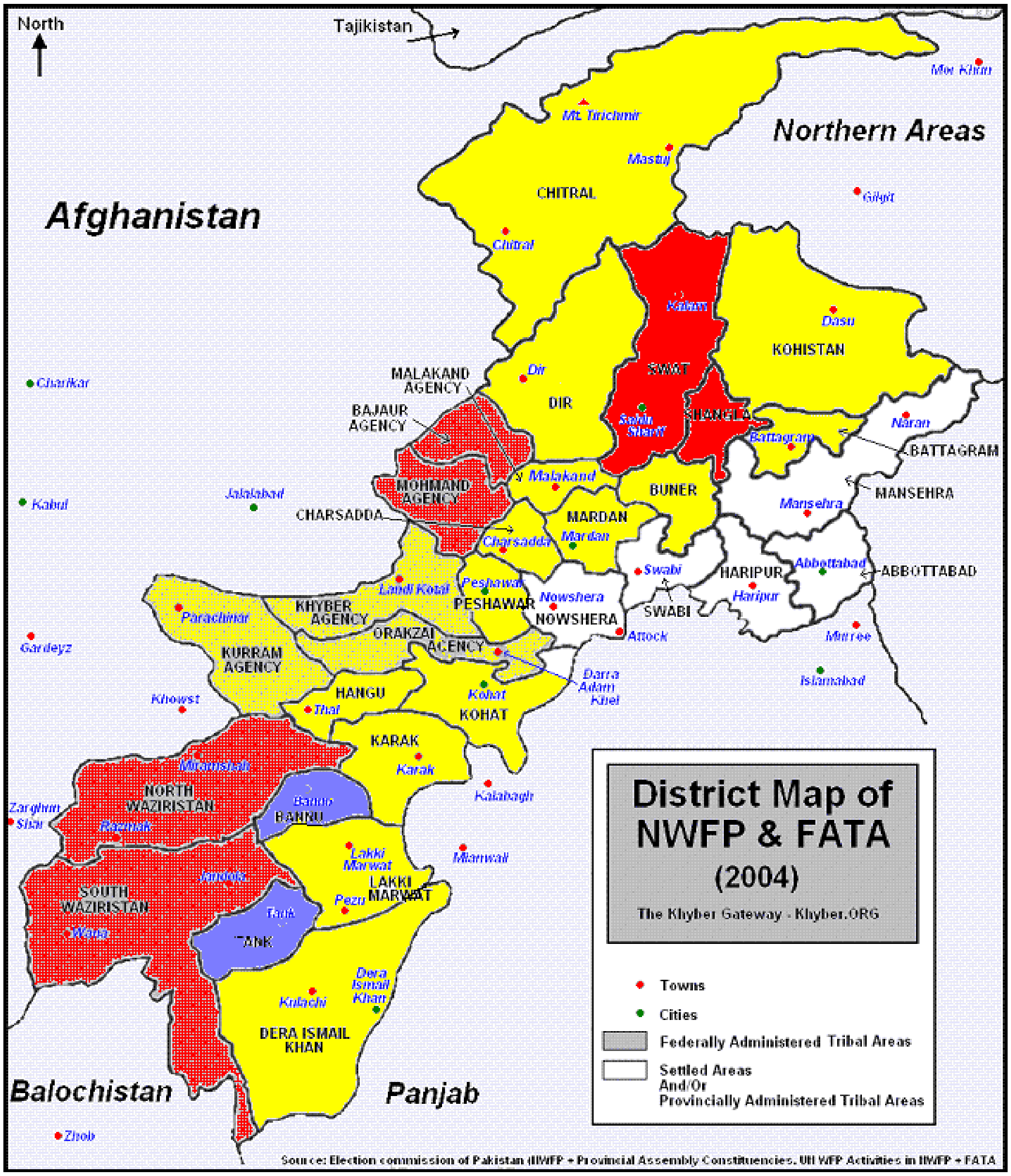
4.2.1. Agricultural Systems of Pakistan

According to Byerlee and Husain (1993), the agricultural systems of Pakistan are quite diverse and divided into the Indus plains, rainfed plains, and the mountain farming systems, both rainfed and irrigated. These authors compared the farming systems of Pakistan and classified it into three categories: (1) Irrigated lowlands of Punjab and NWFP, (2) Rainfed Lowlands of Punjab, and (3) Mountain Areas (NWFP). Kharif crops are typically sown in late July, and harvested between October and December giving them the name of autumn harvest, and include crops such as rice, sugarcane, cotton, maize and millet (Chaudhary et al. 2008; FAO 2004).

The Mardan district of the NWFP is characterized by Kharif crops such as sugarcane, maize, and tobacco, and wheat with many farmers using improved varieties of crops along with fertilizer (SMEDA 2009; Byerlee and Husain 1993). The district of Mardan fits into category one because parts of it are irrigated lowlands, and it is more low lying than the mountainous areas of Swat Valley and Swat Mountains of the NWFP which were put into category three. Since Mardan is located in a more irrigated area, the land is easier to farm with the given machinery, implying that farm sizes will be greater in Mardan, than in the Swat Valley (Byerlee and Husain 1993). Furthermore, summers are extremely hot, and rain falls during the months of July, August, December, and January (SMEDA 2009).

Mardan is located in the NWFP, which is the northwestern portion of Pakistan. The map in Figure 2 shows the location of Mardan. Pakistan is situated between Afghanistan and India.

Figure 2: Map of Mardan, NWFP in Pakistan



Agricultural producers in developing countries such as Pakistan face problems such as poor infrastructure, informational asymmetry, limited bargaining power with regards to prices of outputs and inputs, and market distortions which result from government induced programs that lead to price variations throughout a developing country (Masood 2010; Norton et al. 2006).

In term of specific problems, Pakistani farmers face problems in agricultural productivity. This is due to many factors such as soil depletion, limited water supply, delayed sowing, improper fertilizer application, and lack of weed management (Technology Times 2011). Furthermore, farmers are not aware of recent technologies and agricultural practices, instead many rely on traditional farming methods that have not resulted in the optimal use of resources (Technology Times 2011), and need access to more extension and agricultural education (Masood 2010). Food security is a concern among Pakistanis since many farmers have migrated from rural to urban areas, in hopes of finding employment that will at least provide them with more economic stability than farming (Masood 2010).

4.2.2. Use of Manure and Fertilizer

In Pakistan it has been found that farmers who own more land, labor, capital, and have access to irrigation adopt improved technology such as recommended fertilizer application, use of improved varieties of food and cash crops, and recommended agricultural practices (Cain et al. 2007). There is a contrast as to how farmers apply manure in irrigated and less irrigated regions of Pakistan (Byerlee and Husain 1993). In the more irrigated areas of the country, farmers are more likely not to use manure as an input since the availability of chemical fertilizer provides the nutrient requirement. In marginal areas of the country where farmers are operating at a subsistence level, the application of manure is used carefully since supply of manure is low, and it is also used as a fuel source (Byerlee and Husain 1993). Marginal farmers also realize the benefits of using chemical fertilizer as an input, and many have access to it despite its cost. Many farmers prefer to burn manure in order to conserve wood according to a study done by Dove (1994), who surveyed Pakistani farmers and foresters in the three provinces of NWFP, Punjab, and Balochistan.

In the NWFP, chemical fertilizer (fertilizer in the rest of the chapter) is placed on cash crops such as sugarcane, maize, and high yielding varieties of wheat (Ministry of Food and Agriculture 2006-2007). Manure is also applied to cash crops in order to supplement nutrient requirements; however fertilizer application is given priority to cash crops.

In the rainfed plains of the Punjab province, improved wheat varieties, mechanical innovations, and other technologies were adopted as a package during the Green Revolution. In the northern, mountainous areas, the adoption of chemical fertilizers was more prevalent due to the fact there was better physical infrastructure that facilitated the transportation of chemical fertilizers to farmers in remote regions (Byerlee and Husain 1993). In terms of adoption times, farmers in irrigated regions adopted fertilizer and varieties at the same time, in line with the literature, while in the northern areas, farmers adopted fertilizers first, and then adopted new varieties as a way of coping with risk (Byerlee and Husain 1993). Also, in the northern areas, farmers plant different varieties due to the fact that they mature at different times, which enables better risk management and income smoothing. Different crops and maturities also allow for manure use and production to be spread out over time, since manure is used an input in addition to chemical fertilizer, there needs to be time to collect the manure for application. Another risk management strategy is to have off-farm income that may complement their subsistence farming (Byerlee and Husain 1993). Pakistani farmers face problems such as input efficiency and sustainability which can be addressed by the use of best management practices (BMPs), which in turn will help to improve fertilizer productivity (Byerlee and Hussain 1993).

4.2.3. Government Policy

Current Pakistani agricultural policy has focused on providing farmers with government subsidies to purchase commercial fertilizers (Ministry of Food and Agriculture 2006-2007). The adoption of chemical fertilizers in Pakistan has been quite widespread with public investment by the government, and private investment by chemical fertilizer firms such as Dawood Hercules Chemicals Ltd. in 1971 and Fauji Fertilisers Co. Ltd. in 1978 (Ahmad and Nagy 1999), resulting in about 90 percent of Pakistan farmers adopting chemical fertilizer (Ahmad 2007). The Pakistani government has provided fertilizer companies with import, marketing, and price subsidies (Ali 1995). The trend has changed in recent years in that the fertilizer market has become privatized (FAO 2004), where only 11 percent of the fertilizer market is publicly owned (FAO 2004).

4.2.4. Fertilizer Demand

Fertilizer demand is a function of many factors such as the price of the fertilizer (Quddus et al. 2008; Kelly 2006, Ahmad and Muhammad 1998), the price of related substitutes, price of market outputs, (Kelly 2006), and whether or not it was used in the production of cash crops (Ahmad and Muhammad 1998). As Kelly (2006) argues, in developing countries, fertilizer demand is based on potential financial benefits the farmer can acquire from using the input, and the ability to use and acquire it (Reardon et al. 1995; Reardon et al.1999).

Fertilizer's primary purpose during the Green Revolution was to increase crop yields, however over time, many farmers in South Asia over-farmed lands and some returned to the use of traditional manure (Ghosh 2004). Fertilizer is often used together with other inputs such as pesticides and HYVs.

4.2.5. Barriers to Adoption in the NWFP

Since the Green Revolution in South Asia, new modern varieties (MVs) have been introduced, thus increasing yields of crops such as rice, wheat, and maize, while the increased use of mechanization, access to more irrigation, and changes in demand and market access have also contributed to increased agricultural yields (Gollin et al. 2005). The Green Revolution transformed agriculture in Pakistan. Pakistan's agricultural GDP increased 4.1 percent on average per year from 1975 to 2000 (Dorosh et al. 2003). This is especially true in the Punjab province. For example, crop yields increased in the Punjab province by 1.8% per annum (Ali & Byerlee 2002). Farmers in the Punjab province utilize the highest amount of commercial fertilizers relative to the other three provinces; 68 percent of all fertilizer consumption in the country as of 2007 can be attributed to farmers in this province alone (Ministry of Food and Agriculture 2006-2007).

The use of chemical fertilizer by farmers in the NWFP is the least compared to the other three provinces of Pakistan which include Punjab, Sindh, and Balochistan (Ahmad et al. 2000). The literature indicates that distance from the central market and lack of physical infrastructure are factors that prevent many farmers from adopting fertilizer (Razzaq et al. 2004; Perkins et al. 2001; Omamo 1998), instead farmers rely on traditional manure as a source of nutrients.

The literature on the adoption of agricultural technology in the NWFP is not as developed as it is in the Punjab province. There are many studies that have focused specifically on the Punjab province due its accessibility, and many researchers have compared and contrasted it to the Punjab province of India. In a study of the NWFP, Punjab, and Sindh provinces from 1997 to 1998, it was shown that fertilizer and farmyard manure both increased yields, however for every 10 percent increase, fertilizer increased yields by 2.3%, and farmyard manure increased yields by .48 percent (Chaudhry 2001). Nevertheless, the demand for manure exceeds the supply of manure in the country, since much of it is burned as an energy source (FAO 2004; Zia et al. 1992), or just not collected due to the costs of collecting, storing, and spreading it (FAO 2004).

It has been found that in Pakistan, actual fertilizer application rates are lower than the recommended rates of fertilizer application (Cain et al. 2007; Ahmad 2007). Often times this can be attributed to lack of knowledge about application rates, lack of fertilizer, or cost of fertilizer which explains the disparity between recommended and actual fertilizer application rates (Cain et al. 2007; Khan and Keatinge 2000; Qazi and

Rana 1994). The major obstacle to fertilizer adoption for farmers in the Swat Valley, NWFP was that it was expensive, followed by problems in obtaining it, and then being unable to get it in a sufficient amount, and also not being convinced that it brought value to farming (Khan and Keatinge 2000). Furthermore, Khan and Keatinge (2000) found that fertilizer demand was adversely affected by the decline of government subsidies, which prompted farmers to believe that fertilizers were tainted with other inferior ingredients, therefore they were less inclined to purchase fertilizers. Other obstacles that prevent farmers from adopting fertilizer in Pakistan include lack of irrigation, high fertilizer prices, lack of credit (Coady 1995), and lack of knowledge (Razzaq et al. 2004). Farmers in the NWFP face rain variability, infrastructure issues, small sized farming operations, physical isolation, long distances from the central market, lack of developed markets, high transportation costs which induce farmers to migrate out of the area, and an increase in off-farm income in the less irrigated areas of the NWFP (Afzal and Ahmad 2009; Suleri et al. 2009; Byerlee and Husain 1993).

4.2.6. Farm Size

The adoption of technology and its relation to farm size depends on other factors such as risk aversion, credit constraints, and access to other inputs and information (Feder et al. 1985). In the case of developing countries, farm size was positively related to the adoption of tractors and HYVs. While there have been conflicting studies, two studies in Pakistan found a positive relationship between farm size and fertilizer adoption. In one study, fertilizer use in Pakistan and farm size showed a positive relationship, as did access to fertilizer and farm size (Coady 1995). Another study of farmers in the Swat Valley of the NWFP resulted in larger sized farms adopting improved technology such as fertilizer, pesticide, and high yielding varieties (Khan and Keatinge 2000).

4.2.7. Age

The development literature indicates that older farmers are less likely to adopt new technologies. According to the literature, older farmers tend to discount their future stream of income more than younger farmers. In one study as cited by Chaudhry (2001), older farmers in Pakistan were less likely to use chemical fertilizer and also had less output than younger farmers (Ahmad et al. 2000). Younger farmers are more likely to adopt fertilizer because they are more likely to invest time and education into learning how to apply fertilizer than older farmers.

4.2.8. Education

Educated farmers tend to adopt new technology such as chemical fertilizers since their human capital will yield higher marginal returns than those who were not educated (Feder et al 1985). Education also facilitates the implementation of new technology that requires some initial investment of time, knowledge, and training. In the case of chemical fertilizer, it was found that educated farmers were more likely to use chemical fertilizers in all four Pakistani provinces (Ahmad et al. 2000), which was facilitated by the use of extension services. Those individuals that utilized the services of extension applied more fertilizer nutrients per acre in the Punjab and Sindh province than those who did not (Ahmad et al. 2000). Farmers still lack information regarding agricultural practices (Coady 1995), and need information on ways to promote sustainable agriculture that also examines soil fertility, fertilizer productivity, and BMPs (Ahmad and Muhammad 1998).

The inefficient use of extension and lack of farming knowledge among Pakistani farmers contributes to the informational asymmetry and improper agricultural practices. For example, the lack of knowledge about animal nutrition results in poor animal diets, and inefficient use of irrigation leads to low crop and forage yields (Cain et al. 2007). According to the literature, there is a difference as to how farmers in the Punjab province versus the NWFP learn about modern varieties (Tripp 2001). Ahmad et al. 2000 found that extension use was lower in the NWFP as compared to the other provinces, indicating that ties between extension workers and farmers in the NWFP were weaker than in the other provinces. In the NWFP more farmers learned about modern varieties from other farmers, and also more farmers in the NWFP than in the Punjab province could not name the crop they were growing in Urdu nor Pashtu because they did not have the adequate agricultural knowledge (Tripp 2001).

4.2.9. Land Tenure

The relationship between land tenure and adoption of technology has been suggested theoretically but the empirical evidence has been weak according to Feder et al. (1985). The adoption of technology and land tenancy can also depend on whether the technology will be profitable in the short run or long run (Soule et al. 2000). It was found by Soule et al. (2000), that those who were owner operators were more likely to adopt conservation tillage than cash-renters, and share renters and cash renters were less likely to adopt practices that resulted in benefits over the long term than owner operators. Other studies have indicated that land tenure and adoption of best management practices is positive (Prokopy et al. 2008).

In the context of developing countries, those who are renting are less likely to adopt new technologies (Lee 2005). Fertilizer users in Niger were more likely to own land than non-users (Pender et al. 2008). The case of fertilizer adoption in Pakistan shows that those who owned their land were less likely to apply fertilizer, however Coady (1995) attributes this to resource constraints.

4.2.10. Animal Units

In the U.S., an increase in animal units could imply that less fertilizer will be required by farmers if there is substitution, but some farms in the U.S. use excess manure as an energy source (MacDonald et al. 2009). In the development context, Croppenstedt et al. 2003 found that owning cattle would marginally increase the use of fertilizer in Ethiopia. Those who owned more draft animals were likely to use fertilizer than non-users in a study done in Niger (Pender et al. 2008).

4.2.11. Credit & Risk

Liquidity constraints are a common problem faced by farmers in developing countries. In Pakistan, the formal sources of credit that farmers use include the Agricultural Development Bank of Pakistan now known as Zarai Taraqiati Bank Limited (ZTBL), commercial banks, and Federal Bank for Cooperatives (Iqbal et al. 2003). Farmers with small sized farms rely on informal sources of credit, rather than going through the agricultural banks due to high transactions costs (Masood 2010), only larger sized farms can pay back loans to the agricultural development bank. Informal sources of credit include friends, relatives, or other individuals. As argued by Carter (1989), access to formal sources of credit will help farmers expand their production possibilities frontier, increase food consumption and production, and increase the utilization of fixed inputs such as land and labor as cited by Iqbal et al. (2003). Agricultural yields were shown to increase with the use of formal sources of credit (Iqbal et al. 2003) whereby farmers purchased tractors, tubewells, and other inputs (Khan 1988). According to the Ministry of Pakistani Agriculture, Agricultural Statistics of Pakistan 2008-2009, the number of loans disbursed by the Agricultural Credit Bank, Zarai Tarqiati Bank Ltd. in the NWFP increased from 2005 to 2009 by 2.47% for fertilizer, 56.19 % for seeds, 4.12 % for pesticides, 1.57 % for tractors, and decreased for tubewells by .67 %. Fertilizer helps to increase yields in the short run, however due to credit constraints (Coady 1995), farmers are unable to access fertilizer regularly, therefore relying on manure if it is available to complement fertilizer.

Furthermore, the lack of commercial fertilizer use by rural households was primarily due to the lack of money, which was constrained by the lack of complete credit markets in the country (Coady 1995). Farmers in Pakistan typically use land as collateral and many prefer to obtain credit from informal institutions, since many fear that their land maybe confiscated if they default on a loan issued by a bank (Akram et al. 2009). Problems that farmers faced in the rural Punjab province included, inadequate collateral, or it involved paying bribes to bank officials (Akram et al. 2009). Many farmers are subsistence farmers who obtain credit through means of bartering goods or labor since they lack collateral or even a credit history to borrow from major financial institutions of Pakistan. Inputs such as fertilizer and manure are usually purchased with cash (Coady 1995). The use of credit is more prevalent in urban areas, but still uncommon throughout the country. In the case of subsistence farmers, they are less likely to adopt divisible technologies, such as chemical fertilizer, if credit is not available or other inputs are required such as access to a stable water source (Feder et al. 1985).

Farmers in developing countries face various forms of risk. Agricultural yields will vary depending on weather conditions, input availability, and credit constraints (Feder et al. 1985), and this is also evident in Pakistan (Byerlee and Husain 1993; Coady 1995; Razzaq et al. 2004; Afzal and Ahmad 2009; Suleri et al. 2009). Subsistence farmers in developing countries are typically risk averse. Subsistence farmers bear more risk from technology investment than non-subsistence farmers (Feder et al. 1985). Despite the fluctuating supply of chemical fertilizer, farmers of various risk levels will still utilize the input; however its use may be limited to cash crops such as wheat, sugarcane, cotton, and rice that generate higher streams of income (Khaskheli 2009).

Farmers can mitigate risk by planting other crops (Cain et al. 2007), consuming less, seeking off-farm income, and borrowing from other formal and informal sources of credit. Some of the strategies that Pakistani farmers used to smooth income as identified by Kurosaki and Khan (2001) were the following: accumulation and decumulation of productive assets, gold and jewelry management, food storage, and the adjustment of children's schooling. Other risk coping strategies include mixed farming which allows farmers to grow a variety of crops and increase the number of animal units to counter any possible shocks (Cain et al. 2007).

In accordance with the literature, a series of negative shocks causes farmers to decrease consumption (Deaton 1989; Alderman 1996). According to Kurosaki (2006), farmers in the villages of Peshawar in the NWFP who were aged, landless, and did not receive remittances were unable to cope with negative income shocks.

The existence of complete credit markets influences how farmers cope with income shocks and strategies in terms of smoothing their income (Alderman 1996). Kurosaki and Khan (2001) found that farmers in the NWFP of Pakistan who had access to financial institutions and complete labor markets were located in more developed villages than those farmers who did not have access to these resources in terms of post-shock consumption smoothing mechanisms. In Alderman's 1996 study of rural Pakistani farmers, it was found that in the district of Dir located in the NWFP, farmers from 1986 to 1989 had the highest savings rate compared to the other districts located in the Punjab, Sindh, and Balochistan provinces, which may imply that farmers in the NWFP maybe more concerned about income smoothing than other Pakistani farmers in the country. Depending on the institutions available, farmers develop appropriate risk coping strategies in order to mitigate risk.

4.2.12. Distance & Transportation Costs

Another factor which hindered the adoption of fertilizer was the distance between the point of purchase and the resident's home (Razzaq et al. 2004). Farmers also indicated that the lack of infrastructure such as badly paved roads created barriers, which prevented them from obtaining commercial fertilizers (Razzaq et al. 2004). In the NWFP poorly paved roads create problems for farmers who lack transportation such as cars, and result in long journeys to the market with animals or tractors. The literature indicates that those who are further away from central markets tend to pay higher prices, and receive less for their goods due to high transportation costs (Khan and Ahmad 2003; Perkins et al. 2001; Omamo 1998). Razzaq et al. (2004) conducted a study in the Mandi Bahuddin district of the Punjab province where it was found that 47.5 percent of respondents traveled one to three kilometers, while only 20 percent traveled six to nine kilometers to purchase fertilizer. According to the survey data collected, the time it took for farmers to transport inputs and outputs is on average 2 hours. Furthermore, 23.4 percent indicated that the main market was 5 km away from their home, while the average distance was reported as 6.14 km (Razzaq et al. 2004).

The prices of homogenous goods in the provinces of NWFP and Punjab differ due to transportation costs. Three indicators which measure inflation in Pakistan are the Consumer Price Index (CPI), Wholesale Price Index (WPI) and the Sensitivity Price Indicator (SPI) (Khan 2009). According to the data, the price of wheat, rice, and sugar are slightly higher in the city of Peshawar (NWFP) than in the city of Lahore (Punjab) (Khan 2009). Many farmers who incur transportation costs to travel great distances in order to sell their agricultural output also receive a lower price for their output in the NWFP (Khan and Ahmad 2003). Furthermore, poor infrastructure results in delayed travel to central markets for farmers in the NWFP (Sardar 2003). The result is that the weight of the cattle also decreases along the journey to the central market, which in turn causes the value of livestock to decrease (Sardar 2003).

Apart from the distance between central markets and farming villages in the NWFP, there are other aspects of the physical geography to consider that contribute to high transportation costs. The mountainous terrain makes it difficult for contractors to develop roads, thus limiting market access for farmers and making transporting their crops and animals to the market place difficult.

4.2.13. Institutions

There are institutional barriers which prevent farmers from utilizing human capital and contribute to the lack of private competition in Pakistani agriculture (Hamid and Ahmed 2009). The government of Pakistan operates from the capital city of Islamabad, and to this day has had trouble enforcing rules within parts of the federally administered area tribal area (FATA), however there has been more flexibility within the NWFP region (Johnson and Mason 2008).

Other problems include the mistrust by farmers of the government officials due to the rampant corruption that can result in higher prices of inputs such as fertilizers (Ahmad et al. 2008), and other informational asymmetries that exist in the market (Shahbaz et al. 2008). The adoption of fertilizer in the NWFP of Pakistan is a different case than fertilizer adoption in the Punjab province of Pakistan. The physical and political inaccessibility of the NWFP makes it difficult for the Pakistani government to impose rules or regulations within the region. The lack of trust in the government by rural farmers and the reliance on tribal leaders to address economic and societal problems result in large time lags in terms of implementing policy. In the case of the Green Revolution, there were communication problems between the agricultural research institutions in the Punjab and NWFP provinces (Wheeler 2007), however the establishment of the Pakistan National Research Council helped alleviate some of these inter provincial communication problems that addressed language barriers and other issues of general mistrust of the capital city government by farmers in these provinces (Wheeler 2007).

4.3. Objectives

The proposed analysis will determine the factors which influence farmers in rural Mardan, NWFP to adopt phosphorous fertilizer. It is assumed that they behaved as rational agents living in an environment subject to risk, financial constraints, and productivity constraints.

The following variables, based on the literature presented earlier, were hypothesized to affect the adoption of phosphorous fertilizer:

Age (-), Education (+), Farm Size (+), Land Tenure (+), Aggregate Animal Units (+), Manure Use (-), Distance to Central Market (-), Distance to Central Market Squared (+), Fuel Source (+), Access to Formal Credit (+), Meet with Agricultural Adviser (+), Obtain information about prices, supply, and demand for inputs and outputs (+), and obtain information about agricultural practices from farmers and businesses (+).

The following hypotheses will be tested using a logit regression:

Farmers who have larger sized farms, fewer animal units, borrow from formal institutions of credit, are closer to main markets, younger, more educated, place value on the use of chemical fertilizer, often meet with agricultural advisers, are exposed to multiple sources of information, and use natural gas as a source of fuel are likely to adopt chemical fertilizer. The following hypotheses will be tested qualitatively: Manure will be a more localized product due to bulk and weight and the manure market will be more informal and local.

4.4. Empirical Model

The expected utility from using phosphorous fertilizer will be denoted by E [U_{FZ}], while the expected utility from not using phosphorous fertilizer will be denoted by E[U_{NFZ}].

$$y = \begin{cases} 1 \ if \ E\ [U_{FZ}] > \ E\ [U_{NFZ}] \\ 0 \ if \ E\ [U_{FZ}] \leq \ E\ [U_{NFZ}] \end{cases}$$

The initial analysis focused on asking farmers questions about their use of other chemical fertilizers, but there was only variation in the use of phosphorous fertilizer, therefore it was used as the dependent variable in the binary logit regression. Furthermore, the literature has shown that Pakistani farmers demand for phosphorous fertilizer has increased in recent years (Ministry of Food and Agriculture 2007-2008) and that diets consisting of meat and dairy need inputs with high amounts of phosphorous, and phosphorous fertilizer demand is increasing in Asia such as in countries like India and China (Cordell et al. 2009). Furthermore, the use of phosphorous fertilizer is quite prevalent in the NWFP of Pakistan among cereal based agriculture (Amanullah et al. 2010), while 93 percent of Pakistan's soil are phosphorous deficient (Khan et al. 2010), therefore its demand is quite high. The variable farm sales was not included in this regression because 49 cases were missing, so for the purpose of not losing observations, this variable was removed from the regression.

Bivariate logit regressions will be used to analyze the data. The use of maximum likelihood was used for this binary response model. The density of y_i given x is (Wooldridge 2002):

$F(y|x_i; \beta) = [G(x_i; \beta)]y[1- G(x_i; \beta)]1-y$, y = 0,1

The log-likelihood function takes the following form:

$\ell i(\beta) = y_i \log[G(x_i \beta)] + (1 - y_i)\log[1 - G(x_i \ \beta)]$ and the log likelihood for sample size N is denoted by $L(\beta) = \sum_{i=1}^{N} \ell_i(\beta)$ where G(◦) is the logistic cumulative distribution function, then $\hat{\beta}$ is the logit estimator.

4.5. Methodology

Primary data collection using surveys of farm households was conducted in the district of Mardan, located in the NWFP of Pakistan. The survey was modeled in some ways after the Rozelle's (1991) work on data collection in developing countries. Some of the answer choices were similar to Rozelle's work, since Pakistan is a developing country, and some answer choices seemed appropriate for the study. The survey used random sampling techniques (Casley and Lur 1987). The random sampling consisted of interviewing every 4th household in each village located in the district of Mardan. Four individuals who spoke English, Urdu, and Pashtu asked questions to farmers who mostly spoke Pashtu, and in turn communicated with me in English about the survey. The data collection included questions about farmers' use of fertilizer and manure as well as socioeconomic variables.

The actual survey was initially pre-tested among five farmers on October 4th, 2009 and resulted in no changes to the original survey. The duration of the survey lasted for four weeks, even though originally it was planned for seven weeks. The political situation in Pakistan during the month of October 2009 forced me to end my trip early. Farmers were asked questions about their use of manure, fertilizer, and their views on manure and fertilizer. Furthermore, questions were also asked about infrastructure, credit, and type of energy source used. Responses were either categorical answers or asked respondents to fill out tables about their farm production or transportation choices. Respondents were also asked to explain their answers if necessary, however many were not inclined toward that. The data collection resulted in 149 surveys.

During the data collection, there were some obstacles that the interviewers faced, as well as the principal author of the survey. Farmers in the NWFP are not accustomed to being asked questions about their farming practices, and are usually suspicious of strangers. Respondents faced difficulty in terms of finding farmers that were willing to answer these questions. Furthermore, farmers did not trust women and were less likely to be receptive towards me. In addition to the cultural differences, I adjusted myself and wore a traditional niqab or face cover that allowed me to blend into the surroundings and not be identified as an American woman. Finally, the political situation in the country was unstable and made traveling for an American difficult. Safety was a concern since there was an average of three bomb blasts per week during the month of October 2009.

4.6. Results and Discussion

The descriptive statistics for this analysis are listed in table 3. The data from Pakistan was compared to a paper that utilized estimates from the Pakistan Rural Household Survey (PRHS) of 2001 (Anriquez and Valdes 2006). It was found that the average education of farmers was six years from the PRHS survey, whereas in the data from 2009, it was five years. Furthermore, the operational farm size of farmers in the 2001 data set was ten hectares, and the data set indicated it was seventeen hectares. Thus, the farmers we surveyed may be larger than the actual population.

The results from the survey (table 3) indicate that the average age of respondents was 48, and 31 percent of respondents had only primary schooling, followed by 26 percent who had middle school level education. The average number of hectares cultivated by farmers was 16.8, and 91.3 percent of respondents owned all their land. In contrast to the U.S. manure testing data set where the average animal units was 1177, for the case of Pakistani farmers in Mardan, the average animal units was 3.19. The distance to the central market was 6.14 kilometers, and 46 percent of respondents borrowed from the Agricultural Bank for agricultural purposes. Meeting with an agricultural adviser only occurred for 30.9 percent of respondents.

Table 3: Descriptive Statistics Factors that Affect the Adoption of Phosphorous Fertilizer

Variable	Description	N	Mean	Std. Dev.	Min.	Max
Farmer Characteristics						
Age	Age in Years	147	48	8.29	22	65
Education	Categorical Variable					
Primary Schooling	Base Category	----	-----	----	-----	-----
Middle School	Category 1	148	.26	.44	0	1
High School	Category 2	148	.25	.43	0	1
Intermediate	Category 3	148	.10	.31	0	1
Graduate & Post-Graduate	Category 4	148	.08	.28	0	1
Farm Characteristics						
Farm Size	Number of hectares cultivated	139	16.81	12.21	1	100
Farm Sales	Sales in Laks (1 Lak = 100,000 Rupees)	106	4.32	3.73	0	28
Land Tenure	Percentage of land owned	144	97.36	11.09	40	100
Aggregate Animal Units		146	3.19	1.84	0	12.6
Manure Use	Obtain manure from other farmers =1; otherwise = 0	148	.85	.35	0	1
Physical Infrastructure Characteristics						
Distance to Central Market	Maximum distance fertilizer was transported (km)	145	6.14	6.47	0	50
Distance to Central Market2		145	79.36	281.11	0	2500
Fuel Source	Primary source of fuel is natural gas =1; otherwise = 0	146	.06	.25	0	1
Institutional Characteristics						
Access to Formal Source of Credit	Borrow from credit cooperative for agricultural purposes =1; otherwise = 0	146	.03	.18	0	1
Access to Formal Source of Credit	Borrow from agricultural bank for agricultural purposes =1; otherwise = 0	146	.31	.46	0	1
Sources of Information						
Meet with Agricultural Adviser	Yes =1; Otherwise = 0	147	.44	.49	0	1
Obtain information about prices, supply, and demand for inputs and outputs from other farmers	Yes =1; Otherwise = 0	148	.85	.35	0	1
Obtain information about prices, supply, and demand for inputs and outputs from personal contacts with businesses.	Yes = 1; Otherwise = 0	148	.42	.49	0	1
Obtain information about agricultural practices from other farmers.	Yes =1; Otherwise = 0	148	.86	.34	0	1
Obtain information about agricultural practices from personal contacts with businesses.	Yes = 1; Otherwise = 0	148	.35	.47	0	1
Dependent Variable: Did you use Phosphorous Fertilizer?	Yes =1; No = 0	149	.87	.335	0	1

The descriptive statistics were in accordance with the literature in that the district of Mardan was composed of smaller sized farms owned and operated by farmers with primary education and little contact with agricultural advisers. During the data collection, questions were asked about crops that were grown during the month of October, which were primarily Kharif crops such as sugarcane, citrus, maize, tobacco, wheat, and vegetables.

It is quite evident from the data that farmers are using different types of fertilizer as seen in Table 4. The use of fertilizer among farmers is fairly prevalent given the distance to the central market. Furthermore, it can be seen from Table 4 that the use of urea and phosphorous fertilizers is quite high among respondents. Among respondents, urea fertilizer use was 93 percent while phosphorous fertilizer was 87 percent. Badly paved roads and lack of transportation contributed to the long journey in reaching the central market of Mardan. Manure supply is low and demand is high, thus manure has been substituted by chemical fertilizer. The use of both manure and fertilizer is confirmed by the data in Table 5, especially for crops such as citrus and tobacco, manure use is greater than fertilizer use. This could imply that these crops are used more for home consumption rather than market sales. Fertilizer demand is still high among farmers, thus prompting many farmers to overcome credit constraints in a traditional society, where cash is the most commonly accepted form of payment.

Table 4: Different Types of Fertilizer Use Among Pakistani Farmers

Type of Fertilizer	Percentage of Respondents
Urea	93
NPK	38
Nitrate	2
Diammonium phosphate	4
Phosphorous	87
Potash	6
Other	7

Table 5: Percentage of Manure and Chemical Fertilizer Applied to Crop

Type of Crop	Traditional Wheat	HYVs Wheat	Sugarcane	Citrus	Maize	Tobacco	Vegetables	Other
Chemical Fertilizer	6.45	9.09	13.33	8	6.52	5.06	17.28	50
Manure	4.84	1.3	3.33	12	4.35	7.59	7.41	25
Both	88.7	89.6	83.3	80	89.13	87.34	75.31	25

In this analysis, 96.6 percent of farmers indicated that lack of credit was the primary reason for not buying fertilizer, followed by lack of fertilizer supply, and time. Credit is a big constraint in the adoption of chemical fertilizers according to the data, only 31.5 percent of respondents borrowed from the agricultural bank, while 79.4 percent borrowed from relatives and 81.5 percent borrowed from friends. Furthermore, respondents borrowed the most from relatives, followed by friends, indicating that informal networks are an important part of the society in the NWFP district of Mardan.

According to the data, the availability of fertilizer is not a problem. Over 95 percent of respondents indicated fertilizer was available, however the lack of credit is a major obstacle to the purchase of chemical fertilizer since 96.6 percent of respondents indicated that credit was not available to them. The relationship between farm size and percentage of farmers who borrowed from the Agricultural Development Bank was examined in Table 6.

Table 6: Relationship between Farm Size and Percentage of Farmers who borrowed from the Agricultural Development Bank

Farm Size (Hectares)	Percentage of Farmers who Borrowed from the Agricultural Development Bank
1 – 10	33.33 %
11- 20	35.71 %
21-30	16.67 %
31-40	7.14 %
41-49	2.38 %
50 or greater	4.76 %

The highest percentage of farmers who borrowed from the Agricultural Development Bank had farm sizes that ranged from 11 to 20 hectares, followed by those with farm sizes that ranged from 1 to 10 hectares. According to the data, smaller sized farms borrowed from the Agricultural Development Bank, and fewer larger sized farms borrowed from the Agricultural Development Bank.

Before discussing the regression results, the qualitative hypotheses regarding manure will be presented. The first hypothesis is that manure will be a more localized product due to bulk and weight. The second hypothesis is that manure markets in the NWFP will be more informal than fertilizer markets.

The first hypothesis was that manure will be a more localized product due to bulk and weight. The average distance to buy manure was 2.29 km, while the average distance to buy fertilizer was 5.94 km. The data showed that manure traveled less than fertilizer as can be seen in Table 7.

Table 7: Distance to Buy Manure & Fertilizer (km)

Percentage of respondents who traveled to buy Fertilizer	Distance to Buy Input (km)	Percentage of respondents who traveled to buy manure
67.12	0-5	96.53
21.92	5-10	1.39
6.17	10-15	2.08
2.05	15-20	--------
2.74	20-25	---------

The second hypothesis was that the manure markets in the NWFP will be more informal than fertilizer markets. According to the data, 87 percent of those surveyed used manure, higher than expected, but there are still barriers in obtaining it. In the NWFP, farmers use a variety of fertilizers since manure could not meet all the nutrients required by plants, and there is also a shortage of manure, since demand for it is high. Of respondents who were buyers of manure, 72.5 percent obtained it from other farmers who were not relatives, nor neighbors. Farmers tended to stay within their village to obtain inputs such as manure, and most respondents also indicated that manure was transported by foot and truck. Cash payment rather than barter or credit was used for 94 percent of manure transactions, also no manure was given away. Regarding the selling of manure, 91.9 percent had no formal arrangement to sell manure to someone else, and of those who bought manure, 91.3 percent had no formal arrangement. The low supply of manure was quite evident in the district of Mardan, since 88.6 percent of total respondents indicated that lack of manure supply was the primary factor preventing them from buying manure. The lack of infrastructure available to facilitate the possible exchange of manure is probably a reason as to why the price of manure does not increase to equalize supply and demand in this market.

Comments were also made by respondents about the use of manure compared to fertilizer as an input. Many farmers indicated that using manure instead of fertilizer resulted in better tasting fruits and vegetables. The perception of fertilizer as an input among respondents was that 39.6 percent believed that the quality of crops were better, 22.15 percent did not comment, and 17.45 percent reported that manure could be used for a long duration. Other comments that are in Table 8 indicate that respondents believed that manure was beneficial since it was a natural input, yields were higher, it was an inexpensive input, environmentally friendly, and good for soil properties. In addition to using manure as an input, 12.3 percent of respondents used it as a source of fuel.

Table 8: Benefits of Using Manure

Comment	Percentage
Quality of crops better	39.60 %
Blank	22.15%
Long duration	17.45%
Natural input	8.72%
Food tastes better	5.37%
Other responses (Good for soil properties, inexpensive, environmentally friendly, prevent crop disease)	4.7%
Higher Yields	2.01%

The dependent variable in this analysis was whether a farmer used phosphorous fertilizer. Farmers used various fertilizers such as Urea, NPK (Different Grades), Phosphate (DAP/MAP/SSP), Potash (SOP/MOP), and Other (Liquid fertilizer etc.). Respondents did not report the amount of fertilizer they used, but answered either 'yes' or 'no' as to whether they used a specific type of fertilizer, thus the dependent variable was a discrete variable. The most variability in answers occurred for the phosphorous fertilizer, and Pakistani soils are low in phosphorous, therefore this was used as the dependent variable. Furthermore, farmers were asked questions about the amount of fertilizer they used, but many could not recall this information, or were just not sure how much fertilizer they applied, therefore this question could not be used as a possible dependent variable. A number of regressions were attempted by using other types of fertilizers as possible dependent variables and other explanatory variables were considered such as including all the different credit sources and fuel sources, but were not included in the final regression, since it resulted in a high number of missing values.

Finally, all respondents to questions were males, since women in the NWFP tend to minimize contact with outsiders, therefore answers about the use of manure will exhibit a gender bias. Manure is also used as a source of fuel, and turned into dung patties by female domestic servants. The supply of manure used by farmers maybe understated since some may not report its alternate use.

The goodness of fit for this logistic regression included a number of tests. After conducting the Omnibus Tests of Model Coefficients, it was found that the model is statistically significant because the p-value is less than 0.01, therefore the null hypothesis that H0 = $\beta_1 ... \beta_k$ = 0 can be rejected. The logit model in its fullest form predicted 96.1 percent of the cases correctly, and the pseudo r-square value using the Cox & Snell was 0.345 and the Nagelkerke was 0.668. Furthermore, the Hosmer and Lemeshow Test shows that there is no difference between the observed and predicted values of y, indicating that this model is appropriate for this data set. Finally, diagnostic tests such as the tolerance values and VIF found that the model did not display multicollinearity. The results of the bivariate logistic regression are reported in Table 9.

Table 9: Logit Regression Results: Factors that Affect the Adoption of Phosphorous Fertilizer n =129

Variable	Description	B	S.E.	Wald	Sig.	Exp(B)	Marginal Effects (dy/dx)
Farmer Characteristics							
Age	Age in Years	-.119	.112	1.123	.289	.888	-.055
Education	Categorical Variable						
Primary Schooling	Base Category	----	-----	----	-----	-----	
Middle School	Category 1	-1.840	1.910	.928	.335	.159	1.335
High School	Category 2	-3.367	2.175	2.396	.122	.034	3.148
Intermediate	Category 3	-3.651	2.419	2.278	.131	.026	3.485
Graduate & Post-Graduate	Category 4	-2.583	2.239	1.331	.249	.076	2.219
Farm Characteristics							
Farm Size	Number of hectares owned	.116	.054	4.595	.032	1.123	.061
Land Tenure	Percentage of land owned	.068	.038	3.237	.072	1.071	.035
Aggregate Animal Units		-.057	.261	.047	.828	.945	-.027
Manure Use	Obtain manure from other farmers =1; otherwise = 0	2.386	1.559	2.343	.126	10.874	1.982
Physical Infrastructure Characteristics							
Distance to Central Market	Maximum distance fertilizer was transported (km)	-2.274	1.042	4.763	.029	.103	-.212
Distance to Central Market2		.194	.093	4.381	.036	1.214	.106
Fuel Source	Primary source of fuel is natural gas =1; otherwise = 0	-.336	2.123	.025	.874	.715	.056
Institutional Characteristics							
Access to Formal Source of Credit	Borrow from credit cooperative for agricultural purposes =1; otherwise = 0	1.645	2.138	.592	.442	5.179	1.099
Access to Formal Source of Credit	Borrow from agricultural bank for agricultural purposes =1; otherwise = 0	-2.917	1.611	3.281	.070	.054	2.621
Sources of Information							
Meet with Agricultural Adviser	Yes =1; Otherwise = 0	1.781	1.575	1.278	.258	5.933	1.256
Obtain information about prices, supply, and demand for inputs and outputs from other farmers	Yes =1; Otherwise = 0	4.419	2.288	3.732	.053	83.001	4.278
Obtain information about prices, supply, and demand for inputs and outputs from personal contacts with businesses.	Yes = 1; Otherwise = 0	-1.752	1.135	2.385	.122	.173	1.236
Obtain information about agricultural practices from other farmers.	Yes =1; Otherwise = 0	3.327	1.769	3.536	.060	27.853	3.078
Obtain information about agricultural practices from personal contacts with businesses.	Yes = 1; Otherwise = 0	3.118	1.655	3.549	.060	22.607	2.830
Constant		-.522	6.803	.006	.939	.593	

Factors such as age and education were not found significant in this regression, contrary to the literature on adoption and fertilizer adoption in particular. Factors that were found to be significant in the adoption of phosphorous fertilizer were the following: farm size, land tenure, distance to the central market, borrowing from the agricultural bank, obtaining information about prices, supply, and demand for inputs from other farmers, and obtaining information about agricultural practices from other farmers and from personal contacts with businesses. Larger sized farms and farmers owning more of the land were both found to be significant and positive, as expected (Feder et al. 1985). The distance to the central market was negative as expected, since the farmers who lived farther away from the central market were less likely to use fertilizer and substitute it with manure. The majority of respondents traveled 5 kilometers at least to obtain fertilizer as shown in Table 8. There was a positive relationship between the distance to buy fertilizer and distance to the market from the correlation coefficient of .6, and graphing this relationship also resulted in a positive, linear relationship. This relationship between the two variables was positive since fertilizer was available at the central market for purchase, whereas the source for manure, if purchased, was other farmers.

Farmers who borrowed from the agricultural bank for agricultural purposes were less likely to use fertilizer, and this result is not consistent with the literature, since access to formal institutions of credit would be expected to increase adoption of fertilizer (Ahmad et al. 2000; Coady 1995). Often times, farmers would use loans to pay off other outstanding loans, purchase machinery, land, or even use it for personal expenses such as their children’s weddings (Akram et al. 2009). In an e-mail message received by the Deputy Chief of the National Fertilizer Development Centre in Islamabad, Pakistan on July 8th, 2011, Dr. Saleem Mohsan stated that “Farmers who borrowed money from the Agricultural Development Bank spend it on goods such as the purchase of motorcycles or on the marriages of their children. Furthermore, the uncertainty of the selling price for crops deters farmers from buying inputs such as fertilizer, which could result in high yields."

Furthermore, there have been time lags in terms of when the bank will issue the loan, and the time when the farmer receives the loan (Akram et al. 2009). Fertilizer can be used during a certain time, and farmers could possibly be receiving loans from the bank when it is too late for them to use it. Obstacles that farmers face in Pakistan from banks are the following (Bashir and Azeem 2008): lengthy bank procedures, high interest rates, lack of cooperation from bank staff, loans are not provided on time, security problems, and the repayment terms of loans are too rigid.

Furthermore, another logit regression was conducted to determine which factors affect the farmers’ choice of borrowing from the agricultural bank. It was found that those who met with agricultural advisers, had intermediate education versus those who had elementary education, and obtained information about prices, supply, and demand for inputs and output from business contacts were likely to borrow from agricultural banks. While those who were far from the market and obtained information about agricultural practices from other farmers were less likely to borrow from the agricultural credit bank. The agricultural development bank is located in the capital city of

Islamabad, which is about a hundred miles away from the district of Mardan. Only farmers who had cars and access to public transportation such as buses could make the commute to borrow funds from the agricultural development bank. Farmers who communicated with each other learned information about other aspects related to farming such as problems with credit constraints, management of resources, and those who may have experienced problems with the agricultural credit bank probably discouraged other farmers who may have asked them for financial advice.

Other factors that were found significant were under the category of sources of information. Personal contacts play a pivotal role in the dissemination of information among farmers in the NWFP. Farmers who obtained information about prices, supply and demand for inputs and outputs from other farmers were more likely to adopt fertilizer, as well as those who obtained information on agricultural practices from other farmers and personal contacts with businesses. The positive signs of the factors which were under the sources of information category show that networking with farmers and other businesses is one of the ways farmers obtain information. It can also be noted that farmers in this data set primarily obtained more information from private sources such as farms and other businesses rather than public sources such as extension services, since only about 44.9 percent of farmers had access to extension services. The rest of respondents could have obtained information about agricultural practices from other agricultural advisers who were not formally a part of agricultural extension.

In this analysis, animal units was not significant in the regression and a cross tabulation showed that there was no relationship between the number of animal units and phosphorous fertilizer use. Farmers with a low number of animal units used phosphorous fertilizer as well as farmers with a high number of animal units. Pakistani farmers can purchase manure if they do not have animals. The manure supply will be larger for those farmers who have more animal units, however there is not enough manure to meet the nutritional requirements of the crops, therefore chemical fertilizer will supplement manure. The hypothesized sign of animal units is positive, since the number of animals owned by farmers is low. Farmers obtain manure from animals which they own, however most farmers supplement their nutrient requirement with chemical fertilizer.

4.7. Conclusion

Poverty is one of the many problems faced by Pakistan, especially in the NWFP. According to Kurosaki and Khan (2001), the U.N. has cited various data sets that indicate rural regions are experiencing more poverty than urban areas, and in Pakistan specifically, the NWFP has higher levels of poverty than the other three provinces and the scarcity of resources such as land makes it more difficult for farmers to cope with negative income shocks (Chaudhry 2006; Kurosaki and Khan 2001). Alleviating poverty among subsistence farmers through the adoption of technologies that will help to increase yields, thus an increase in incomes is an important step to decreasing poverty.

Subsistence farmers in developing countries who use chemical fertilizers will increase yields, thus incomes, which can take them out of subsistence and give them opportunities to sell extra yield for cash in the open market. From an economic perspective, their welfare has risen. Adoption of divisible technologies such as chemical fertilizers has occurred in developing countries, and governments in developing countries play an instrumental role in the implementation of such technologies through credit subsidies or providing funding and development for extension agencies that can communicate the benefits of these technologies to farmers.

Fertilizer adoption in the NWFP of Pakistan has implications for policy makers. The results showed that credit is major obstacle to the purchase of fertilizer. The purpose of the Agricultural Credit Bank of Pakistan was to provide credit for small farmers living in rural Pakistan, however large landowners had the resources to collude with bank officials which secured them credit (Qureshi 1995). This type of behavior will further marginalize subsistence farmers, and create more informational asymmetry in the credit markets. There is credible enforcement within the informal market institutions such as farmers borrowing from friends, neighbors, or relatives, since defaulting on a loan could lead to possible ostracization from an individual's village. In terms of policy solutions, possible corruption in government institutions such as the Agricultural Credit Bank of Pakistan need to be remedied, in order for credit markets to function.

CHAPTER 5: ADOPTION OF ENVIRONMENTAL PRACTICES AMONG U.S. CONSUMERS

5.1. Introduction

A recent trend in the U.S. has been a general inclination of firms and consumers to adopt green practices. The onset of global warming and other negative externalities that have resulted from individuals and firms polluting the environment has created great concern among many in the U.S. population to take some action. This paper will use a holistic approach to analyze the factors that influenced U.S. consumers to recycle, use mass transit, and buy compact fluorescent light bulbs during April 2007, based on a CBS News/New York Times Monthly Poll.

Other studies in the literature have focused on the adoption of one or many environmental practices at a time in specific regions of the country, but this paper will use a national data set collected before the U.S. economic recession of 2008, focusing on these three practices. It will employ the econometric tools of multivariate probit analysis, rather than the individual bivariate probit regressions typically employed, which will be an innovation to the literature. Furthermore, other studies that have examined the use of mass transit and recycling (Carrus et al. 2008) primarily focused on the role of behavior and psychological motivation, while this paper will examine socioeconomic characteristics. This newer data set will attempt to test the literature's findings regarding these socioeconomic variables as well as the variables associated with political party affiliation, and the views of the role of government in the environment.

This paper will examine the adoption of environmental practices by U.S. consumers and attempt to characterize adopters versus non-adopters of environmental practices such as recycling, use of mass transit, and purchase of compact florescent light bulbs. Furthermore, the comparison of different technologies that are available or not available in terms of the urban versus rural setting is also an innovation in this paper. For example, CFLs are available in both rural and urban settings, however the availability of mass transit is likely to be available in an urban setting. Any differences in preferences for environmental practices can also be due to availability of such environmental practices.

5.2. Technologies Evaluated

5.2.1. Recycling

The term recycling has been used in a general sense, but for the purpose of this paper, recycling refers to the removal of trash from the waste stream. The term 'recycling' in this survey was defined as separating out newspapers, cans, or glass containers. It did not include donating used items to Goodwill or similar organizations. The Environmental Protection Agency's (EPA) definition of recycling is to turn waste into something that could be a valuable resource (U.S. EPA 2010). According to the EPA, the recycling rate in 2009 was 33.8 percent, while 82.0 tons of materials were recycled (U.S. EPA 2009). The EPA calculated the recycling rates of the following items in 2009: auto batteries (95.7 percent), office type papers (74.2 percent), steel cans (66.0 percent), yard trimmings (59.9 percent), aluminum beer and soft drink cans (50.7 percent), tires (35.3 percent), glass containers (31.1 percent), HDPE Natural (White Translucent) bottles (28.9 percent) and PET bottles and jars (28.0 percent). In addition to the environmental benefits that result from recycling, the EPA found that many jobs have been created in the recycle and reuse industry since goods and services are needed to process municipal solid waste (U.S. EPA 2002).

In the U.S., financial incentives are lacking for people to recycle and it is not mandatory in most places, therefore people are less inclined towards recycling. The availability of curbside recycling, according to Jenkins et al. (2003), showed a positive relationship between waste that is recycled rather than being used in a landfill (Boyer 2006). In one study, the decision to recycle was analyzed using an individual threshold model, whereby individuals will only make decisions if others do so (Lüdemann 1999). Other reasons as to why people donate items for reuse is to achieve a level of altruism or a sense of inner peace with regards to their efforts in protecting the environment since they perceive their efforts in recycling have made a difference in the sustainability of the environment (Granzin and Olsen 1991).

5.2.2. Mass transit

According to the U.S. Department of Transportation, statistics compiled from the 2001 National Household Travel Survey, 91.2 percent of U.S. commuters took their personal vehicles to work, while 4.9 percent used mass transit, 2.8 percent walked, and 1.1 percent used other means (U.S. Department of Transportation 2001). Furthermore, according to the U.S. Census Bureau, 2007 American Community Survey, 4.8 percent of Americans took public transportation to work while the number increased to 4.9 percent in 2009 (U.S. Environmental Protection Agency 2009).The adoption of mass transit among U.S. consumers has been empirically studied by a number of researchers. Some of the densely populated U.S. cities have public transportation systems which serve millions of commuters who would otherwise waste time looking for parking and driving around in traffic. These cities have the resources to adopt and implement a specific system of public transit, however a larger number of individuals still use their private vehicle than use public transportation (Batterbury 2003), thus many individuals in the U.S. perceive driving as a luxury and right, preferring it to public transportation. In contrast to the U.S., private vehicles and fuel are more expensive in Europe, therefore cars per family are fewer than they are in the U.S. and people resort to public transportation. In addition, land for parking lots is more scarce.

5.2.3. Compact Florescent Light Bulbs

The adoption of compact florescent light bulbs (CFLs) were received with apprehension in the 1980s by the U.S. population due to costs, informational asymmetry about compatibility with existing light fixtures, and other concerns (Menanteau and Lefebvre 2000). According to the 2009 U.S. Residential Energy Consumption Survey, 16.4 million housing units in the Western portion of the U.S., which included Mountain and Pacific census division answered ‘yes’ to the question of using energy efficient light bulbs. The southern portion reported 25.1 million, the Midwest region was 15.3 million, and the northeast region reported 11.2 million household units. The adoption of CFLs is more prevalent in the Western part of the U.S. such as in states like California (Lefevre et al. 2006). People adopt CFLs for many reasons, which include both environmental and financial reasons (Wall and Crosbie 2009).

According to the studies that have been done before, the adoption of CFLs in the U.S. has been observed among individuals that are more educated, have higher income levels (Mills and Schleich 2010), and who also live in urban areas (Sandhal et al. 2006).

5.3. Factors that Influence Adoption of Environmental Practices

The socio-demographic variables are not the only determinants of environmental practice adoption however; there are other behavioral and causal factors that also need to be accounted for using utility functions that can place weights representing an individual's preferences for certain goods and services (Boyer 2006). Research in this field continues given the complexity of how individual decisions are made and gaps in research on how to implement policies that would generate the greatest amount of welfare.

5.3.1 Age

There is mixed evidence in the literature on how age affects the adoption of environmental practices. Younger people tend to be more environmentally concerned than older people due to the fact that it is analogous to the youth of the 1960s who supported issues such as the environment, world peace, and other movements (Uyeki and Holland 2000; Van Liere and Dunlap 1980). Today, youth seem to have access to a wider set of technologies than previous generations, making them more cognizant of the pollution and other externalities that are generated from the production and consumption of new goods and services.

Furthermore, the studies from the late 1970s interviewed young people who are middle aged today, and their views may not have changed towards recycling. Some of the earlier studies found that older people had less time than younger people to derive the long term benefits from the short term costs incurred in order to promote environmental conservation (Buttel 1979). Older people are accustomed to certain institutions and adhere to the status quo, whereas younger people are more likely to participate in environmental movements which challenge the status quo and are better able to adapt to risk and uncertainty than older people with regards to changes in the environment (Buttel 1979). Other studies from that era also found that younger people are more likely to recycle than older people (Buttel and Flinn 1974; Dillman and Christenson 1972; and Dunlap et al. 1973).

However, there are studies in the literature that indicate age and adoption of environmental practices is positive. For example, there was a small, positive relationship for residents of the Canadian province of Alberta which showed that older people tended to recycle more than younger people (Derksen and Gartrell 1993). Other studies show that older people are more willing to participate in environmental activities such as recycling than younger people (Granzin and Olsen 1991; Vining and Ebreo 1990; Mohai and Twight 1987;). Older individuals who recycled could attribute this to possible differences in life experiences and attitudes towards recycling, and may also have larger homes and thus more room to store recyclables.

In terms of recycling, there has thus been a mix in the literature about age. Some have reported age as insignificant (Werner & Makela 1998; Corral-Verdugo

1996; Oskamp et al. 1991), while others have found a positive relationship (Scott 1999; Margai 1997; Gamba & Oskamp 1994; Derksen & Gartrell 1993 ; Hormuth 1992; Lansana 1992; Folz & Hazlett 1991; Vining & Ebreo 1990).

The use of mass transit was common among the working age population as shown in the 2001 National Household Travel Survey, in which the working age population, which ranged from 18 to 64, made the longest trips in terms of time and distance (Public 2005).

In terms of the adoption of compact florescent light bulbs, older, retired individuals may have a lower adoption rate if the medium of information they use to obtain information about CFLs is not the internet (Mills and Schleich 2010), with the internet being a primary mode of dispersing information. However, the counterargument to that is retired people spend more time at home and have higher lighting needs and may obtain more information on the purchases of CFLs (Mills and Schleich 2010). Kumar et al. 2003 found that older individuals in India were more likely to adopt CFLs than younger individuals.

5.3.2 Education

Those who have higher education will tend to adopt more environmental practices since they have acquired more knowledge about the environment, and may perceive that such practices will benefit society in the long run. Furthermore, educated individuals will have higher disposable incomes than those who are less educated, thus enabling them to purchase more environmentally friendly technology which is sometimes more expensive than standard technology. Finally, those who are less educated may be inclined towards other priorities if their income is low, such as finding steady income, housing, or healthcare, therefore the adoption of environmental practices will not be a top priority. The literature indicates that adoption of environmental practices will increase for those who are more educated (Saphores et al. 2006; Diamantopoulos 2003; Buttel and Flinn 1974; Dillman and Christenson 1972; Good 1979; Jackson 1983; Samdahl and Robertson 1989; Van Liere and Dunlap 1980).

In terms of recycling, some studies have shown that education is positively related to recycling (Owens, Dickerson & Macintosh 2000; Derksen & Gartrell 1993; Lansana 1992; Folz & Hazlett 1991; Vining & Ebreo 1990; Jacobs et al. 1984; McGuire 1984; Webster 1975).

With regards to education and mass transit , it was shown that college educated students were more likely to demand mass transit (Taylor et al. 2009). Other studies in the literature did not include education as a variable, rather employment status was used (Cervero 1990; Polydoropoulou and Ben-Akiva(2001).

In terms of (CFLs), Corrado et al. 2010 reported that individuals with secondary and university educations in Ireland were more likely to use CFLs. Kumar et al. 2003 found that educated individuals in India were likely to adopt CFLs. Educated individuals should have lower information costs than non-educated individuals (Schultz 1975), and therefore can adopt technologies such as CFLs (Mills and Schleich 2010).

5.3.3 Income

Individuals who belong to the middle and upper income bracket are not concerned about fulfilling their basic (e.g. food and shelter) needs according to

Maslow's hierarchy of needs, therefore they have moved up the hierarchy into social needs and thus, the environment falls into this category (Van Liere and Dunlap 1980). In one study it was found that income positively affected the adoption of solar energy (Zahran et al 2008), and the adoption of energy efficient technologies was more prevalent in areas where individuals had higher incomes (Kok et al. 2011). Other studies indicate that income positively affects the adoption of environmental practices (Diamantopoulos 2003; Buttel and Flinn 1978; Hurley 1988; Mohai 1985; Van Houwelingen an Raaij 1989; Zeidner and Shechter 1988). Furthermore, some studies have shown that higher income individuals are more likely to recycle (Viscusi et al. 2011; Owens et al. 2000; Berger 1997; Jacobs et al. 1984; McGuire 1984; Vining & Ebreo 1990).

In terms of mass transit, one study showed that higher income individuals were more likely to walk or bike to transit stations in California (Cervero 2007). It was also found that many people from the affluent neighborhoods of Arlington County, Virginia used the Washington D.C. metro (Cervero 2009). In another study, however, Kim et al. 2007 found that middle income individuals were less likely to use the bus than low income individuals.

Individuals with higher incomes were also more likely to use CFLs in Ireland (Corrado et al. 2010), while Kumar et al. 2003 found this result in India. In general, higher income individuals were likely to adopt CFLs (Mills and Schleich 2010).

5.3.4 Political Ideology

The adoption of green practices among U.S. consumers reflects a schism between green and brown users. Many environmentalists in the U.S. live near the central business district and close to rail transit stations (Kahn 2007). Kahn (2007) found that members of the Green Party consume less gasoline, are more likely to walk to work, and less likely to own a private vehicle. Furthermore, political party affiliation can also determine the consumer's conservation behavior and attitude. Those who affiliated themselves with the Green Party were more likely to engage in conservation (Kahn 2007), because they were more likely to internalize the externalities associated with excessive driving and change their own behavior. Furthermore, those who are in green parties also adhere to social norms, and may derive social prestige with conservation (Kotchen and Moore 2008), and do not want to deviate from the group's standards such as participating in various conservation practices (Kahn 2007). Finally, many affiliated with the Green Party do not want to compromise the legitimacy of the party, nor its credibility of being environmentally friendly, therefore are more likely to engage in conservation practices (Kahn 2007). It was found that green consumers are likely to exhibit green travel behavior (Kahn and Morris 2009).

The adoption of green technologies is also more likely to be observed by those who are members of the Democratic Party (Uyeki and Holland 2000; Zahran 2008; Taylor et al. 2009). Furthermore, individuals in the Democratic party consumed less electricity than those in the Republican party (Costa and Kahn 2009).

5.3.5 Urbanity

The location of an individual's residence or business also determines the price the household or firm will pay for utilities such as electricity, water, and gas, thus being a contributing factor to the adoption of conservation technology (Andrews and Krogmann 2009). The adoption of energy efficient technology by U.S. commercial buildings was influenced by factors such as building specific characteristics, primary activities of the building, and locational factors. Those more likely to adopt energy efficient technologies also lived in densely populated areas (Kok et al. 2011).

Another hypothesis introduced by Tremblay and Dunlap (1978) addresses individuals concern for the environment and argues that residents in urban areas are more concerned about the environment than rural residents, because urban residents are exposed to higher levels of pollution and that rural residents are more exposed to activities that deplete natural resources (Van Liere and Dunlap 1980).

In terms of recycling, urban residents were more likely to recycle bottles and cans than rural residents (Derksen and Gartrell 1993) which may be due to more extensive recycling programs in cities.

Furthermore, those living in densely populated areas are more likely to use mass transit since it is more convenient than driving around, and they can resort to walking and bicycling (Kahn and Morris 2009; Cervero 2002; Srinivasan and Ferreira 2002; Spillar and Rutherford 1998; Ewing et al. 1994). Accessibility to mass transit is also something that researchers have found to significantly influence the use of mass transit (Srinivasan and Ferreira 2002).

Residents living in a rural area were less likely to adopt CFLs than those living in an urban area according to an Irish data set (Corrado et al. 2010). Individuals living in densely populated areas were more likely to adopt CFLs since they were readily accessible, and since many were instructed by local government energies to minimize their energy consumption (Sandahl et al., 2006).

5.3.6 Geography

The adoption of environmental practices occurs more in the western part of the U.S., specifically in the state of California (Kahn and Vaughn 2009), which has been the first state to set precedents regarding environmental trends (Kahn and Vaughn 2009; Kahn and Matsusaka 1997, Fredriksson and Millimet 2002). Environmentally friendly cars such as Hybrid and Prius were shown to be driven by many in San Francisco, California (Kahn and Vaughn 2009). Furthermore, the Pacific northwestern part of the U.S. which includes the states of Idaho, Washington, and Oregon had the highest largest per-capita Leadership in Energy and Environmental Design (LEED) building count. LEED buildings have been certified by the U.S Green Building Council as environmentally friendly (Kahn and Vaughn 2009). The western part of the U.S. mainly the state of California, was one of the first places that was hit hard during the energy crisis of 2001 (Lefevre et al. 2006). The sale of CFLs was higher among California residents than non-California residents from 1998 to 2004, but it peaked during the 2001 energy crisis that engulfed California (Lefevre et al. 2006).

In this paper, factors which influence the adoption of the following three environmental practices will be analyzed: recycling, use of mass transit, and the purchase of compact florescent light bulbs. Utilizing a multivariate probit regression, the following factors with their hypothesized signs will be examined: income (+), education (+), age (+/-), gender (+/-), belonging to the Democratic party (+), type of vehicle driven (+/-), level of urbanity (+), and the level of government that should handle the environment, whether it be state or federal (+/-).

5.4. Model

The empirical model for whether consumers adopted environmental practices will be in the theoretical context of utility maximization discussed below. The expected utility from adopting environmental practices will be denoted by E $[U_{Aep}]$, while the expected utility from not adopting environmental practices will be denoted by $E[U_{Nep}]$.

$$y = \begin{cases} 1 \; if \; E\left[U_{Aep}\right] > \; E\left[U_{Nep}\right] \\ 0 \; if \; E\left[U_{Aep}\right] \leq \; E\left[U_{Nep}\right] \end{cases}$$

A multivariate probit regression will be used to analyze two dependent variables that have binary choices with the value of “1” as adopt and “0” as not adopt. According to Khanna (2001), a multivariate probit regression will be used over a bivariate probit regression since correlation can arise in the error terms of the equations if a bivariate probit regression is used. Furthermore, if the technologies are interrelated, this type of model captures this relationship better than multivariate logit regressions (Khanna 2001; Dorfman 1996; Woznaik 1984; Hausman and Wise 1978), since adoption decisions of inter-related technologies modeled as independent single equations can be inefficient (Khanna 2001).

The model will take the following form with a multivariate normal distribution:

$Y1 = X1\ \beta1 + \varepsilon1$, $y1 = 1$ if Recycled, 0 otherwise.

$Y2 = X2\ \beta2 + \varepsilon2$, $y2 = 1$ if Used Mass Transit, 0 otherwise.

$Y3 = X3\ \beta3 + \varepsilon3$, $y3 = 1$ if Bought florescent light bulbs, 0 otherwise.

where Y1, Y2, and Y3 are the respective latent dependent variables, X1, X2, and X3 are the matrices of explanatory variables, and the vector of coefficients are represented by the **β1, β2,** and **β3**. Finally, the observed binary dependent variables are y1, y2, y3.

5.5. Data & Methodology

Data taken from the CBS News/New York Times Monthly Poll, April 2007 was used to determine which factors affect U.S. consumer's adoption of environmental practices. This particular data set has 1,052 observations with a number of different explanatory variables that can be possibly explored. The data was randomly selected by random digital dialing that attempted to be representative of the U.S. population.

5.6. Results and Discussion

Among respondents, 48 percent lived in the suburbs and 57 percent of respondents indicated that the federal government was responsible for handling problems related to the environment. Among respondents, 79 percent recycled, while 20 percent used mass transit, 78 percent of respondents bought compact fluorescent light bulbs, while 23 percent of respondents recycled and used mass transit. Other descriptive statistics regarding the data can be found in Table 9. The results of the U.S. Department of Transportation's 2001 household survey showed that only 4.9 percent of respondents relied on mass transit as a way of commuting to work.

There is reason to think that the dataset may not be representative. For example, according to the U.S. Census 2010, 30 percent of adults over the age of twenty five had a least a bachelor's degree, whereas the descriptive results of the data set indicated that 22 percent of adults had a college degree. Furthermore, as of 2008 according to the Population Survey, Annual Social and Economic Supplement, 17.9% of Americans fell into the category of income that ranged from $50,000 to $74,999 whereas the data indicated that 29% of respondents reported income that ranged from $50,000 to $75,000. Regarding age, U.S. Census 2010 reported that the average age of Americans was 36, and 50.7 percent of the population as of 2009 were females, whereas the data indicated that the average age was 53, and 42 percent of respondents were females. Random digital dialing may miss younger, more mobile people without landlines. Furthermore, as of 2008, 55 percent of voters were registered as Democrats and 45 percent as Republicans in a Two-Party Presidential Vote, whereas respondents in this survey were 32 percent Democrat, 27 percent Republican, and 41 percent answered neither party. Those who comprised the 41 percent could be affiliated with another party such as Independent or may not affiliate themselves with any political party. Finally, according to the U.S. Census 2000 Population Statistics, 79 percent of the U.S. population lived in urban areas and 20 percent in rural areas. The data was closer to these numbers in that 74 percent of respondents lived in urban areas, and 26 percent lived in rural areas.

Table 10: Descriptive Statistics: Factors that Affect the Adoption of Environmental Practices Among U.S. Consumers

Variable	Description	N	Mean	Std. Dev.	Min.	Max
Socio-demographic Characteristics						
Age	Age in Years	1052	53	17.18	18	99
Gender	Categorical Variable					
Female	Category 1	1052	.42	.49	0	1
Male	Base Category	----	----	----	----	----
Education	Categorical Variable					
Not a High School grad	Category 1	1052	.05	.22	0	1
High School Grad	Category 2	1052	.25	.43	0	1
Some College	Base Category	----	-----	-----	----	-----
College Grad	Category 3	1052	.22	.41	0	1
Post-Graduate	Category 4	1052	.18	.38	0	1
Income	Categorical Variable					
Under $15,000	Category 1	1052	.07	.26	0	1
$15,000-$30,000	Category 2	1052	.15	.35	0	1
$30,000-$50,000	Category 3	1052	.17	.38	0	1
$50,0000-$75,000	Base Category	----	----	----	----	----
$75,000-$100,000	Category 4	1052	.14	.35	0	1
Over $100,000	Category 5	1052	.18	.39	0	1
Other Characteristics						
Political Party	Categorical Variable					
Republican	Category 1	1052	.27	.44	0	1
Democrat	Category 2	1052	.32	.46	0	1
Independent	Base Category	----	----	----	----	----
Type of Vehicle	Categorical Variable					
Car	Base Category	----	----	----	----	----
SUV	Category 1	1052	.18	.38	0	1
Minivan	Category 2	1052	.11	.31	0	1
Truck	Category 3	1052	.11	.31	0	1
Don’t have a Car	Category 4	1052	.02	.14	0	1
Type of Community	Categorical Variable					
Large Central City (Over 500K)	Category 1	1052	.06	.25	0	1

Variable	Description	N	Mean	Std. Dev.	Min.	Max
Central City (50 to 500K)	Category 2	1052	.20	.40	0	1
Suburbs	Base Category	----	----	----	----	----
Variable	Description	N	Mean	Std. Dev.	Min.	Max
Other Community (10 to 50K)	Category 3	1052	.00	.03	0	1
Rural	Category 4	1052	.26	.44	0	1
Level of Government that should handle the environment.						
Federal Government	Base Category	----	----	----	----	----
State Government	Category 1	1052	.39	.48	0	1
Both Federal and State Government	Category 2	1052	.04	.21	0	1
Geography						
South	Base Category					
North East	Category 1	1052	.18	.38	0	1
North Central	Category 2	1052	.27	.44	0	1
West	Category 3	1052	.20	.40	0	1
Dependent Variable (1): Did you recycle	Yes =1; No = 0	1052	.79	.40	0	1
Dependent Variable (2): Did you use mass transit?	Yes =1; No = 0	1052	.20	.40	0	1
Dependent Variable (3): Did you buy florescent light bulbs?	Yes =1; No = 0	1052	.78	.41	0	1

The Rivers-Vuong test was conducted in order to determine whether three bivariate probit regressions or one multivariate probit regression was appropriate to analyze the factors that affect adoption of these practices. After conducting the Rivers-Vuong test, it was found that one of the coefficients on the OLS residuals was found to be significant, therefore at least one of the y's was endogenous in the model, therefore multivariate probit analysis was used for this analysis. The goodness of fit for this multivariate probit regression included a number of tests. It was found that the model is statistically significant because the p-value is less than 0.01, therefore the null hypothesis that $H_0 = \beta_1 \ldots \beta_k = 0$ can be rejected. Also, there was no presence of heteroskedasiticity in the multivariate probit regression after examining a covariance matrix of coefficients.

After conducting the multivariate probit regression for each environmental practice, the p-value ($p < .10$), and coefficient are reported in Table 11. The significant results will be discussed for each practice in turn.

In the multivariate probit regression, those who belonged to the Democratic party were more likely to recycle than those in neither party. Furthermore, those who drove SUVs were more likely to recycle than those who drove cars. Individuals living in the central city were more likely to recycle while those living in a rural area were less likely to recycle than those who lived in the suburbs. This result was consistent with the literature in that rural communities may not have places or resources for residents to recycle waste. Furthermore, individuals living in the northeast, north central, and western parts of the U.S. were more likely to recycle than those living the southern part of the U.S. These effects were more significant and of greater magnitude than those for the variables associated with rural and urban.

The use of mass transit was more likely to be adopted by individuals with post graduate education compared to those who had some college education. As the literature confirms, educated individuals will adopt such practices since they are better informed. Individuals with income levels of under $15,000, $15,000 to $30,000, and above $100,000 were more likely to use mass transit than those whose income was between $50,000 and $75,000. Those whose income was below $15,000 probably relied on mass transit services out of necessity, while those with higher incomes could have utilized mass transit for either actual concern for the environment, or for the sake of convenience, since parking and traffic are problematic in densely populated cities. Furthermore, the coefficient on Republicans was found to negatively significant affect the adoption of mass transit. This result was consistent with the literature. Those who drove trucks were less likely to use mass transit than those who drove cars. Respondents with no cars were more likely to use mass transit than those with cars, since it could serve as mode of transportation. Furthermore, individuals who lived in large central cities were more likely to use transit while those in rural areas were less likely than the base category of living in the suburbs. Finally, individuals living in the northeastern and western parts of the U.S. were more likely to use mass transit than those individuals living in the southern part of the U.S.

Contrary to the other two practices, CFLs are widely available in the U.S. Those who were not high school graduates, high school graduates, and college graduates, and were all less likely to buy fluorescent light bulbs compared to those who had some college education. Individuals with an income from $15,000 to $30,000, were less likely to buy fluorescent light bulbs compared to those with an income of $50,000 to $75,000. Those who drive a minivan compared to those who drove cars were likely to buy fluorescent light bulbs, and those who lived in the western part of the U.S. were more likely to buy fluorescent light bulbs than those living in the southern part of the U.S. There were no rural/urban differences for this practice, indicating that availability rather than ideology may be driving the earlier rural/urban differences.

Variables that were not significant included age, gender, and level of government that should handle the environment. It was interesting to note that 57 percent of respondents believed that the federal government should handle the environment whereas 39 percent believed that the state government should. There were no answer choices in the survey for those individuals who believe that there should be no government involvement.

Table 11 : Multivariate Probit Regression: Factors that Affect the Adoption of Environmental Practices Among U.S. Consumers

Variable		Recycled	Recycled	Mass Transit	Mass Transit	Buys Florescent bulbs	Buys Fluorescent bulbs
Socio-demographic Characteristics	Description	Coefficient	P>|z|	Coefficient	P>|z|	Coefficient	P>|z|
Age	Age in Years	0.00	0.82	-0.00	.17	-0.00	.62
Gender	Categorical Variable						
Female	Category 1	-0.11	.24	0.13	.18	0.11	.23
Male	Base Category	----	----				
Education	Categorical Variable						
Not a High School grad	Category 1	-0.00	.97	-0.20	.38	-0.35	.09
High School Grad	Category 2	-0.02	.81	-0.17	.20	-0.55	.00
Some College	Base Category	----	----				
College Grad	Category 3	0.09	.46	0.21	.11	-0.24	.06
Post-Graduate	Category 4	0.13	.36	0.26	.06	-0.23	.11
Income	Categorical Variable						
Under $15,000	Category 1	-0.27	0.14	0.37	.06	0.14	.47
$15,000-$30,000	Category 2	-0.22	0.13	0.36	.01	-0.35	.01
$30,000-$50,000	Category 3	-0.21	0.13	0.07	.60	-0.18	.16
$50,0000-$75,000	Base Category	----	----				
$75,000-$100,000	Category 4	-0.05	0.72	0.02	.87	0.05	.70
Over $100,000	Category 5	0.10	0.50	0.25	.07	0.17	.24
Other Characteristics							
Political Party	Categorical Variable						
Republican	Category 1	-0.17	0.11	-0.41	.00	-0.17	.11
Democrat	Category 2	0.18	0.10	0.13	.21	0.05	.64
Neither Democrat nor Republican	Base Category	----	----	----	------		

		Recycled	Recycled	Mass Transit	Mass Transit	Buys Florescent bulbs	Buys Fluorescent bulbs
Variable	Description	Coefficient	P>|z|	Coefficient	P>|z|	Coefficient	P>|z|
Type of Vehicle	Categorical Variable						
Car	Base Category	----	----	----	----		
SUV	Category 1	0.24	0.07	-0.06	.62	0.05	.65
Minivan	Category 2	0.04	0.78	-0.00	.98	0.48	.00
Truck	Category 3	-0.16	0.23	-0.42	.02	0.13	.37
Don't have a Car	Category 4	-0.25	0.40	0.51	.08	-0.45	.11
Type of Community	Categorical Variable						
Large Central City (Over 500K)	Category 1	-0.02	0.88	0.63	.00	0.07	.69
Central City (50 to 500K)	Category 2	0.21	.08	-0.00	.94	0.04	.73
Suburbs	Base Category	----	----	----	----		
Other Community (10 to 50K)	Category 3	3.62	0.98	-4.03	.97	4.4	.97
Rural	Category 4	-0.19	0.08	-0.47	.00	-0.00	.93
Level of Government that should handle the environment.							
Federal Government	Base Category	----	----	----	----	----	----
State Government	Category 1	-0.07	0.44	0.08	.41	-0.09	.31
Both Federal and State Government	Category 2	0.05	0.79	0.11	.60	-0.04	.84
Geography							
South	Base Category	----	----	----	----	----	----
North East	Category 1	0.81	.00	0.56	.00	0.00	.99
North Central	Category 2	0.37	.00	0.04	.73	0.16	.14
West	Category 3	0.56	.00	0.27	.03	0.25	.04
Constant		0.58	0.00	-0.86	.00	1.04	0.00

5.7. Conclusion

There were some caveats with this survey. The data collected in this poll did not ask consumers as to whether they walked or bicycled, and these are environmental practices that should have been included in the initial survey since they are also substitutes for driving. Furthermore, there are search costs involved in obtaining information about recycling and using mass transit, and there were no questions in the survey that asked consumers about this. The survey could have asked respondents questions about what factors prevent them from adopting recycling, mass transit, and buying florescent light bulbs or other environmental practices.

Future analysis could compare and contrast these answers from an earlier time period in order to analyze whether consumer preferences have changed. The data was taken from 2007, and a new data set could examine whether the adoption of CFLs would increase, since a new law will require that all incandescent bulbs manufactured in 2012 have to be 25 to 30 percent more efficient than traditional incandescent bulbs (Semple 2011). The results of the regression indicate that the availability of certain practices was an issue for individuals living in rural settings. CFLs and the choice to recycle was an option for more individuals in rural settings than mass transit. Multivariate regression was able to elucidate the difference between availability of a practice and rural/urban differences that may relate to preferences since the rural category was not significant for CFLs. There was no room for commentary in the survey, which could help policy makers determine appropriate public campaigns that would promote this type of conservation.

The global concern of pollution and excess use of resources has finally been recognized by not only scientists, but the rest of society which will need to change its behavior in order to sustain the current stock of natural resources left in the Earth today.

CHAPTER 6: FINAL CONCLUSION

Although each of the discussed practices are different, each is beneficial to society, and its magnitude at an aggregate level can be large. Manure testing decreases non-point source water pollution, which helps improve water quality. Excess nutrients in water bodies are a problem in the U.S. However, increased fertilizer adoption in Pakistan can increase crop yields and help take farmers out of subsistence and enable them to diversify their crop production and increase income levels. The adoption of recycling, mass transit, and the purchase of florescent compact bulbs are just a few environmental practices that can collectively reduce emissions, and conserve natural resources. Individual actions collectively can impact society as seen by the aforementioned practices.

Analyzing these practices together allowed a comparison between American and Pakistani farmers with regards to issues such as contracts and environmental sustainability. From the U.S. data set, 13 percent of farmers had formal contracts for manure testing, while 8.1 percent of Pakistani farmers had a formal arrangement to sell manure. Both American and Pakistani farmers thus conducted transactions related to manure based on informal sets of rules. BMPs such as manure testing would not be a top priority for subsistence farmers in Pakistan, whose goals included increasing yields, and selling extra yields as source of income. Rather than overuse of fertilizer and manure, the problem in Pakistan is that they are applied at lower than recommended rates.

Furthermore examining variables such as age and education across the studies showed that the variable age did not show up as significant in any of the three studies, however education did. U.S. farmers were mostly high school educated, whereas in Pakistan the majority of farmers had only primary schooling. This difference is expected since the U.S. is a developed country with a higher standard of living, and Pakistan is classified as a developing country. The average education for U.S. consumers was some college education. Education was found to be significant in the adoption of manure testing, and for the adoption of CFLs, but was not significant for the adoption of fertilizer in Pakistan. Those with less than high school education versus those with high school education were likely to conduct manure testing which was contrary to expectations but similar to the results of Dorfman (1996). In terms of CFL adoption, those who were not high school graduates, high school graduates, and college graduates versus those who had some college were less likely to adopt CFLs. While the results as far as less than high school and high school are in line with the literature, the college graduate results were not.

Future research on each of these practices could help policymakers and practitioners develop tools that could provide institutions and extension agencies with useful information that would further increase adoption rates for each practice. For example, manure transferred off the farm has not been studied widely in the economic literature, and more research could possibly examine the barriers to adoption of manure testing under these circumstances. New methods to sample solid manure or on-farm testing methods may be needed.

In the case of fertilizer adoption in Pakistan, the biggest factor that affected fertilizer supply was credit constraints. It was found that farmers who borrowed from the Agricultural Development Bank were less likely to use fertilizer, instead the credit was used to pay for other goods and services. Furthermore, personal contacts corroborated that many farmers had to pay loan agents at the Agricultural Development Bank a commission prior to receiving the loan, thus leaving farmers with less credit. Although, corruption was an exogenous factor in the model, future research could examine how it influences farmer's ability to acquire credit for agricultural purposes. The relationship between the purchase of agricultural inputs and agricultural credit institutions could be further researched. Microcredit institutions might be a potential solution to the problem.

The data set from the environmental practices paper represented a small portion of those individuals from the age group of 18 to 29. Future research could collect a more representative sample of this age group. U.S. consumers' adoption of other environmental practices could be studied such as the purchase of hybrid vehicles or the use of solar energy using newer data sources.

In terms of economics, these results showed that individuals made decisions based on observable factors that could be confirmed with the data, and unobservable characteristics which were unique to each individual. It was difficult to determine whether individuals knew all the benefits and costs associated with each practice. Time constraints were not addressed directly in the surveys and this may affect adoption. An individual's utility is subjective and subject to a number of constraints that the researcher may not be aware of.

While utility maximization or profit maximization may in some cases encourage people to adopt practices, such as manure testing and CFLs, that have environmental benefits, the optimal level of adoption may not occur without government policies.

APPENDIX A: MANURE MANAGEMENT SURVEY

Farm operators should complete this questionnaire. (For the purposes of this questionnaire, a farm operator is someone who is currently farming and makes major decisions regarding the farm operation.) If you are not a farm operator, please give this questionnaire to the farm operator in your household. If there is no farm operator in your household, answer only question #1 and return the questionnaire in the business reply envelope provided.

1. Are you a farm operator with livestock (other than for your own use)? (Check your answer.)
☐Yes ☐No → STOP and return the blank questionnaire in the business reply envelope provided.

Section 1: Information about farming systems is useful in the design of programs.

2. On average, HOW MANY of the following livestock animals of all ages did you have on your farm at one time in 2005 (other than for your family's use)? Please write number of animals on the line.

________ Dairy cattle

________ Beef cattle on feed

________ Beef cows

________ Swine 55 lb or less

________ Swine more than 55 lb

________ Broilers

________ Turkeys

________ Other livestock (please list) _________________________

3. How many acres of land did you own in January 2005? (Please write the number of acres on the line.)
_________ Acres (crop, pasture, and forest)

4. How many acres of land did you rent out to other farmers in 2005?
_________ Acres

5. How many acres of land did you rent from others in 2005?
_________ Acres (if None, please skip to question #8)

6. Do you apply manure or poultry litter to land that you rent from others? (Check the appropriate box.)
☐ Yes ☐ No

7. In the rental contract, are there clauses that specify required manure application practices?
☐ Yes ☐ No ☐ There is no written contract

8. In 2005, how many acres of the following crops did you have planted? (Please write number of acres)
☐ I don't have crops

__________ Acres of corn

__________ Acres of soybeans

__________ Acres of wheat

__________ Acres of alfalfa

__________ Acres of other hay

__________ Acres of pasture

__________ Acres of other crop(s) (please list) ________________________

9. How many years have you been the primary farm operator?
_________ Years

10. Please list the county (or counties) and state(s) where your farm is located.
_________________________ County (or counties)

_________________________ State (or states)

According to the Environmental Protection Agency (EPA), an animal feeding operation (AFO) is a lot or facility where the following conditions are met:

- Animals are stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and
- A ground cover of vegetation is sustained over less than 50% of the animal confinement area.

11. Could your farm be considered an animal feeding operation according to the definition above?
☐ Yes ☐ No

12. Are you a permitted concentrated animal feeding operation (CAFO)?
☐ Yes ☐ No

13. Is there a lake or stream on the land that you own?
☐ Yes ☐ No

14. My land is mostly (check one);
☐ flat

☐ rolling hills

☐ steep hills

15. Which of the following changes do you expect to occur on your farm in the next 5 years? (Please check one box in each row. N/A means not applicable to your farm.)

In the next 5 years do you expect...	
a. you or a family member will continue farming this farm.	☐ Yes ☐ No ☐ Not Sure ☐ N/A
b. to sell the farm	☐ Yes ☐ No ☐ Not Sure ☐ N/A
c. to increase livestock numbers	☐ Yes ☐ No ☐ Not Sure ☐ N/A
d. to expand crop acreage	☐ Yes ☐ No ☐ Not Sure ☐ N/A
e. to invest in new buildings on your farm	☐ Yes ☐ No ☐ Not Sure ☐ N/A

Section 2: There are several incentive programs available through USDA's Natural Resource Conservation Service (NRCS) and we are interested in awareness among the farm population of these programs and what can be done to improve the programs. We are also interested in the availability of private financing for equipment.

16. Are you aware of the Environmental Quality Incentives Program (EQIP)?
☐ Yes ☐ No (if No, please skip to question #20)

17. Do you currently have an EQIP contract through NRCS?
☐ Yes (if Yes, please skip to question #20) ☐ No

18. Did you apply for EQIP?
☐ Yes ☐ No

19. If you have not applied for EQIP, why not?

20. Have you prepared a Comprehensive Nutrient Management Plan (CNMP) following NRCS guidelines?
☐ Yes ☐ No (if No, please skip to question #26)

21. What year did you develop a CNMP?
_________ Year

22. Who prepared the CNMP?

☐ A private technical service provider

☐ NRCS staff

☐ Myself since I received CNMP training

23. If you used a technical service provider how much did it cost?
_________ dollars

24. How much time did you spend in meetings with NRCS staff or your technical service provider?
_________ days OR _________ hours

25. How much time did you spend on reading, paperwork and pulling together information for the CNMP?
_________ days OR _________ hours

26. In your experience, are banks willing to loan money to farmers for improving water quality?

☐ Yes ☐ No ☐ Don't know

27. Do you own equipment for injecting manure into the soil?

☐ Yes ☐ No (if No, please skip to question #30)

28. If you bought equipment for injecting manure into the soil, were you able to get a bank loan for it?

☐ Yes ☐ No ☐ Did not seek a bank loan

29. If you answered "Yes" to question #28, what percent of the cost was borrowed?

________%

30. Do you have an underground pipe system to move manure to some or all of your fields?

☐ Yes ☐ No (if No, please skip to question #33)

31. If you installed an underground piping system to move manure, were you able to get a bank loan for it?

☐ Yes ☐ No ☐ Did not seek a bank loan

32. If you answered "Yes" to question #31, what percent of the cost was borrowed?

_______%

Section 3: Questions about the use of manure as a fertilizer.

33. To how many acres of each crop do you apply manure?

☐ I don't have crops

_________ Acres of corn

_________ Acres of soybeans

_________ Acres of wheat

_________ Acres of oats

_________ Acres of alfalfa

_________ Acres of pasture/hay

_________ Acres of another crop (please list) ____________________

34. Do you apply commercial fertilizer to any of your manured fields?
☐ Yes ☐ No

35. To what extent do you agree or disagree with the following statements? Please circle the number that best corresponds to your answer.

1. Strongly Disagree 2. Disagree 3. Neither 4. Agree 5. Strongly Agree

a. The smell of manure bothers me or my family.	1	2	3	4	5
b. The smell of manure bothers my neighbors.	1	2	3	4	5
c. It is difficult to determine how much manure to apply to my crops, so I don't under or over apply nutrients.	1	2	3	4	5
d. Transportation costs and time affect which of my fields receive manure.	1	2	3	4	5
e. I'm not sure how my crops would respond to manure as compared to commercial fertilizer.	1	2	3	4	5
f. I am concerned about the water quality of streams and lakes in my county.	1	2	3	4	5
g. Properly managing manure improves water quality.	1	2	3	4	5
h. Agricultural regulations regarding water quality will become stricter in the next five years.	1	2	3	4	5

36. Have you provided manure to other farm operations or individuals in the past two years?
☐ Yes (if Yes, answer the following questions for the farm that received the most

manure from you)

☐ No (if No, please skip to question #44)

37. What was the maximum distance the manure was transported?
About _________ Miles

38. Who applied the manure to the other farm?
a. ☐ Custom applicator
b. ☐ The farmer receiving the manure
c. ☐ I did
d. ☐ Other (please explain) __________________________

39. Were you paid for the manure?
☐ Yes ☐ No (if No, please skip to question #42)

40. How much money did you receive for the manure? (Check one measurement or indicate other quantity.)
$_______

☐ per ton? ☐ per acre? ☐ per pick-up load? ☐ per spreader load? ☐ per semi load?

41. Did this price include application of the manure?
☐ Yes ☐ No

42. Was there a written contract between you and the other farmer involved with the manure transfer?
☐ Yes ☐ No

43. Did either you or the farmer receiving the manure test the manure for nutrient content before applying it?
☐ Yes ☐ No ☐ I don't know

44. What type of manure storage facility do you have? (Check all that apply.)
a. ☐ None
b. ☐ Lagoon(s)
c. ☐ Cement or glass-lined tank(s)
d. ☐ Earthen basin(s)
e. ☐ Stack house
f. ☐ Other (please specify) ___________________________

45. Which of the following structures and/or equipment do you use to manage manure? (Check all that apply.)
a. ☐ Handle solid manure with a loader
b. ☐ Scrape manure with a tractor
c. ☐ Use a gutter scraping system
d. ☐ Apply manure using a solids spreader
e. ☐ Apply manure using a tank wagon
f. ☐ Apply manure by an irrigation system
g. ☐ Use traveling gun
h. ☐ Use dragline injection system
i. ☐ Other (please specify) ___________________________

46. Given your typical livestock production, how many months of manure storage capacity do you have?

a. ☐ 0-3 months
b. ☐ 3-6 months
c. ☐ 6-9 months
d. ☐ 9-12 months
e. ☐ More than 12 months

47. Did you hire a custom applicator to apply manure on your farm in the past two years?

☐ Yes ☐ No (If No, skip to question # 49)

48. What was the cost of having them apply the manure? (Put price and check one measurement.)

$___________ ☐ per ton ☐ per acre ☐ per pick-up load ☐ per spreader load ☐

per semi load

49. What period(s) of the year did you apply manure in 2005? (Check all that apply)

a. ☐ January-February
b. ☐ March-April
c. ☐ May-June
d. ☐ July-August
e. ☐ September-October
f. ☐ November-December

50. Approximately how many hours per year do you spend applying manure?

__________hours

51. How much influence does each of the following have on agricultural production decisions you make? (Please circle the number that best indicates the amount of influence.)

	None		Some		Very Much
a. Other farmers	1	2	3	4	5
b. Non-farming neighbors	1	2	3	4	5
c. Banking/Lending institutions	1	2	3	4	5
d. Contractors / Integrators	1	2	3	4	5
e. University	1	2	3	4	5
f. NRCS	1	2	3	4	5
g. Other government organizations	1	2	3	4	5

The following questions regarding manure management activities are very important to this study. Please answer them as completely and carefully as possible. Remember, only completed questionnaires will be considered for the Wal-Mart gift certificate drawing.

52. Please give your opinion regarding the following characteristics of the given practices even if you don't perform them. (Circle the number that best corresponds to your opinion about each of the characteristics.)

1. Strongly Disagree 2. Disagree 3. Neither 4. Agree 5. Strongly Agree

Practice	**This is a profitable practice, it improves my bottom line**	**This practice improves water quality.**	**This practice is time consuming.**	**This practice is complicated.**
a. Use Round-up Ready soybeans	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
b. Use phytase in my feed rations	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
c. Test soil for nutrients at least every THREE years.	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
d. Test manure for nutrients at least annually	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
e. Maintain a setback between streams and lakes and manure application areas of 100 feet	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
f. Inject manure into the soil during application	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
g. Calibrate manure spreaders at least annually	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
h. Keep detailed records on what day, how much and to what field manure was applied	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
i. Use a grass filter system as a buffer around water sources	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5
j. Use an underground pipe system to move manure to some or all your fields	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5

53. Again, these questions are important to this study so please answer them and the questions on the following page as completely as you can.

- Please check Yes or No in questions (A) and (C).

- In questions (B) and (D), please write the relevant years in the blanks.

Practice	(A) Do you perform the practice?	(B) If you currently do the practice, when did you start doing it?	(C) If you don't currently do the practice, have you done it in the past?	(D) If you answered yes to question (C), what year did you start and end doing the practice?
a. Use Round-up Ready soybeans	o Yes o No	Year______	o Yes o No	Start_____ End _____
b. Use phytase in my feed rations	oYes oNo oDon't know	Year______	o Yes o No	Start_____ End _____
c. Test soil for nutrients at least every THREE years.	o Yes o No	Year______	o Yes o No	Start_____ End _____
d. Test manure for nutrients at least annually	o Yes o No	Year______	o Yes o No	Start_____ End _____
e. Maintain a setback between streams and lakes and manure application areas of 100 feet	o Yes o No	Year______	o Yes o No	Start_____ End _____
f. Inject manure into the soil during application	o Yes o No	Year______	o Yes o No	Start_____ End _____
g. Calibrate manure spreaders at least annually	o Yes o No	Year______	o Yes o No	Start_____ End _____
h. Keep detailed records on what day, how much and to what field manure was applied	o Yes o No	Year______	o Yes o No	Start_____ End _____
i. Use a grass filter system as a buffer around water sources	o Yes o No	Year______	o Yes o No	Start_____ End _____
j. Use an underground pipe system to move manure to some or all your fields	o Yes o No	Year______	o Yes o No	Start_____ End _____

Section 4: Off-farm employment is important for many farmers and may have an impact on the farming operation. Please answer the following questions for 2005.

54. Please check your answer for questions a and b and write the relevant hours for question c.

	Farm Operator	Spouse ☐Not Applicable	Other Family Member #1 ☐Not Applicable	Other Family Member #2 ☐Not Applicable
a. Contributes significantly to farm work	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
b. Has off-farm work (check one box per person)	☐ none ☐ seasonal ☐ year round	☐ none ☐ seasonal ☐ year round	☐ none ☐ seasonal ☐ year round	☐ none ☐ seasonal ☐ year round
c. Hours per week worked off the farm	______hours per week (during the weeks worked)	______hours per week (during the weeks worked)	______hours per week (during the weeks worked)	______hours per week (during the weeks worked)

55. Does your off-farm work interfere with the timing of your farming operations?
☐ Yes ☐ No (if No, please skip to question #57) ☐ Not applicable

56. What periods and activities cause severe time crunch problems? (Check the two worst problems.)

a. ☐ Planting in spring
b. ☐ Fall harvest
c. ☐ Cleaning out livestock facilities
d. ☐ Haying
e. ☐ Timing of manure applications
f. ☐ Other __________________

57. Did you hire non-family farm labor in 2005?
☐ Yes ☐ No

58. What is your household's annual off-farm gross income?

a. ☐ No off-farm income
b. ☐ Between $0 and $9,999
c. ☐ Between $10,000 and $24,999
d. ☐ Between $25,000 and $49,999
e. ☐ Between $50,000 and $99,999
f. ☐ $100,000 or more

59. What amount of gross farm sales did you have in 2005?

a. ☐ Between $0 and $9,999
b. ☐ Between $10,000 and $99,999
c. ☐ Between $100,000 and $249,999
d. ☐ Between $250,000 and $499,999
e. ☐ $500,000 or more

60. What is the highest level of education you have completed?
a. ☐ Less than High School
b. ☐ High School
c. ☐ Some college or vocational school
d. ☐ Bachelor’s degree
e. ☐ Graduate degree, such as Master’s

61. What year were you born? _________________

Thank you for your participation. Feel free to use the space below or above right to write any comments you have about the questionnaire or manure issues in general.

Then, return the questionnaire in the business reply envelope.

APPENDIX B: PAKISTAN AGRICULTURAL PRODUCER SURVEY

Pakistan Agricultural Producer Survey Questionnaire, Rabi season 2009-10
Date:
District:
Village:
****
Instruction Issues:
1. Make sure everyone is answering for same time frame.
2. Respondents should be those who make the most agricultural decisions.
****

1.
A. Please check whether you use chemical fertilizer, manure, or both inputs for each crop.
B. Then please place a (*) on the input which has been given priority for each crop.

Crop Produced	Chemical Fertilizer	Manure	Neither
Wheat A. Traditional Variety B. Modern HYV			
Sugarcane			
Citrus			
Maize			
Tobacco			
Vegetables			
Other (Specify)			

2.

Crop Produced	Total Output Produced (Units: Maunds or Kilo)
Wheat	
Sugarcane	
Citrus	
Maize	
Tobacco	
Vegetables	
Other	

3. How many adult animals do you own?
__________Cattle
__________Buffalo
__________Sheep
__________Goats

4. What type of fertilizer do you use? (Circle only 1 answer)
1 = Only use manure
2 = Only use chemical fertilizer
3 = Use manure and chemical fertilizer
4 = neither

Manure Questions
5. Do you obtain manure from another farmer?
1 = yes
2 = no ➔(Go to Question 11)

6. If you obtain manure, whom do you obtain it from? (Circle all that apply)
1 = neighbor (not relative)
2 = relative in my village
3 = someone else in my village
4= relative outside my village
5 =other

7. If you receive manure, how did you pay if you paid? (If people have multiple responses to #6, then, use the most important source).
1 = Received for Free
2 = Cash
3 = Credit (from manure seller)
4 = Barter (payment of other form (i.e.,: labor, crops)

8. Do you have an arrangement with someone to buy manure, if so, is this written or oral (informal agreement)?
1 = no agreement
2 = written
3 = informal agreement (oral, handshake, traditional social ties)
4 = no agreement, but always obtain it from the same person (how many years?)_______

9. If you bought manure, what was the typical distance the manure was transported?
_________# of Kilometers

10. How did the manure get transported?

1 = personal car
2 = animal cart
3 = foot
4 = tractor
5 = truck
6 = other (specify)_____________

11. Do you give manure?
1 = yes
2 = no ➔ (Go to Question 14)

12. Do you have an arrangement to sell manure to someone; if so, is this written or oral (informal agreement)?
1 = no agreement
2 =written
3 = informal agreement (oral, handshake, traditional social ties)

13. If you were paid for the manure, what type of payment did you receive?
1 = Cash
2 = Credit (from manure seller)
3 = Barter (payment of other form (i.e., labor, crops)
4 = gave for free

14. Regarding manure, when do you either buy or sell manure?
1 = before field preparation
2 = during growing season
3= whenever it is available

15. Which factors prevent you from buying manure?
1 = credit
2 = lack of manure supply
3 = time
4 = other (Please explain)

Fertilizer Questions
16. Do you buy chemical fertilizer?
1 = yes
2 = no (Go to Question 21)

17. If you do buy fertilizer, which one and how much did it cost you?

	Cost/per bag (50 kg)	Number of Bags Purchased
1 = Urea	____________________	____________________
2 = NPK (Different Grades)	____________________	____________________
3 = Phosphate (DAP/MAP/SSP)	____________________	____________________
4 = Potash (SOP/MOP)	____________________	____________________
5= Other (Liquid fertilizer etc.)	___________________	___ __________________

18. Where do you buy the fertilizer from?

1 = State supply/ Cooperative society
2 = Open-air Market
3 = Store that sells farm inputs
4 = Directly from the fertilizer factory
5 = Other (specify)

19 When do you buy fertilizer?
1 = before field preparation
2 = during growing season
3 = whenever it is available

20. If you bought fertilizer, what was the typical distance the fertilizer was transported?
______Kilometers

21. Which factors prevent you from buying chemical fertilizer?
1 = credit not available
2 = lack of fertilizer supply
3 = time
4 = other (Please explain)

22. Do you always have physical access to manure or chemical fertilizer?
1 = Yes
2 = No

23. Do you use other inputs such as pesticides, herbicides?
1 = yes
2 = no

24. Do you believe there are any benefits to using farm manure compared to chemical fertilizers?
1 = yes

2 = no
3 = I don’t know

25. If your answer is yes, please describe the benefits of using farm manure.

26. Do you believe there are any benefits of using chemical fertilizers compared to farm manure?
1 = yes
2 = no
3 = I don’t know

27. Please describe the benefits of using chemical fertilizers over farm manure.

28. Do you trust that chemical fertilizer will be more reliable than manure in enhancing crop yield?
1 = yes
2 = no

29. How far is the main market (Place where you buy inputs or sell your farm output) from your home? Kilometers

30. What are your farm sales?

31. How many acres of land you cultivate?

32a.How many of these do you own?

32b.How many of these do you co-own?

32c.How many of these do you share crop (land that you farm for others and share in the product)?

32d.How many of these you rent for cash?

33. What is your age?

34. How many family members over the age of 10 contribute to farm labor?

35. What is the highest level of education you have completed?
1 = primary (grades 1- 5)
2 = middle school (grades 6-8)
3 = high school (grade 9-10)

4 = Intermediate, FSc/FA (grades 11-12)
5 = graduate (BSc/BA)
6 = Post-graduate (MSc/MA) or above

36. A. If you decide to borrow for agricultural purposes, which of the following do you use? (Circle all that apply)
1 = credit cooperative
2 = agricultural bank
3 = supply/marketing coop
4 = other government agency
5 = private financial institutions
6 = relative
7 = friend
8 = someone outside of village
9 = township or village enterprise
10 = moneylender
11 = other

B. Also indicate from which source you borrowed the most from with a (x) or a (*).

37A. From whom do you obtain information about prices, supply and demand for inputs and outputs? (Source)
A = other farmers
B = personal contacts with business
C = extension workers
D = news organization
E = non-governmental organizations (NGOs)
F = none of the above

37B. How do you come to know about prices, supply and demand for inputs and outputs? (Medium)
A = face to face contact
B = newspaper
C = internet
D = radio

38A. From whom do you obtain information about agricultural practices? (Source)
A = other farmers
B = personal contacts with business
C = extension workers
D = news organization
E = non-governmental organizations (NGOs)

38B. How do you come to know about agricultural practices? (Medium)
A = face to face contact
B = newspaper
C = internet
D = radio

39. How often do you meet with an agriculture expert/advisor?
_____times/year

40. Do you have access to canal water or streams for irrigation?
1 = yes
2 = no

41. Do you have a tubewell?
1 = yes
2 = no

42. Is your farm accessible by car or by truck?
1 = yes
2 = no

43. A. How do you transport inputs? (Circle all that apply)
B. Also, (*) your mode of transportation
1 = personal car
2= animal
3= foot
4= tractor
5= truck
6 = delivered by supplier
7 = other (specify)_________

44. Depending on your main mode of transportation from part B of the previous question, How long does it take to transport inputs to your farm from the major market in terms of time?
_________ Number of hours
_________ Number of days

45. Who transports the harvested crop to the market?
1 = I go by myself.
2 = I use a middleman.
3 = Other, I rely on family members to help me.

46. How do you transport harvested products?

Crops	Personal Car	Animal	Foot	Tractor	Other
Wheat (traditional)					
Wheat (modern HYV)					
Sugarcane					
Citrus					
Maize					
Tobacco					
Vegetables					
Other (specify)					

47. Depending on your main mode of transportation from part B of question # 43b ,How long it takes to transport harvested products in terms of time?
__________ Number of hours
__________ Number of days

48. What is your major source of fuel?

1 = natural gas (methane)
2 = timber/wood
3 = manure/dung cakes
4= electrical heater
5 = propane

6 = diesel

THANK YOU FOR PARTICIPATING IN THIS SURVEY. IF YOU WOULD LIKE TO LEARN ABOUT THE RESULTS PLEASE LET ME KNOW HOW IT WOULD BE BEST TO MAKE THEM ACCESSIBLE TO YOU> DO YOU HAVE ANY COMMENTS, OF THE STUDY THAT WE MAY HAVE NOT ASKED YOU ABOUT?

INTERVIEWER: Please write any comments, incidents.

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