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Experimental Analysis of Crop Insurance - Cognitive Bias in Decision Making

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Experimental analysis of crop insurance - Cognitive bias in decision making

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This study is set out to explore how cognitive biases, gambler's fallacy and hot hand effect, exert an effect on individual crop insurance purchase decision. A laboratory experiment comprised of two separate games was used to establish an insurance purchase environment to induce individual's behavior. The gambler's fallacy and hot hand effect failed to be found in the experiment. But the subjects' perceived probability of loss plays a significant role in determine their purchase decisions—the higher probability they predicted, the more likely to buy insurance they were. It is also fascinating to find that the longer the exposure to random risks the subjects had, the more willing to engage in insurance protection they were.

DEDICATION

I would dedicate this research to my parents, Qian Zhongqing and Wan Xiaohong. Thank you for your encouragement, sacrifice and deep love to me.

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First of all, I would like to give all of my most earnest gratitude to my major professor, Dr. Keith Coble, for your professional guidance and enthusiastic inspiration..

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Insurance is a vital tool to protect people from losses such as unexpected accidents or significant financial catastrophes. Farmers are especially vulnerable to financial harm caused by low probability high consequence events such as drought, flood or disease.[1] Crops are commodities without brand attributes, meaning farmers are more vulnerable to price fluctuations from selling the undifferentiated products.

Brief history of Federal crop insurance program

In the United States, a variety of crop insurance programs have been developed and regulated by the government, but delivered to farmers by private insurance companies. Meanwhile, the federal government also offers farmers a considerable number of subsidies to reduce the costs. Established on a small scale in 1938, the U.S. federal crop insurance program has grown into a sizable risk management system with numerous programs holding a total liability exceeding $123.6 billion and a coverage of 296.2 million acres in 2013 (Figure1.1 and Figure 1.2). However, this has been accompanied by a significant cost to the taxpayers, and government expenditure on crop

[1] This state of the world is no different than people/firms living/operating in flood, forest fire, hurricane and earthquake areas, as well as in foreign countries.

insurance is expected to exceed all other spending on farm commodity programs during the fiscal periods 2011 to 2020 (Bulut et al., 2012).

Figure 1.1 Insured Acres from 1989 to 2013 in United States[2]

[2] The data source from current year-to-date national summary of summary reports, http://www.rma.usda.gov/data/sob.html

Figure 1.2 Crop Insurance Liabilities From 1989 to 2013 in United States[3]

Federal crop insurance was first authorized in 1938 in a support of Roosevelt's presidential campaign. In the first 40 years of its existence, only limited types of crops and a limited number of counties were eligible for coverage. The Federal Crop Insurance Act of 1980 came into effect and expanded the coverage for more types of crops. Under the 1980 Act, the federal government transitioned the delivery of crop insurance to private insurance companies and began subsidizing premiums to boost participation. Despite these innovative reforms, participation rates still remained low during the 1980's. In their analysis of U.S. crop insurance participation rates, Gardner and Kramer (1986) concluded that to obtain a 50% participation rate, insurance had to be subsidized by as much as 50% due to adverse selection and moral hazard.

[3] The data source from current year-to-date national summary of summary reports, http://www.rma.usda.gov/data/sob.html

In response to low participation, in 1994 the Congress attempted to link insurance to other USDA benefits and further increased premium subsidies (Glauber, 2012). As a result, the Crop Insurance Reform Act of 1994 was enacted and provided coverage starting at a basic level. Catastrophic risk protection (CAT) was fully subsidized but required producers to participate in commodity price support. A series of farm programs followed these developments. Under the incentive of the Reform Act, enrollment in buy-up coverage strongly increased during the late 1990s. To further stimulate participation, Congress later updated the Reform Act to include greater premium subsidies in 1999 and 2000. As shown in figure 1.1, the acres enrolled in the crop insurance program increased from 182 million areas in 1998 to over 296.2 million in 2013 -- a 62.7% increase in 15 years. Additionally, total liabilities rose to $123.4 billion in 2013 from $44.3 billion (figure 1.2), almost a tripling in as short as 8 years.

Premium Subsidy in Crop Insurance

Crop insurance is different from many other forms of insurance in that the government has to entice people with subsidies to buy it. This kind of stimulus is not required for many other types of low probability high consequence insurance. For example, Eisner and Strotz (1961) found that people tend to pay far more for flight insurance than the breakeven cost of the seller. Stimulating such a substantial growth in crop insurance participation is costly. Each year the federal government subsidizes farmers, on average, $7 billion from 2011 through 2013 (shown in Figure 1.3). In all, premium, administrative and operating cost subsidies constitute most of the costs of the U.S. crop insurance programs. For example in 2008, roughly 60 percent of premiums (more than $5.5 billion) were paid to insured producers. Additionally, roughly $2 billion in administrative and operating subsidies was paid to the private companies that sell and service insurance policies.[4]

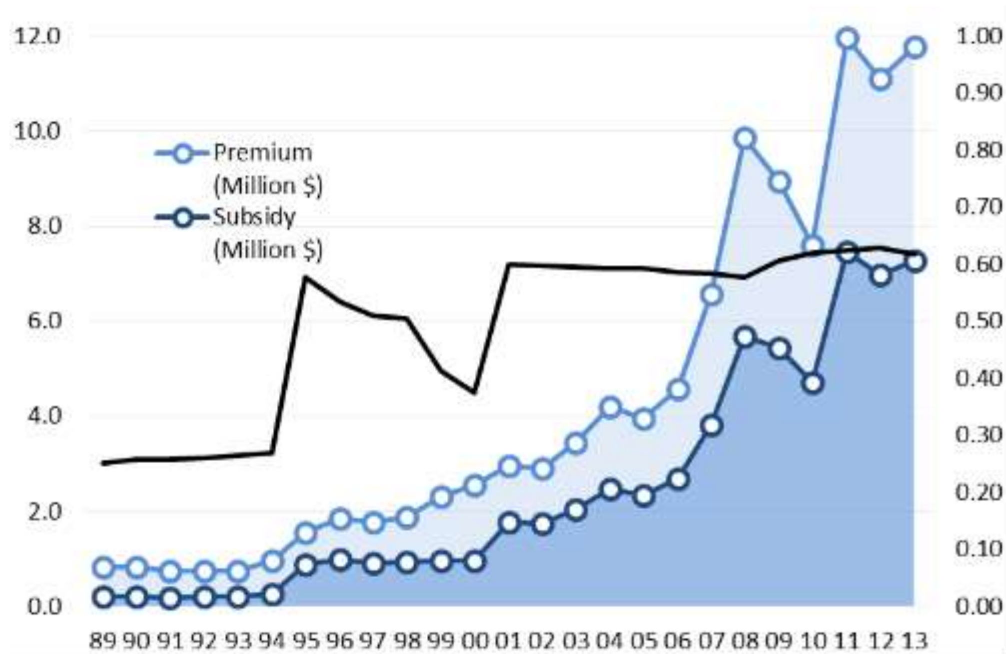

Figure 1.3 Premiums, Subsidy and Subsidy Rate in Crop Insurance From 1989 to 2013[5]

It is widely agreed upon in the academic literature that increased participation in crop insurance program requires an increase in premium subsidies; and without adequate subsidies, producers are not likely to buy crop insurance (Coble and Barnett, 2012; Glauber, 2004; Goodwin and Smith, 2012; Glauber, 2012). Goodwin, Coble, and Knight

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[4] Data source from Risk Management of USDA, http://www.ers.usda.gov/topics/farm-practices-management/risk-management/government-programs-risk.aspx#.UXtRu7WG3YQ

[5] Data source from current year-to-date national summary of summary reports, http://www.rma.usda.gov/data/sob.html

found that the demand for crop insurance is inelastic at low with respect to premium. In addition, the marginal costs per acre for enrollment into the program are high relative to other lines of insurance, which causes a greater level of premium subsidies to achieve politically acceptable participation rate (Glauber, 2004).

Because crop insurance is subsidized it is insightful to view both the official actuarial loss ratio which shows how well rate are set and producer loss ratio which offers a more insightful perspective in terms of producer benefits. The loss ratio, equal to the indemnity divided by premiums paid by producers, still remains high in the recent decade (the black line in Figure 1.4). An actuarial fair program would have an average loss ratio of 1.0. It unveils the problem completely when indemnities are compared to the adjusted premium (total premium minus premium subsidy): each dollar paid by farmers receives $2.67 in indemnity repayments in 2013 (the red line in Figure 1.4).

So far as we can see the crop insurance that I have been discussing is nothing but an “income transfer policy” (pp490, Goodwin and Smith, 2012) The financial burden on taxpayers also makes it difficult to replicate the insurance program in other countries, not to mention the market distortion crop insurance may cause (Goodwin and Smith, 2012). Ultimately one may ask: why does crop insurance need such high subsidies?

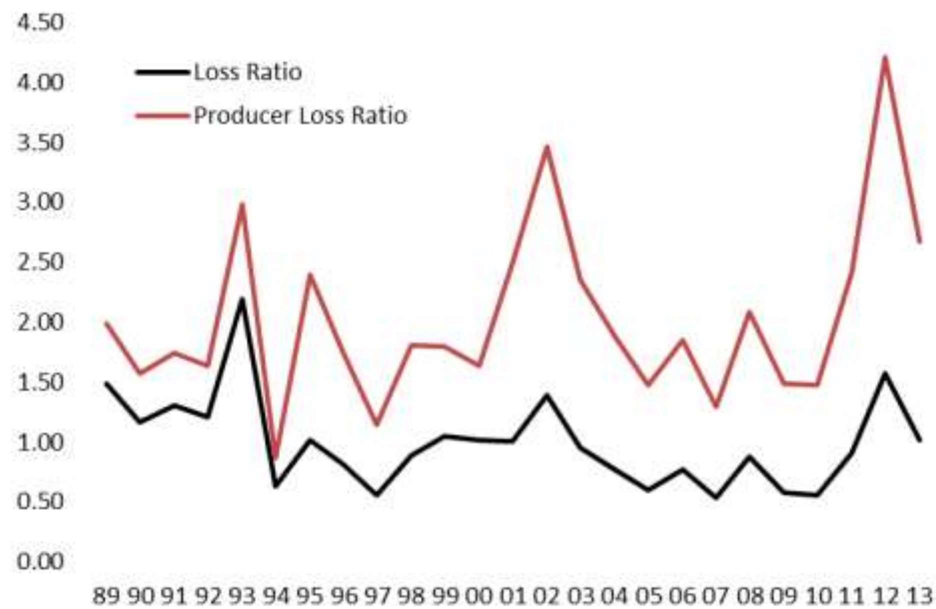

Figure 1.4 Loss Ratio and Producer Loss Ratio in Crop Insurance from 1989 to 2013[6]

Normative vs Behavioral

Numerous research projects have been motivated by an attempt to explain why crop insurance requires such significant subsidization. Most of the research concerning crop insurance demand is based on normative models of choice, such as expected utility theory and Bayesian updating. But increasing empirical evidence suggests that normative models cannot explain individual choices adequately (Camerer and Kunreuther, 1989). Also, people tend to exhibit certain biases in the perception of risks. Psychology is being increasingly applied to economics research as market behaviors cannot be adequately explained through traditional economic theories. It is suggested that both economic factors and psychology should be considered when an individual's insurance purchase is

[6] The data source from current year-to-date national summary of summary reports, http://www.rma.usda.gov/data/sob.html

studied. Camerer and Kunreuther (1989) also argued that while normative models are less identifiable, laboratory experiments and surveys can provide deep insight into individual decision making process and help design more effective public policies.

Cognitive Errors in Crop Insurance Purchase

Policy makers and researchers have frequently questioned whether there are cognitive errors made by producers when they are considering participation in crop insurance programs. Further, could these biases affect the desirability of crop insurance? Several papers have addressed cognitive bias in other lines of insurance (McClelland et al., 1993) but none have specifically addressed cognitive bias with crop insurance.

The objective of this research is to evaluate whether cognitive bias is a viable explanation of why farmers refrain from purchasing crop insurance. To do so, I conducted a series of experiments designed to identify two plausible cognitive biases in a simplified setting related to raw crop production, event probability assessment and perception of loss.

CHAPTER II

LITERATURE REVIEW

Risk Reference

Sitkin and Weingart (1995) assert that taking actions involving risks is influenced by both risk perception and risk attitude. Expected Utility theory (EU) is a long asserted theory of decision making under risk. Daniel Bernoulli (1954) first introduced an EU hypothesis in 1738 to address the St. Petersburg paradox which argues that expected values are infinite due to a feature of lack of upper bounds in some probability distributions. Later, Von Neumann and Morgenstern (1947) formally proposed a theorem of EU and proved that any individual whose preferences satisfy the four following axioms has a utility function: completeness, transitivity, continuity, and Archimedean property. In the theorem, a finite set of *n* mutually exclusive outcomes ($a_i \in A$) each occurs with probability p_i. The decision maker observes two (or more) compound lottery choices X and Y expressed as: $X = \sum p_i a_i$ and $Y = \sum p_j a_i \;\; i \neq j$ For a given individual, there exists such a utility function that satisfies the statement: $X \prec Y$, if and only if, $E(u(X)) < E(u(Y))$, where $E(u(X))$ represents the expected utility :
$E(u(p_1 a_1 + \cdots + p_n a_n)) = p_1 u(a_1) + ... + p_n u(a_n)$.

Risk preferences are generally divided into three categories: risk averse, risk neural and risk seeking. However, despite its wide application, expected utility theory is faced with challenges for example, from prospect theory.

Alternatively, prospect theory provides a more flexible model of risk behavior than EU (Barberis, 2013). Kahneman and Tversky (1979) proposed prospect theory in four components:

(i) Reference dependence - people have reference points to value gains and losses when evaluating risks.

(ii) Loss aversion - concave in gains and convex in losses; in other words, the disutility from losing an amount of money is larger than the happiness from gaining the same amount of money.

(iii) Diminishing sensitivity - people tend to be risk averse over moderate probability gains but risk seeking over losses.

(iv) Probability weighting - overestimating low probabilities and underestimating high probabilities.

Over the last few decades, researchers have attempted to apply prospect theory to economic situations such as insurance. Using insurance purchase data from a large home insurance company, Sydnor (2010) found that households are willing to pay higher premiums to purchase a lower deductible policy. This sounds unreasonable but can be explained by the use of prospect theory. Sydnor (2010) suggested an explanation based on the probability weighting in prospect theory. A household is inclined to overestimate the low-probability event under the force of unbalanced probability weighting. Due to this overwhelming concern about claims in tail events, the household would readily pay a higher premium to prevent from an extreme event. Barseghyan et al. (2012) found evidence suggesting that probability weighting plays a vital role in individual decisions when analyzing insurance deductible choices.

There are also some other violations of EU, for example, the violation of "independence axiom". This axiom states that the utility and the probability of outcome are independent and should first be evaluated separately and then multiplied by each other. Machina (1982) mathematically demonstrated that the results of expected utility analysis do not necessarily rely on the "independent axiom", which means that the utility and the probability have an interactive impact mutually; for example, Camerer (1989) explains how the independence axiom is inconsistent with some realistic situations where people may overestimate the probability of winning a lottery because of the positive utility like a huge amount of unexpected bonus it would bring in while underestimating the chance of having their houses ruined by an earthquake because of the negative utility like financial loss it would cause.

Weber and Camerer (1987) relaxed this assumption and presented a modified model allowing interaction between outcomes and probabilities.

Risk perception and subjective probability

Risk perception

The normative model and alternative theories supplementing the expected utility theory for risk preference are far from enough to understand how people make decisions under risky circumstances. Risk perception is another important contributor to influence individual's risky decision.

The risk in our world is perceived by individual, and thus the degree of risk perceived of the same event may vary from individual to individual. Risk perception is the process where people make a risk judgment subjectively. Subjective risk assessment may provide a deeper understanding of what drives decision making under risk. The study of risk perception began to boom during the early 1980's when the public perceived high risks from nuclear power while experts regarded it as a low-risk issue (Drottz-Sjöberg, 1991).

Weber (2001) reviewed three approaches to investigate risk perception: the axiomatic measurement paradigm, the social-cultural paradigm, and the psychometric paradigm. Axiomatic measurement paradigm focuses on the way people transform the objective information subjectively to perceive the effect of risks on their daily life. Within social-cultural paradigm study, the variable of dissimilarity between groups or cultures on risk perceptions is examined. The psychometric paradigm relates people's reactions to risky situations to emotional fluctuation that affect the assessment of riskiness of practical environment in ways that are in odds with their rational and objective judgments. Slovic and Peters (2006) refer to risk perception as a feeling or affection which is our instinctive reactions to danger. They further suggest that risk as a feeling interpretation is not enough; in other situations affect would lead us to judge probabilities in inefficient ways. In the other hand, using probability principles to perceive risks would be beneficial to help decision makers manage and address complex risks.

Subjective Probability

Because individual risk perceptions are subjective, researchers must attempt to elicit the risk perception from subjects. Subjective probability is the way to measure a person's belief towards risks or in other words, risk perception, from the perspective of the personalistic school of probability (Hogarth, 1975). Fishburn (1986) argued that the theory of subjective probability attempts to connect inherent dispositions towards uncertainty and quantitative probability. Grisley and Kellogg (1983) provided a more elaborate definition of subjective probability: a subjective probability is the decision maker's beliefs concerning the probability of an uncertain outcome. They further state that a subjective probability distribution is individualistic and can neither be proven right or wrong. From a statistical standpoint, each subjective probability is subject to a certain distribution. If a decision maker's subjective probability distribution can be measured, then researchers can better understand the manner in which individuals perceive specified risks.

Few economic studies have focused on eliciting individual subjective probability. Grisley and Kellogg (1983) conducted a survey in northern Thailand where they attempted to elicit farmers' subjective probability towards agricultural decisions such as crop production and marketing. Their results demonstrated that it is feasible to obtain farmers' subjective probability distributions directly for economic indicators, such as crop yields, prices, and net incomes. They further emphasized that the distributions they elicited can be thought of as realistic and logical in general. Coble et al. (2011) utilized elicitation and aggregation techniques to guide participants to acquire accurate subjective estimates of unknown probabilities. Their findings suggested that subjective probability assessment is feasible to elicit, at least in a laboratory setting.

Bayesian updating

Bayesian updating is another normative model that is extensively used by economists to examine decisions under uncertainty. This approach posits that people are able to update their information and change their subjective probability beliefs and its distribution according to the Bayes' theorem. Bayes' theorem refers to the relationship between the individual's posterior beliefs about the probabilities of events A and B occurring given, a set of priors. The most common mathematical statement of Bayes Rule is $P(A \mid B) = \frac{P(B \mid A)P(A)}{P(B)}$. Here, the conditional probability A given B represents the individual's posterior beliefs derived from the individual's priors $P(A)$, $P(B)$ and the likelihood function $P(B \mid A)$.

However, normative models, including Bayesian updating, have difficulty in adequately explaining the human behavior observed in the real world. Camerer et al. (2005) criticized Bayesian updating as "unlikely to be correct descriptively" since it is based on a stack of assumptions that are cognitively unrealistic, such as, a requirement of a separation between the probabilities of previous-judged events, and no effects of the order of information received. Gilboa et al. (2008) stated that although Bayesian updating fails to suggest a feasible model of prior belief formation; it illustrates how these beliefs are updated according to Bayes' rule. Furthermore, there have been some experimental studies in economics and psychology on whether or how people update information according to Bayes' rule. Kahneman and Tversky (1971 and 1973) found that people update subjective probability of an uncertain event subject to its parent population, which is known as representativeness heuristic[7]. Grether (1980) found experimental evidence to support the idea that people tend to ignore previous information when a belief is formed, which is contrary to the Bayesian rule. But Offerman and Sonnemans (2004) determined that people indeed exhibit Bayesian behaviors and nevertheless tend to overreact beyond Bayesian updating as a result of showing the hot hand effect or the recency effect.

Biases in Risk Perception and Its Application in Insurance

Decisions making under uncertainty are dependent on the "belief" in the perceived risks or subjective probability towards risky events. I raise the questions; what determines an individual's beliefs, and what impacts an individual's subjective assessments of the probability of uncertain events? In a famous paper by Tversky and Kahneman (1974), they asserted that people tend to rely on a few heuristic principles which reduce difficulty or complexity of assessing probability and therefore simplify the process of predicting outcomes. A heuristic principle is a rule of thumb, which is generally useful, but sometimes may lead to systematic decision errors. In their study, Tverskey and Kahneman described three of heuristics: representativeness, availability, and adjustment and anchoring. Tversky and Kahneman also provided a plausible explanation--a lack of appropriate code-- for the failure of people to learn statistical rules in the lifelong experiences to avoid cognitive biases and detect these biases in their assessments of probability. Tversky and Kahneman (1974) suggested that certain biases in risk

[7] By the definition of proposed by Tversky and Kahneman (1974), the representativeness heuristic leads people to judge the probability of an uncertain event, “by the degree to which it: (i) is similar in essential characteristics to its parent population; and (ii) reflects the salient features of the process by which it is generated” (p.430).

perception or probability assessment are uncovered when these heuristic principles are employed. That is to say heuristic principles are able to account for some cognitive biases.

Schkade and Johnson (1989) analyzed results from a series of gamble experiments to explore bias using methods of both probability and certainty equivalence. They concluded that subjects adopting heuristic response strategies are more likely to show significant biases than those using expectation skills. Schwarz and Strack (1991) point out that Kahneman and Tversky's heuristics could be considered as primary evidence to end the problem of social psychology in terms of fallacies and errors in information processing. Gigerenzer (1996) had some different voices stating that most "errors" in probability judgment are not violations of normative probability models, but ignorance of conceptual distinctions of the fundamentals of probability theory.

In general, cognitive biases have been a focus of study for many years. In recent years a variety of new cognitive biases have been identified and increasingly applied in behavioral economics models. Among them, the "gambler's fallacy" and "hot hand effect" have been more frequently studied than other cognitive fallacies.

Gambler's fallacy & hot hand effect

Gambler's Fallacy

Although gambler's fallacy is said to be an elementary and intuitive judgmental error by Tversky and Kahneman (1974), this fallacy commonly occurs in various occasions. A body of literature has developed in an attempt to interpret whyhis error is made. The heart of the gambler's fallacy is a misinterpretation of the fairness of chance (Tversky and Kahneman, 1971). The gambler has such a feeling that the fairness of a game, like coin flipping, enables him to expect that any deviation in one direction would be offset or corrected by a corresponding deviation in the opposite direction in the next turn, making the overall sequence subject to the underlying probability distribution (in the "coin flipping" case, the sequence is binomially distributed and people tend to overestimate the balance of the sequence). However, based on statistical principles, any two events in this game are statistically independent; in other words, past experience has nothing to with the odds of occurrence of upcoming events in a random series. This inability of detecting randomness is known as "the belief in the law of small numbers" (Tversky and Kahneman, 1971). In statistics, the law of larger numbers tells us that a large amount of samples would be reliably representative of the population from which they are drawn. The law of small numbers asserts that the law of larger numbers is also at work even when the size of sample pool becomes very small.

Clotfelter and Cook (1993) provided evidence that behaviors of lottery players are consistent with the gambler's fallacy. Altmann and Burns (2005) conducted an experiment to examine how different lengths of streaks will bias probability perception. In their experiment, participants were experiencing a series of heads and tails generated by a simulated coin with a 75% or 60% chance to be heads. They found a quadratic trend of prediction of outcomes according to increased streak lengths. At the beginning when a streak of certain heads (two or three) shows up, subjects exhibited a positive recency effect; a negative recency trend was discovered just before reverting back to positive recency in the end. In this study, Altmann and Burns utilized a memory model as an explanation of the experiment results. Barron and Leider (2010) carried out an interesting study specifically on how people acquire information to make decision, either by personal experience or abstract description, exerts an effect on outcome predictions in the future. The results revealed that subjects appeared to employ the Gambler's fallacy when experiencing outcomes sequentially; and the Gambler's fallacy was weakened when outcomes are revealed to subjects all at once.

Hot Hand

"Hot hand" often reminds us of the times that some of the best basketball players, like Michael Jordan or Kobe Bryant, experienced a "shooting streak" and produced phenomenal performances in games. The belief in "hot hand" or "streak shooting" is commonly shared by fans, basketball players, or even coaches. Gilovich et al. (1985) originated a wave of research of hot hand phenomenon. They used field-goal data from 9 members of the Philadelphia 76ers during 1980-1981 season and free-throw data from 9 players in the Boston Celtics during the 1980-1981 and the 191-1982 seasons and found that the outcomes of both field goals and free throws are independent of previous attempts. Later Larkey, Smith, and Kadane (1989) questioned the validity of their statistical analysis. Tversky and Gilovich (1989) latter defended their opinion by saying that there is no evidence for hot hand, even in a local (short-lived) phenomenon case: the overall mean of correlation is just 0.02. Koehler and Conley (2003) examined a unique setting where 23 shooters in the NBA Long Shootout contests, 1994-1997, were used to test the hypothesis of the hot hand effect. The results provided no evidence to support the hot hand even for players who were "on fire". So they concluded that the belief in the "hot hand" by basketball players is a description of historical performance rather than a predictor for future behavior.

On the other hand, Gilden and Wilson (1995) found some evidence of the hot hand in golf and darts or alternatively cold hand, or in their words, “in a streak”. More specifically, they asserted that a streak is a general property of skilled performance. Dorsey-Palmateer and Smith (2004) found supportive evidence in bowling using the real data of 43 plays in Professional Bowlers Association (PBA) during the 2002-2003 season.

Hot hand seems to be a misconception of randomness. Gilovich et al. (1985) suggested that the hot hand belief might be caused by a memory bias. Streaks are more memorable than alternations, so the probability of a streak occurring will be overestimated by observer. Another explanation is that people tend to believe there is a predictable pattern in a series of random and independent events even when one does not (Tversky and Gilovich, 1989).

Some researchers have made use of simulations to study hot hand behavior. For example, Miyoshi (2000) simulated shooting records based on Bernoulli trials where successful shots were manipulated to follow streaks of hot-hand attempts. The results indicated that the tests run by Gilovich et al. (1985) are not significantly sensitive to detect the hot-hand effect (only 12% of hot hand phenomenon was discovered in the test). Burns (2004) generated a program based on the Markov process. Basketball shooting success was simulated using several parameters, including a hot hand belief. Only 43 out of 4752 (48×99) pairs of simulation trials resulted in negative advantage scores. Therefore, they concluded that relying on the hot hand is an efficient strategy as this behavior gains more scores.

Differences between Hot Hand and Gambler's Fallacy

In many studies, the gambler's fallacy and hot hand effect are discussed together. These two fallacies both refer to a misconception of chance based on representativeness (Gilovich, Vallone, and Tversky, 1985). Rabin (2002) proposed a clear explanation with respect to representativeness using a well-known "run" experiment to explain how the two different beliefs relate to a misconception of chance. Some individuals may think of this urn as a small urn and a streak of balls with one color would sufficiently decrease the probability of its appearance in the next draw. However, a small urn, as Rabin proposed, could lead us to the other side as well; a streak of balls with one color in such a small urn would force people to reconsider the proportion of this color in it. Thus, as more and more balls with one color show up, the expectation of presence of the same color in the next time will be increased. Unfortunately, Rabin did not determine a general conclusion to clarify how these two beliefs of Bayesian updating theories interact. However, this interpretation is questioned by Ayton and Fischer (2004). They argued that the representativeness is incomplete, and possibly erroneous to account for the two opposite reactions to randomness. The experimental results from a simulated roulette wheel game highlights that subjects simultaneously show both hot hand effect and gambler's fallacy respectively for statistically differentiable sequences at the same time. They suggested that both effects can occur as people come across a misconception of randomness.

Croson and Sundali (2005) made a statement that gambler's fallacy occurs when a non-autocorrelated random sequence is perceived as a relationship of negative autocorrelation, while hot hand effect is a belief that non-autocorrelated random sequence has a positive autocorrelation. These definitions of gambler's fallacy and hot hand provide a statistical perspective that can also be found in other related literature. Croson and Sundali (2005) attempted to identify these two biases separately within a given individual player in a field experiment (roulette games in casino), in order to identify the interaction between them. They concluded that a "significant and positive" correlation between gambler's fallacy and hot hand effect within individuals who behave in consistence with both fallacious beliefs. A shared cause for the two cognitive biases however, was not discovered in their study.

Other than the statistical distinction between two fallacies, some other subtle but important differences are found. In Burns and Corpus' study (2004), experimental results demonstrated that when events are perceived to be nonrandom, going with streaks should bring in better outcomes than against streaks; in other words, people tend to believe in a "hand hot" when they believe the sequence of outcomes is nonrandom since this is a dominant strategy compared to when events are judged to be random. However, their experimental results also support that randomness of an event may exert a positive effect on people's utilization of the gambler's fallacy. Nickerson (2002) reported similar results. Moreover, hot hand believers also believe that "hot" applies only to a particular person, and not for a particular outcome (Croson and Sundali, 2005). Ayton and Fischer (2004) utilized computer software to simulate the actions of a hypothetical but schematic roulette wheel, and recorded subject responses and level of confidence in probability judgment and argued that subjects believe that an individual can become "hot", but an inanimate device cannot. , In the last game of general discussion, Ayton and Fischer tried some other explanations of these two phenomena. Representativeness could account for both cognitive biases effectively, though not complete; Life experiences—negative or positive recent experience in daily life—could also be a cause of both erroneous belief In addition, this article concluded that people indeed exhibit a fallible belief of hot hand or gambler's fallacy in terms of the randomness concept and suggested that people would use a means of encoding to reduce the difficulty of identifying the randomness of a series.

A simple conclusion can be drawn that an individuals' understanding of randomness of a sequence of successive events plays a vital role in generating their beliefs about these two fallacies.

Application of cognitive biases in insurance study

The decision making process of insurance purchase, where consumers are seen as judging probability for risks, offers a potentially interesting environment where cognitive biases can occur. However, few research studies have addressed the issues specifically concerning the interaction between cognitive heuristics or bias and insurance purchase behavior. Existing research has revealed some interesting findings and also led to further study of cognitive bias in the context of decision-making in crop insurance purchase.

Kunreuther et al. (1978) showed that flood insurance is not popular in hazard-prone areas even when it is highly subsidized or its price is driven far below the actuarially fair value. Camerer and Kunreuther (1989) utilized a double-oral auction experiment to investigate the effect of past losses on the impending behavior by setting up the hypothesis of gambler's fallacy. The authors, however, found no strong support for the theory from their regression results. Johnson et al. (1993) made a summary after reviewing several surveys and studies regarding insurance decisions that consumers' insurance decisions is affected by the perceived risk, and these decisions are inconsistent with basic principles of probability. McClelland et al. (1993) constructed an experiment where a Vickrey auction was used to investigate insurance purchase behavior in the presence of low-probability risk. The results in the experiments reveal that people tend to employ either one of the two opposite strategies when confronted with low-probability hazards: ignoring it or worrying too much about it. Neither Johnson et al or McClelland et al. however, provided further explanations for these distorted perceptions of risks during the insurance decision making process. Experimental results in Shapira and Venezia's research (2008) indicated that anchoring heuristic principles is an explanation for this misperception of risks in insurance buying. The people tend to anchor on the size of the deductible but fail to adjust price upward effectively to consider the fact that they just own a little chance to claim the deductible, which distort the judgment in their payments. Galarza and Carter (2010) found evidence of the "hot-hand"[8] effect in their analysis that insurance buyers tend to underestimate the autocorrelation of the sequence of "bad" years. In Galarza and Carter's study on the full-coverage insurance policy, it is found that amateur subjects are prone to underestimate the value of a deductible policy.

Research on Crop Insurance Demand

In the United States, the federal government started to provide farmers with risk management programs in the 1930's. In the last decades, several changes in insurance legislation have resulted in the steady growth in federal crop insurance participation.

Goodwin (1993) established an empirical model to investigate factors which affect the demand for insurance by using county data in Ohio. The results suggested that

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[8] Given the description of the "hot-hand" effect in their article, the phenomenon of this "hot hand" is essentially consistent with gambler's fallacy which is in accordance with foresaid definitions of hot hand and gambler's fallacy.

raising premium rates might aggravate the severity of adverse selection[9] problems and greatly increase the possibility of inflating the industry loss ratio since low loss-risks enjoy a significantly more elastic demand than high loss-risks. Smith and Baquet (1996) modelled Montana wheat farmers' participation decisions and coverage-level selections separately and found that increases in premium rates do not exert an apparent effect on participation but materially depress the coverage level. Another comment based on the results is that increasing overall premium rates inefficiently reduce the loss ratios as adverse selection would limit its efficacy, just like what Goodwin (1993) suggested above. Coble et al. (1996) empirically made use of farm-level panel data to identify what effects certain variables, especially the variance of return in insurance, have on insurance demand. Their estimation results indicated that growers who are willing to receive frequent indemnities with smaller coverage are expected to more readily be insured than those who like indemnities that are rare but large. Serra et al. (2003) conducted research on changes in demand for crop insurance during the 1990's. A basket of variables, including chemical input use, wealth of farms, and expected net income per acre, were put in the right-hand side of the regression model to explain the insurance demand. Focusing on the demand elasticity they conclude that the crop insurance purchase decision represents an inelastic response to premium rates changes. Sherrick (2004) carried out a mail survey of Midwestern U.S. farmers and analyze personal, business and other factors influencing crop insurance purchase decisions. The results revealed that farmers who are more highly leveraged, less wealthy, and operate larger farms with

[9] The adverse selection refers to a phenomenon that individuals with larger risk of loss tend to buy more insurance. In the case of crop insurance, farmers with larger risk of loss are willing to buy insurance so as to insurance companies potentially undertake more financial risks.

higher perceived risks show a higher likelihood of crop insurance purchase and are more willing to run business under revenue protection versus yield protection. Shaik et al. (2008) conducted a survey in four states on four main crops: corn, soybeans, cotton and grain sorghum to study the decision whether to purchase yield or revenue crop insurance. The elasticity of yield insurance demand estimated in this study is -0.40, consistent with the estimates in prior literature and the elasticity for revenue demand insurance is estimated to be slightly higher (-0.88). Their results also showed that farmers who have a high expectation of yields or revenues are less likely to purchase insurance products.

These articles mentioned here, despite diversities in their explanatory variables, all analyze the insurance demand in terms of objective properties, like farmland size, farmer's initial wealth and premium rate across insurance programs. None of the studies, however, attempts to explain the demand from an individual insurance buyer's perspective: a subjective preference and perception towards risks of crop insurance purchase.

CHAPTER III

CONCEPTUAL FRAMEWORK

Conceptual Model

Participation in a crop insurance program could be viewed as a dichotomous choice, whether to be insured or uninsured. Under this view the alternative coverage levels are disregarded. It is assumed that farmers are expected utility maximizers. An individual farmer will choose by comparing the expected utility with insurance, EU_{Ii} to the expected utility without insurance EU_{Ni}. Since farmers' risk preferences and perceptions are difficult to be measured directly, certain observable factors influencing the distribution and the evaluation of expected utility are used to address the choice problem. The model of crop insurance participation put forward by Coble et al. (1996) is used. The expected utility of being insured EU_{Ii} or not being insured EU_{Ni} could be written as functions of a vector of factors,

$$EU_{Ii} = \boldsymbol{\beta}_I{}'\mathbf{x}_i \tag{3.1}$$

$$EU_{Ni} = \boldsymbol{\beta}_N{}'\mathbf{x}_i \tag{3.2}$$

where $\boldsymbol{\beta}_N$ is a vector of estimated impacts from the influencing factors for farmers that do not purchase insurance, $\boldsymbol{\beta}_I$ is a vector of estimated impacts from influencing factors for farmers that purchase insurance, $\mathbf{x}_i$ is a vector of influencing factors on individual i.

The expected utility difference between the two choices, insured and uninsured, could be expressed as,

$$EU_{Ii} - EU_{Ni} = \boldsymbol{\beta}_I{}'\mathbf{x}_i - \boldsymbol{\beta}_N{}'\mathbf{x}_i \,? \\ = \boldsymbol{\lambda}'\mathbf{x}_i \tag{3.3}$$

where $\boldsymbol{\lambda}' = (\boldsymbol{\beta}_I{}' - \boldsymbol{\beta}_N{}')$. A rational individual decides to purchase insurance if $EU_{Ii} - EU_{Ni} > 0$; otherwise no purchase is made.

A further examination of insurance purchase decision is needed to determine variables in $\mathbf{x}_i$ vector. The expected utility for the insured and uninsured situations can be written as follows,

$$EU_{Ni} = \int_{\theta_{min}}^{\theta_{max}} U[W_0 + \{MR(\theta)\}A]g(\theta)d\theta \tag{3.4}$$

And

$$EU_{Ii} = \int_{\theta_{min}}^{\theta^*} U[W_0 + \{MR(\theta) + I(\theta) - \tau\}A]g(\theta)d\theta \\ + \int_{\theta^*}^{\theta_{max}} U[W_0 + \{MR(\theta) - \tau\}A]g(\theta)d\theta \tag{3.5}$$

where $MR(\theta)$ stands for market return, $I(\theta)$ is an indemnity function, τ is the premium, A is planted acres, W_0 represents initial wealth, and $g(\theta)$ is a probability density function of θ, a random state of nature, and note that θ^* means the state of nature which results in a guaranteed level of yield. Market return is equal to market price times yield, minus cost. Here market return and indemnity are both functions of θ.

Based on equations (4) and (5), Coble et al. (1996) constructed an optimal participation choice model for a risk-averse person where the choice variable is a function of parameters including wealth, moments of the random variables $MR(\theta)$ and $I(\theta)$, and individual's risk preference:

$$\delta_i^*(W_0, \mu_i(MR), \mu_i(RI), A, r) \tag{3.6}$$

where $\mu_i(MR)$ and $\mu_i(RI)$ are respectively the moments of individual i 's market return distribution and return to insurance ($RI = I(\theta) - \tau$); r is the risk-aversion coefficient, determined by Arrow-Pratt absolute risk-aversion function.

Optimal risk-taking behavior relies on both risk preference and risk perception. The individual risk preference is measured by risk aversion coefficient r and initial wealth W_0 [10]. The individual risk perception of risk, especially of crop revenue in my experiment, is determined by subjective probability of random revenue. When we examine individual purchase choice, a farmer would formulate their own subjective distribution of revenue to predict the risks of revenue of loss. In equation (6) $\mu_i(MR)$, the moments of market return[11] or revenue, are the influencing variables. Therefore, the subjective moments of revenue, mean $\mu_{\mathrm{Re}v}$ and standard deviation $\sigma_{\mathrm{Re}v}$, are used to explain the consumer behavior in crop insurance purchase in my case as well. In the experiment, a subjective probability of revenue loss $prob$ accounting for the moments of revenue was recorded from subjects and included into the regression function.

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[10] The initial wealth are assumed the same across individuals in my experiment, so it is not regarded as a factor variable in the conceptual model.

[11] Market return of crop, expressed as crop yield times crop price, is an equivalent to crop revenue

Equation (6) is foundation of this research. As discussed above, $prob$ is the key factor variable in my conceptual model. Therefore, a model allowing for behavioral anomalies which are reflected in the variances of subjective probability distribution of revenue is formulated

$$C = f(r, prob, streaks) \tag{3.7}$$

Where purchase choice C is binary category, buying or not buying. The purchase choice is a function of risk preference[12], probability of loss $prob$ and cognitive bias factors $streaks$. $prob$ is the subjective probability of loss or revenue risks which is an equivalent of $\mu_i(MR)$ in equation (3.6). $streaks$ is created to account for the effect of cognitive bias on purchase choice.

Hypotheses

Hypothesis One: Hot (Cold) Hand Effect.

If the revenues have been above the indemnity level over recent years, farmers are less likely to purchase insurance in the next year based on their belief of "hot hand". Conversely, if the revenues have been already standing below the indemnity level for years, farmers are more likely to purchase insurance in the next year based on the belief of "cold hand".

Since the revenue is on a good streak, farmers would prefer to think that the revenue outcomes have a "hot hand" and they expect a good harvest in the next year.

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[12] Theoretically individual risk preference is the influencing factor of purchase choice. But it is not included into the independent variables of the regression empirically since the regression was ran individually and risk preference keeps constant within individual.

Importantly, this reflects a perceived positive autocorrelation of revenues when in fact there is none or a higher positive autocorrelation in case of low positive autocorrelation. A “hot hand” effect occurs when people’s subjective probability for satisfactory revenue in next year is increased because of their consideration of a series of successive years of satisfactory revenue in a short term as a trend which is believed to maintain in the next year. However, in fact this is simply an occasion of well-ordered randomness. If the revenue is on a bad streak, on the other hand, an expectation of positive autocorrelation would lead farmers to increase the probability of loss in the next year and tend to buy more insurance.

Hypothesis Two: Gambler’s Fallacy

If the revenues have been below the indemnity level consecutively in recent years, farmers are less likely to buy insurance in the next year. Or on the other side, farmers are more likely to buy insurance in the next year if the revenues have been above the indemnity level for several years.

Since the past years’ revenues have been below farmers’ expectations, they have a tendency to believe that they cannot be so unlucky that a bad outcome will occur in the subsequent year. Conversely, if they have been experiencing a streak of years with good revenues, they would suppose that good luck is running out and bad revenue is probably around the corner.

Data Analysis

Both descriptive statistics and regression analysis were employed in this study. Descriptive statistics such as means, frequencies, line chart and bar chart show a general description of subjects' performance in the experiment such as their understanding of histogram and autocorrelation, their perception on potential revenue risk and their willingness to purchase insurance. A binary logit regression analysis was used to examine the subjective probability and cognitive bias that influence subjects' decisions to engage in insurance protection.

Binary logistic model

In many cases, the researchers generate models where the dependent variable is categorical. In my study, the insurance purchase decision is a well-explained example which only involves two choices, buy it or not. The estimation method of Ordinary Least Square fails to provide reliable estimates in a regression with a binary dependent variable. Therefore, logistic regression could be considered as a feasible approach which takes into consideration that the dependent variable is categorical.

The basic model of the logit regression is expressed as follow:

$$P_i = probability(C_i = 1) = \frac{1}{1+e^{-(\beta_0+\beta_1 X_{1i}+...+\beta_k X_{ki})}} \tag{3.8}$$

Similarly,

$$1-P_i = probability(C_i = 0) = 1 - probability(C_i = 1) \tag{3.9}$$

$$= \frac{1}{1+e^{(\beta_0+\beta_1 X_{1i}+...+\beta_k X_{ki})}}$$

Dividing (1) by (2),

$$\frac{probability(C_i = 1)}{probability(C_i = 0)} = \frac{P_i}{1-P_i} = e^{(\beta_0+\beta_1 X_{1i}+...+\beta_k X_{ki})} \tag{3.10}$$

Where P_i is the probability that C_i takes the value of 1 and $1-P_i$ is the probability that C_i takes the value of 0. X_{ki} is the influencing factor and e is the exponential constant.

In my study the dependent variable is to buy insurance or not, taking value either 1 meaning willing to buy or 0 meaning unwilling to buy. As shown in (3.7), the influencing factors in the insurance demand regression include subjective probability and streak factors:

$$\ln[\frac{P(C_i=1)}{1-P(C_i=1)}] = \beta_0 + \beta_1(subjective\ probability\ of\ revenue) + \beta_2(streak\ factors) + \varepsilon_i \tag{3.11}$$

where ε_i is an error term subject to a normal distribution.

Experimental Economics

As discussed above, many researchers, like Clotfelter and Cook (1993), Ayton and Fischer (2004), and Burns and Corpus (2004), made use of real gambles to design experiments for pure cognitive research in psychology. Some researchers, based on the needs in their study field, tended to construct specified contexts in experiments to explore how cognitive thinking affect their decision making in the real world, like Camerer and Kunreuther (1989), Mcclelland et al. (1993). In terms of the goal in this research, the effect of certain cognitive biases on crop insurance purchase was to be investigated. In our experiment I created a crop insurance market where an actuarially fair priced insurance was offered to protect from revenue risks and subjects' willingness to pay for the insurance was elicited.

Lab experiments have been gaining increasing popularity among economists in recent decades and hundreds of articles based upon experimental methods were published each year (Levitt and List, 2007). Why would researchers like to make use of experimental methods to study research topics? In lab experiments, investigators can be able to influence the sets including prices, budgets and environment, and measure the effect of every single factor on behavior under the laboratory experimental context with the help of ceteris paribus observations of individual agents in the experiment (Levitt and List, 2007). It is difficult, for example, to observe individual's house insurance purchase behavior over many years and further to examine the effects of a catastrophe occurred in this year on the next year's insurance participation. However, it is comparatively easy to offer participants in the lab experiment exposures to risky situation in continuous periods and obtain their behavioral observations.

On the other hand, laboratory experiments have their shortcomings. One common criticism on laboratory methodology is that participants cannot adequately take a part in the experiment where the context is not sufficiently realistic, especially in terms of the effects of financial incentives on experiment (McClelland et al. 1993). For instance, the monetary gains and losses in the laboratory are trivial compared to, for instance, the real potential losses living in flood-prone area when investigating flood insurance purchase behavior. Nevertheless, there are some observations in the laboratory indicating that small monetary flows are capable of eliciting their true evaluation of risky events. Camerer and Hogarth (1999) discussed the effects of financial incentives depend on what the task is; in some tasks incentives increase performance but in many tasks incentives do not matter. They further stated that the scope of financial incentives does not change subjects' behaviors in a substantive way. Dickhaut et al. (2013) reported evidence that one can use low stakes experiments to produce choices that well-reflect decisions made in that same environment where stakes are much higher.

Other than the concerns about the effect of the scale of monetary incentives on experimental results, a found-money effect also distorts the outcomes of experiments (Laury and Holt, 2008). In Laury and Holt's experiment, to mitigate the found-money effect and make the loss more real to subjects, the participants were allowed to earn their initial endowments before they faced the risk task. Morone and Ozdemir (2006) employed the same strategy in their study in an effort to eliminate the effect of found-money.

A strong attribute of laboratory experiment is that an experiment conducted in a lab offers participants a relative calm environment and repeated experience with a single specified risk. This valuable idea is put forward by McClelland et al. (1993) and they explain that if subjects do not have the cognitive capability to deal with risk problems, we are unlikely to exclude the possibility that they will struggle cognitively to make a decision whether to worry about a risky event like a hazardous facility in their neighborhood under a more highly emotional circumstance. Even though laboratory experiments have advantages and disadvantages that we should take into consideration, in the final analysis, the only one core and fundamental question we are concerned with is whether the findings from the lab are reliable enough to be generalized into the real world and provide credible justifications outside of the laboratory. Numerous studies suggested that if various dimensions in laboratory experiments are manageable, the generalizability of lab data can be also attained (Levitt and List, 2007).

CHAPTER IV

THE CONDUCT OF THE EXPERIMENT AND EXPERIMENTAL DESIGN

This research was approved by the Institutional Review Board (14-048) for research of human subjects at Mississippi State University (see Appendix A). Our subjects were junior or senior undergraduate students and graduate students recruited from agricultural economics, business and science classes at Mississippi State University.

The experiment is Excel (Microsoft) based. All possible choices were recorded on the spreadsheets. After all decisions in all the rounds were made, the final score and accompanying payment were displayed at the top of the spreadsheet. At this time subjects also receive payments from the experimenters. Subjects were told that individual outcomes are independent of choices made by others. Each participant receives a payment for attending the experiment, regardless of participation level.

In this experiment, respondents participated in two consecutive games. To reduce the possibility of an anchoring effect, the order of the two games was changed each session. A total of 9 sessions were conducted and 96 subjects took part in this experiment. Each session began with an introductory talk (see Appendix A). The experimental introductions were read aloud and explained in detail. After the introduction, each individual completes a form of a Holt-Laury lottery choice task ((Holt and Laury, 2002) and then began the game.

Holt-Laury Lottery Choice Task

In Holt-Laury lottery choice task, subjects made 10 choices between option A and Option B and were to be paid one of the two amounts. In each question, Option A has a smaller variation and is considered “safe”, while Option B with a larger variation is considered “risky”. Each question differs in the probability of winning bigger rewards. A more detailed summary of the two options can be found at Table 4.1. Finally a real 10-sided die was thrown twice: the first throw determines which question would be used for the second throw and then the second throw decides which prize is to be paid. In question 1, for example, the higher prize is paid if the throw of die is 1 and the lower prize is paid when any other throw appears. For question 2, the higher prize is paid when the throw is 1 or 2 while the lower prize is paid for 3 through 10. The point at which subjects shift from "safe" to "risky" in lottery can be used to elicit their range of risk aversion. (For more detailed experiment instructions, see Appendix A)

Table 4.1 Risk Preference Decision Sheet

Question	Option A	Option B	Which Option Is preferred?
1	10% chance of $10.00, 90% chance of $8.00	10% chance of $19.00 90% chance of $1.00	
2	20% chance of $10.00, 80% chance of $8.00	20% chance of $19.00 80% chance of $1.00	
3	30% chance of $10.00, 70% chance of $8.00	30% chance of $19.00, 70% chance of 1.00	
4	40% chance of $10.00, 60% chance of $8.00	40% chance of $19.00, 60% chance of $1.00	
5	50% chance of $10.00, 50% chance of $8.00	50% chance of $19.00, 50% chance of $1.00	
6	60% chance of $10.00, 40% chance of $8.00	60% chance of $19.00, 40% chance of $1.00	
7	70% chance of $10.00, 30% chance of $8.00	70% chance of $19.00, 30% chance of $1.00	
8	80% chance of $10.00, 20% chance of $8.00	80% chance of $19.00, 20% chance of $1.00	
9	90% chance of $10.00, 10% chance of $8.00	90% chance of $19.00, 10% chance of $1.00	
10	100% chance of $10.00, 0% chance of $8.00	100% chance of $19.00, 0% chance of $1.00	

Table 4.2 shows expected payoff corresponding to each option of each question. These values are not shown to subjects.

Table 4.2 Expected Payoff

Question	Option A	Option B	Expected payoff difference
1	$8.20	$2.80	$5.40
2	$8.40	$4.60	$3.80
3	$8.60	$6.40	$2.20
4	$8.80	$8.20	$0.60
5	$9.00	$10.00	-$1.00
6	$9.20	$11.80	-$2.60
7	$9.40	$13.60	-$4.20
8	$9.60	$15.40	-$5.80
9	$9.80	$17.20	-$7.40
10	$10.00	$19.00	-$9.00

Two different experimental methods were used in two separate games. The first game is a dichotomous choice task, and the second one is a modified experiment adapted from a paper by Offerman and Sonnemans (2004).

Game One: Dichotomous Choice Task

In this task, each subject played a role of a farmer growing a crop. Like most crop farmers, subjects cannot control either weather, which has an effect on the yield, or the market price. The cost of planting crops was $90 per acre and the expected revenue was $100 per acre. Each farmer grew 100 acres as a total. Therefore, they were expected to earn $1000 in one harvest year.

To help subjects understand the revenue risks of crop production, they were presented with a histogram of 1000 observations (figure 4.1[13]) from the true distribution of revenue outcomes and were informed that the underlying distribution remains constant throughout the game. The outcome is distributed normally with a mean of 100 and a standard deviation of 20, but this piece of information was not revealed to subjects.

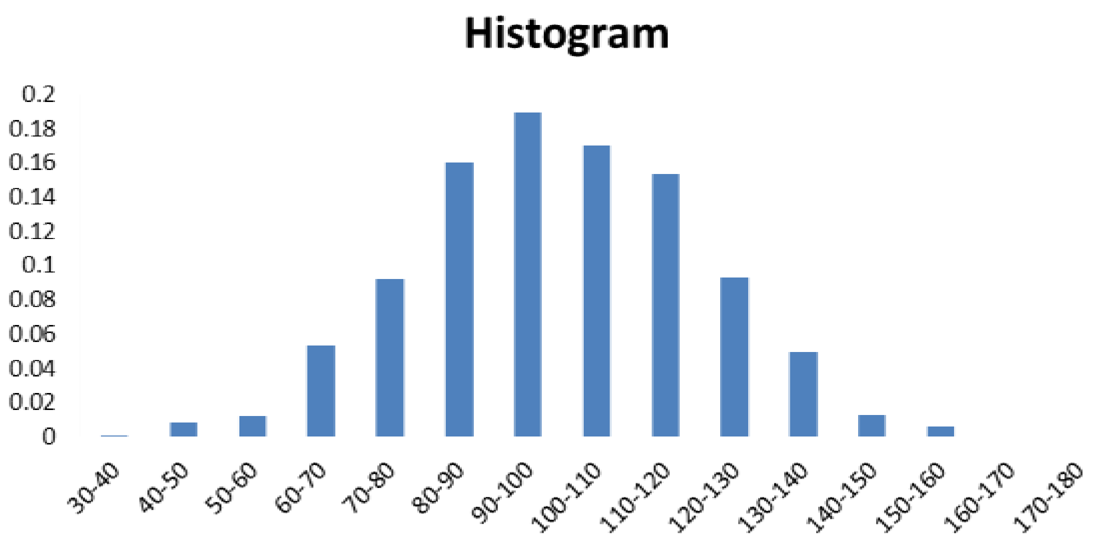

Figure 4.1 The histogram of 1000 revenue observations presented to subjects in Game One

A crop insurance contract allowed subjects to avoid revenue loss. The coverage level was $90/acre; if the revenue fell below $90/acre in a year, the insurance would make up the gap between 90 and actual revenue with an indemnity when farms already held the insurance policy. The premium in this game, an unsubsidized actuarially fair

[13] The horizontal axis shows the revenue ranges; the vertical axis shows the percentages.

premium rate, was based on the 1000 revenue observations previously observed. The premium is \$4/acre, calculated as follow,

$$premium = \frac{1}{1000}\sum_{n=1}^{1000}(90 - revenue_n)\text{, only if } revenue_n < 90 \tag{4.1}$$

Subjects began this game by answering a probability question,

"What is the probability of collecting insurance (the probability that revenue falls below \$90 per acre) do you think it would be in the next year"

and then need to answer a purchase choice question

"Whether or not are you willing to buy the insurance?"

Subject could make use of original prior information (the revenue histogram), and updated their prior information (drawn revenue observations in each period) and perceptions of losses and then maximize their expected profits through buying insurance given an actuarially fair price. Then at the end of each period, an observation of revenue was randomly selected from the distribution and the insurance would cover the losses of those who held the contract if the actual revenue was below the deductible level (\$90 per acre). A total of 50 rounds of choices were observed for each of the subjects. Each 1000 tokens earned in the experiment would be exchanged with one dollar in real cash.

In both games, the payoff function for each individual can be expressed as follow,

$$payoff = \begin{cases} A[\tilde{r}_t + \delta(-c)] & \text{if } \tilde{r}_t > \bar{r} \\ A\{\tilde{r}_t + \delta_t[(\bar{r} - \tilde{r}_t) - c)\} & \text{if } \tilde{r}_t < \bar{r} \end{cases} \tag{4.2}$$

where is A the fixed plant acres; $\tilde{r}_t$ is the random crop revenue in period t; c is the cost of holding an insurance contract (in this game, c is a pre-specified price as premium rate);

$\bar{r}$ is the deductible level of revenue. δ_t is a binary choice variable in period t; 1 denotes holding an insurance policy and 0 means not.

Game Two: Modified Offerman & Sonnemans' Experiment Task

In Game Two, I used Offerman and Sonnemans' (2004) methodology in the crop insurance experiment. (For more detailed experiment instruction, see Appendix A)

In this task, each subject still played a role of farmer and made a dichotomous choice to buy insurance contracts in each period. Every subject was growing 100 acres of the crop with a cost of $90 per acre and expected revenue of $100 per acre. If yields or market prices were low enough subjects would lose money. Likewise, an insurance policy with a coverage level of $90 was provided to protect them from potential losses caused by low revenues.

What differs from the first dichotomous choice task is that, in each period subjects were shown different series of 21 observations that were either correlated or independent with a 50%-50% chance (but the subjects were not told whether the series of randomly selected revenues are independent or correlated). That is, if revenues were independent or uncorrelated across time, then the revenue for this year would have no relationship with next year's revenue. However, if revenues were correlated then if this year's revenue was above average there is a 70% chance next year's revenue would be above average. Conversely, if this year's revenue was below average there would be a 70% chance next year's revenue would be below average. The next is how the uncorrelated and especially correlated revenue series were generated.

Revenue data generation

There are two types of revenues in this game; one is from normal distribution with a mean of 100 and a standard deviation of 20 (game one) and the other is transformed from this normal distribution with the same mean and standard deviation but with auto-correlation across periods. Based on the instruction (see Appendix A) "the next observation of revenue has a chance of 0.7 to be above the previous one", we used a process called "first-order autoregressive process", denoted as AR1 in time series (Gujarati, 1995).

A first-order autoregression (AR1) could be expressed as the following difference equation,

$$Y_t = c + \phi Y_{t-1} + \varepsilon_t \tag{4.3}$$

where { ε_t } is a white noise sequence satisfying the following three conditions: $E(\varepsilon_t) = 0$, $E(\varepsilon_t^2) = \sigma^2$ and $E(\varepsilon_t \varepsilon_\tau) = 0$ for t $\neq \tau$. In our case, it is assumed that ε_t is normally distributed with a normal distribution with a mean of 0 and a standard deviation of σ^2 . Y_t is the crop revenue in period t and Y_{t-1} denotes the crop revenue in period $t-1$. ϕ , which is according to our experimental setting, is 0.3 which is less than 1, so that Y_t can be considered as a covariance-stationary process. Based on the properties of difference equation, equation (4.2) can be transformed as

$$Y_t = (c + \varepsilon_t) + \phi(c + \varepsilon_{t-1}) + \phi^2 (c + \varepsilon_{t-2}) + \phi^3 (c + \varepsilon_{t-3}) + \cdots \tag{4.4}$$

$$= [c/(1-\phi)] + \varepsilon_t + \phi\varepsilon_{t-1} + \phi^2\varepsilon_{t-2} + \phi^3\varepsilon_{t-3} + \cdots$$

Taking expectations of (4.4), we can see that

$$E(Y_t) = [\text{c}/(1\text{-}\phi)] + 0 + 0 + \cdots \tag{4.5}$$

So we can say that the mean of a stationary AR(1) process is

$$\mu_{AR} = c / (1 - \phi) \tag{4.6}$$

The variance is

$$\begin{aligned} \gamma_0 &= E(Y_t - \mu)^2 \\ &= \text{E}(\varepsilon_t + \phi\varepsilon_{t-1} + \phi^2\varepsilon_{t-2} + \phi^3\varepsilon_{t-3} + \cdots)^2 \\ &= (1 + \phi^2 + \phi^4 + \phi^6 + \cdots)\sigma^2 \\ &= \sigma^2 / (1 - \phi^2) \end{aligned} \tag{4.7}$$

Since this stationary AR(1) process is based on the normal distribution with $\mu_N = 100$ and $\sigma_N = 20$, in our case, the revenue series with correlation and that without correlation share the same values of mean and standard deviation. In other words,

$$\mu_N = \mu_{AR} = 100 \tag{4.8}$$

$$\text{and } \sigma_N^2 = \gamma_0 = 20^2 \tag{4.9}$$

By substituting (4.8) into equation (4.6), the value of c is equal to 30. Substitute (4.8) into (4.6), σ is $20\sqrt{5.1}$,

$$Y_t = 30 + 0.7Y_{t-1} + 20\sqrt{.51} \times e_t \text{, where } e_t \sim (0,\ 1) \tag{4.10}$$

Hence, 50 different series of 21 observations with correlation were generated one by one, according to equation (4.10).

The 21 observations would be shown in a form of “20-1”. At first, the computer drew a series of twenty years of crop revenues (“20”) from whatever the revenues were, either independent or correlated, for subjects to observe. (Figure 4.2) The decision makers observed the revenue series and then needed to answer the following two probability questions

“What is the chance that this crop’s revenue is correlated across time?”

“Given the series you are observing, what is the chance that you will collect an indemnity if you purchase the insurance policy?”

and then decided whether to buy the insurance contract. At last the year’s actual revenue from the series was shown after subjects had answered those three questions.

Figure 4.2 The example of a line chart of randomly drawn 20 observations in Game Two

Quadratic scoring rule

The second source of earning from this game was based on each subject's estimate of the probability that revenues were correlated across time. The payoff was determined by the quadratic scoring rule. The quadratic scoring rule works in this manner. Assuming that S is the participant's reported probability that outcomes are correlated, the payoff is $10,000 - S^2$ points if revenues are uncorrelated across time and is $200 * S - S^2$ points if correlated.

As an incentive-compatible mechanism to elicit beliefs, the quadratic scoring rule incentivizes subjects to truthfully reveal their subjective probability (Sonnemans and Offerman, 2001). Clements and Harvey (2010) also used the quadratic scoring rule for probability forecasts. Vanberg (2008) used this rule to investigate the effect of exchange of promises on cooperative behavior in experimental games. In this experiment, subjects were provided with a payoff table based on the formulas above, but the math formulas were not shown to the subjects. The table displayed each payoff corresponding to probabilities in the interval from 0% to 100% both when revenues are correlated and when revenues are uncorrelated. Under this scoring rule, the best strategy for subjects is to report beliefs truthfully.

The payoff table (table 4.3) shows how many points the subjects would obtain based on the reported probability if the revenues are "correlated' or "uncorrelated". At the end of experiment, the earned points were exchanged for dollars (the exchange rate is 8,000 points = one dollar and subjects were instructed with the exchange rate in advance).

Finally, subjects earned the revenues from harvesting the crop. The average revenue per acre is $100 but it costs $90 to grow. The payoff function in this game is shown above as equation (4.1).

Table 4.3 Payoff table of quadratic scoring rule

	Points										
Reported Probability (%)	0	10	20	30	40	50	60	70	80	90	100
Correlated	0	900	600	100	400	500	400	100	600	900	10000
Uncorrelated	10000	900	600	100	400	500	400	100	600	900	0

CHAPTER V

EXPERIMENT RESULTS AND DATA ANALYSIS

Experiment Results

In total 96 subjects participated in this experiment. 92 valid samples in Game One and 95 valid samples in Game Two were collected for analysis[14].

General description of risk preference

At the beginning of the experiment, I collected the risk preference data of each individual, by the use of Holt-Laury Lottery Choice task (see more in Appendix A). A total number of 96 samples were obtained and the number of Option A selections was calculated individually. Table 5.3 displays the relative risk aversion coefficient as an indicator of individual's risk preference (Holt and Laury, 2002). When looking at the lottery choices, I found that some of them failed to understand the instruction well so as to behave in an irrational way of switching choices from option A to option B and then back to A at least once. A value of 99 was assigned to those irrational choices. Therefore a distribution of risk preference across individuals was given in Figure 5.6. There are 18 subjects who were given a 99 risk preference indicating these subjects exhibited irrational

[14] There are 96 subjects participating in this experiment. A subject who was found cheated in the experiment was dropped out from the valid samples. As I mentioned, the order of two games were switched in each section. There are 3 subjects who only finished Game Two and then left without completion of the whole experiment. 92 samples in Game One were collected.

behaviors somehow. Most of the subjects' numbers of Option A are ranging from 4 to 6. Combined with Table 5.3, it implies that most subjects in the sample show a risk neural, mildly risk averse or risk averse attitude towards risk. The most common response was to switch with the 6th choice which is defined as risk averse.

Table 5.1 Risk Aversion Coefficient

Number of safe choices	Range of relative risk aversion for $U(W)=\frac{W^{1-r}}{1-r}$	Middle point of relative risk aversion	Risk preference classification
0-1	-1.76[a] < rr < -0.93	-1.365	Highly risk loving
2	-0.97 < rr < -0.49	-0.73	Very risk loving
3	-0.49 < rr <-0.13	-0.31	Risk loving
4	-0.13 < rr < 0.19	0.03	Risk neutral
5	0.19 < rr < 0.48	0.335	Slightly risk averse
6	0.48< rr < 0.78	0.63	Risk averse
7	0.78< rr < 1.13	0.955	Very risk averse
8	1.13< rr < 1.60	1.365	Highly risk averse
9-10	1.60< rr < 2.2 [a]	1.9	Stay in bed

[a] these two lower and upper bound are subjectively determined

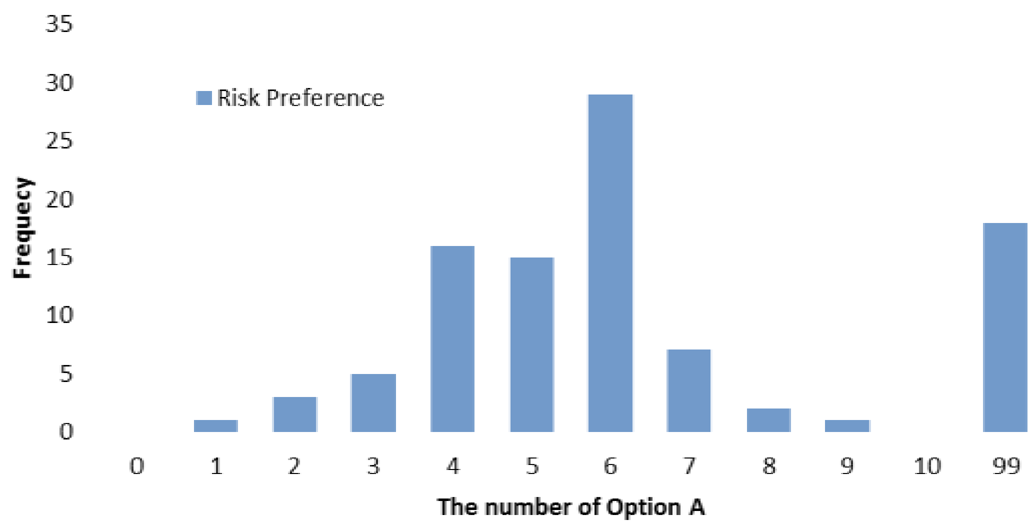

Figure 5.1 The distribution of risk preference across individuals

General description of reported probability

In Game One, subjects needed to answer the question in each period that "what do you think the probability of collecting insurance (the probability that revenue falls below $90 per acre) it would be next year". The probability distribution shown to subjects throughout Game One shows that 33% is the correct probability that the revenue would fall below $90 per acre (Figure 5.1). To measure their understanding of histogram and assessment of probability in Game One, a scoring rule (equation 5.1) were calculated for each subject. The density distribution is given below (Figure 5.2). The formula of this scoring rule is expressed as

$$S1_i = score_i = \sqrt{\sum_{i=1}^{50} (pi_{it} - 33)^2} \tag{5.1}$$

where pi_{it} is reported probability. Therefore, the lower score the subjects gained the better understanding of histogram they have. The distribution of the calculated scores across individuals is plotted in figure 5.2. There is one subject who reported 33% probability across all rounds and another three subjects reported the same probability below 40% in all rounds which implies that these subjects had a clear understanding of this histogram. Among them 21 subjects (over one firth of samples) gained a score larger than 219 meaning that the positive or negative deviations from 33% of their reported probability are on average more than 30 percentage points in each period. So apparently they did not understand the histogram or the revenue risks adequately. The table 5.2 shows the average reported probability of loss across individuals is 46.61, which means that the subjects overestimated the revenue loss risks.

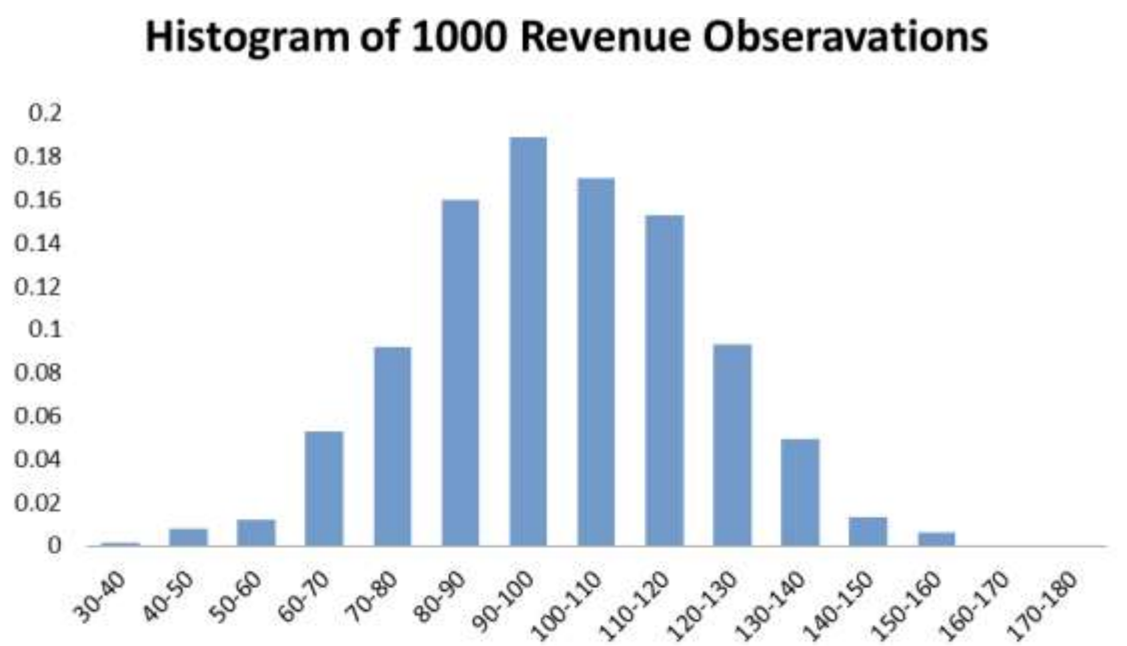

Figure 5.2 The histogram shown to subjects in Game One

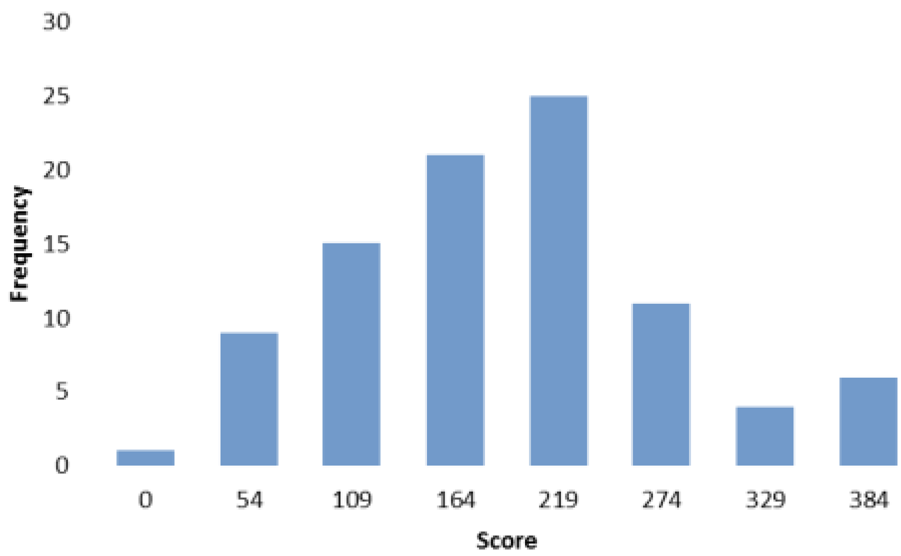

Figure 5.3 The distribution of score across individuals in Game One

In Game Two, we already have the quadratic scoring rule to measure their evaluation of probability of correlation. In each round, subjects gained a score and then the scores in all 50 rounds were averaged:

$$S2 = score_i = \frac{\sum_{i=1}^{50} qsr_{it}}{n}, n = 50 \tag{5.2}$$

where qsr_{it} is the point subjects obtained through the quadratic scoring rule based on the reported probability of the revenue series being correlated. The higher qsr_t is, the better their assessment of correlation probability is. In Figure 5.3, the distribution of scores across individuals in Game Two is negatively skewed, which shows that more of them had a relatively good accuracy of probability of the revenue series being correlated.

Table 5.2 Summary Statistics of Scores and Probability

Variable	Sample Mean (s.d.)	Min	Max	# of obs
Reported probability of loss in Game One	46.61(22.40)	0	100	4600
Reported probability of loss in Game Two	46.12(23.29)	0	100	4750
Score in Game One	162.16(90.20)	0	382.00	92
Score in Game Two	69.42(4.52)	53.17	76.51	95

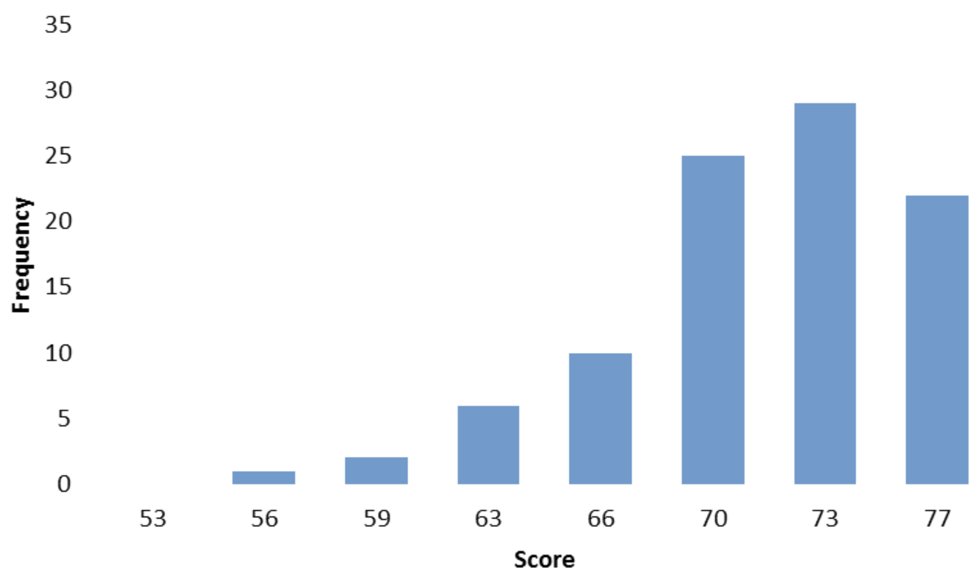

Figure 5.4 The distribution of score across individuals in Game Two

Let us look at their performance of the subjects' assessment of correlation in another perspective. The reported correlation probability larger than 50% is labeled as "perceived correlation" while probability less than 50% is "perceived correlation" (probability equal to 50% were deleted due to subjects' uncertainty in perception). 4048 observations were used to design the Table 5.2 where the percentages that the perceived correlation was right or wrong conditional on that the series was in fact correlated or uncorrelated are displayed. Some interesting relationships are found as follows,

1. Subjects generally did a good job, with more correct answers (61.07%) than wrong answers (38.93%). The percentages of perceived correlation and no-correlation are 44.07% and 55.93% respectively, close to the true percentages of correlation and no-correlation.
2. The fact that the perceived percentage of no-correlation (55.93%) is larger than that of correlation (44.07%) indicates that subjects were not likely to overestimate the probability of correlation but underestimate it although the instruction says that there is a 50-50 chance to be either correlated or uncorrelated.
3. Furthermore, the percentage that subjects' perception of correlation when revenue data was uncorrelated is the lowest one (17.39%) among those four percentages, which confirms the foresaid argument: subjects were not inclined to overestimate the correlation probability.
4. The accuracy of probability perception is 55.3% when the series is correlated while accuracy is 66.4% when it is uncorrelated, which indicates that subjects are better at identifying uncorrelated series than correlated series.

Table 5.3 Subjects' correlation perceptions compared to true correlation

		True		
		correlation	no-correlation	total
perceived	correlation	26.68%	17.39%	44.07%
	no-correlation	21.54%	34.39%	55.93%
	total	48.22%	51.78%	100%

General description of purchase choices

As shown in table 5.2, subjects purchased the insurance contract on average 27.536 periods in 50 periods in Game One. The min and max are 0 and 50. In Game Two subjects bought insurance in average 26.80 rounds out of 50 rounds. The min and max are 2 and 50. Note that 2 subjects bought no insurance in 50 periods but 2 bought it in every round of Game One; while no subjects completed 50 rounds without purchasing insurance in Game Two and 2 subjects purchased insurance in every round. From the results of normality in table 5.5, the Shapiro-Wilk test shows that the distribution purchase choice in Game Two is normally distributed while Game One is not and negatively skewed.

Table 5.4 Summary Statistics of Purchase Choices

Variable	Sample Mean (s.d.)	Min	Max	# of obs
The Count of Purchase Periods for individuals in Game1	27.536(13.144)	0	50	92
The Count of Purchase Periods for individuals in Game2	26.80(11.074)	2	50	95

Table 5.5 Normality test for the purchase choices across individuals in both games

	Game One		Game Two	
Test	Statistics	P Value	Statistics	P Value
Shapiro-Wilk	0.961768	0.0085	0.98407	0.3044

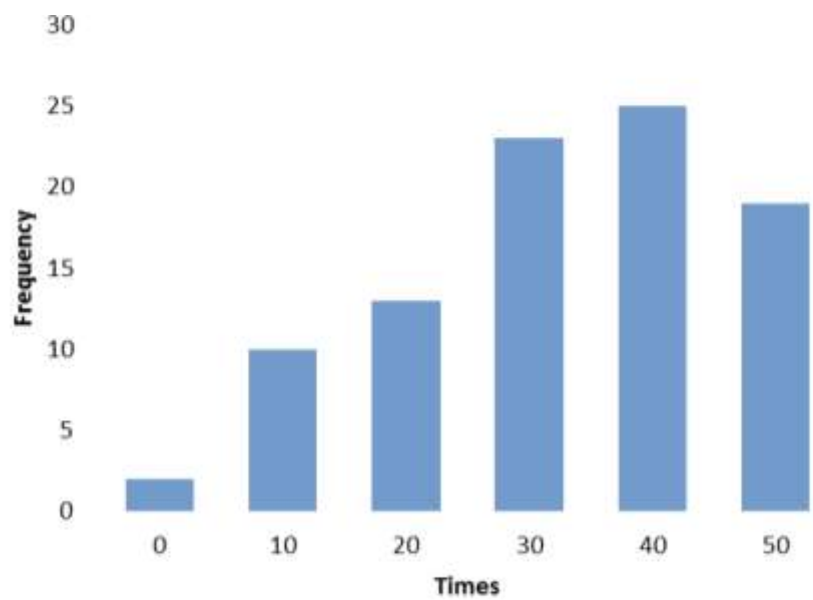

Figure 5.5 The distribution of count of purchase choices across individuals in Game One

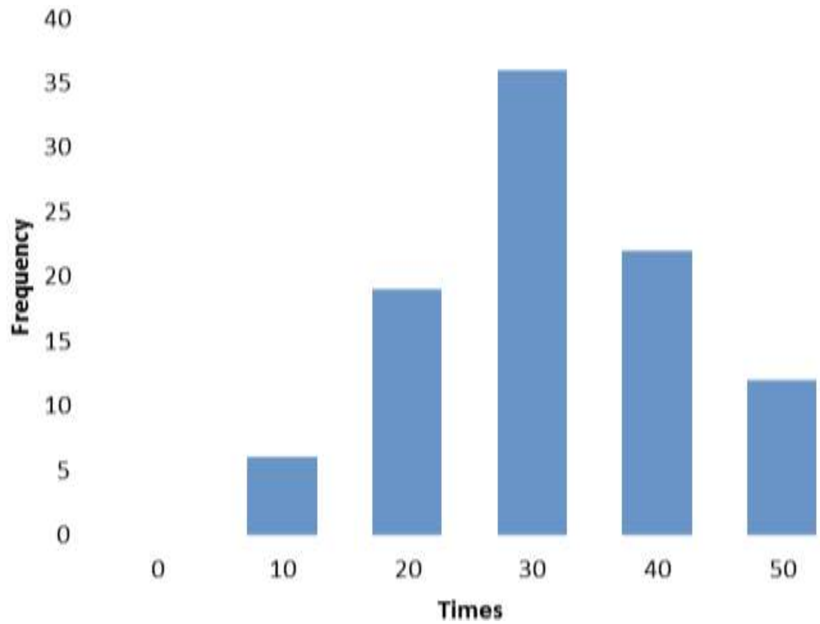

Figure 5.6 The distribution of count of purchase choices across individuals in Game Two

Based on the record of the number of purchase choices across individuals in both games, it is interesting to examine whether there is a distinctive difference of buying behavior between two games. The Wilcoxon Signed Rank Sum and t-test are used to address this issue (Table 5.5). Since Game Two has 3 more samples than Game One, those samples were dropped and 92 samples were used to test.

Table 5.6 Wilcoxon Signed Rank Sum Test

Test	Statistics	P Value
Student's t	0.668317	0.5056
Sign	1.5	0.8323
Signed Rank	200	0.4160

The signed rank sum test result shows no statistically significant difference of the number of purchase choices within two games. This could be concluded that subjects demonstrated an equal willingness to purchase insurance between two games, although with difference experimental settings.

Data Analysis

Probability regression

In both games, subjects were asked to report the probabilities that the revenue will fall below $90 per acre in each period. The regression model trying to examine how the subjects assess the probability of loss is estimated for each individual subject in both games:

$$Probability\ Change = probability\ change_{it} \quad (5.3)$$

$$= f(probabilty\ change1_{it}, probability\ change2_{it}, probability\ change3_{it}) + \varepsilon_{it}$$

where $probch_{it}$ is the difference in subject i's reported probability between the period t and the previous one period $t-1$; $probch1_{it}$ is one period lag of $probch_{it}$, the difference in subject i 's reported probability between the period $t-1$ and the previous one period $t-2$; $probch2_{it}$ is two periods lag of $probch$ and $probch3_{it}$ is three periods lag of $probch_{it}$ and ε_{it} is an error term subject to a normal distribution. So the regression model can also be expressed as follow,

$$probability_{i,t} - probabilty_{i,t-1} = \alpha + \beta_1(probability_{i,t-1} - probability_{i,t-2} + \beta_2(probability_{i,t-2} - probability_{i,t-3}) + \beta_3(probability_{i,t-3} - probabiltiy_{i,t-4}) + \varepsilon_{it} \tag{5.4}$$

where $prob_{i,t}$ is subject i 's reported probability in period t and $prob_{i,t-1}$ is subject i 's reported probability in period $t-1$, etc.

Probability regression for Game One

Table 5.7 Definitions and Summary Statistics for Variables Used in Probability Regression in Game One

Variable Name	Definition	Sample Mean (s.d.)	Min	Max
probability change	The difference of reported probability between the current period t and the previous one period $t-1$; $prob_{i,t} - prob_{i,t-1}$	0.14(20.58)	-100	100
probability change1	The difference of reported probability between the period $t-1$ and the period $t-2$; $prob_{i,t-1} - prob_{i,t-2}$	0.12(20.43)	-100	100
probability change2	The difference of reported probability between the period $t-2$ and the period $t-3$; $prob_{i,t-2} - prob_{i,t-3}$	0.11(20.47)	-100	100
probability change3	The difference of reported probability between the period $t-3$ and the period $t-4$; $prob_{i,t-3} - prob_{i,t-4}$	0.13(20.47)	-100	100

In Game One, there are 8 subjects who reported the same probability of loss across all the rounds. Due to the lack of sufficient variation in the dependent variable, only 84 samples are used in the regression for Game One. The regression results are following in Table 5.7.

Table 5.8 Results from Probability Regression in Game One

Variable Name	The number of significant samples out of all used samples [**84**]	Positive Sign/ Negative sign
probability change1	67	0 / 67
probability change2	57	0 / 57
probability change3	27	1 / 26

Note: A10% significance level is used

As we can see, one period lag and two periods of lag of probability change are both significant in more than half of samples and all have a negative sign.

This strong significance of negative signs in one period and two periods lag variables are telling us that, if there is an increase in the reported probability of loss in this period compared to the last period, then the reported probability will either increase but in a smaller scale or even decrease in the next first period and the probability in the next second period will probably increase a further smaller scale or drop down.

Conversely, if the reported probability in the current period decreases compared to the last period, the probability in the next first period will either decrease but in a smaller scale or even bouncing up. The probability in the next second period will probably decrease in an even smaller scale or even spring back up.

The reported probability is bouncing up and down and subjects were seemingly looking for the equilibrium of probability of loss. I randomly selected the reported probability of loss data from 4 subjects whose regression models have significant probability change lag variables in order to help illustrate the issue (Figure 5.7).

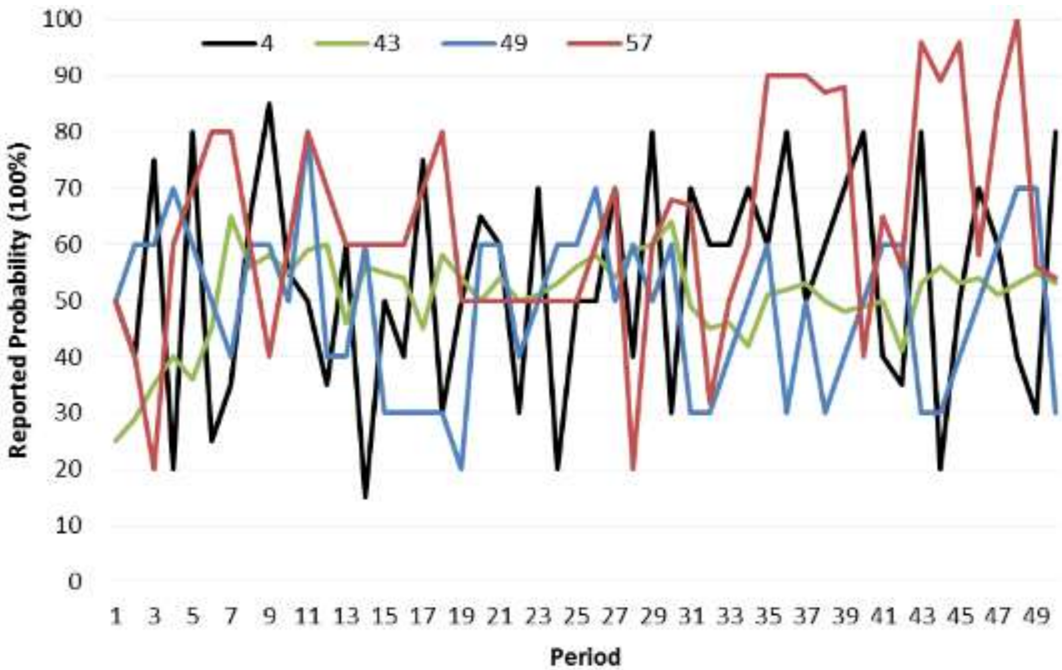

Figure 5.7 Reported probability of loss from 4 randomly drawn subjects who all have significant lag probability change variables

Different colors represent different subjects' reported probability of loss. All of these four individuals, either those who changed the probability in a strong manner like subject 4 or those who changed in a mild manner like subject 43, indeed had the reported probability bounce up and down frequently. However, it is important to evaluate this behavior given the parent probability of loss is 33%. It can be an interpretation that subjects were seeking the equilibrium through updating their probability round by round. However, they were in generally upwardly biased.

Probability regression for Game Two

In Game Two, the same regression model is estimated,

$$Probability\ Change = probability\ change_{it} \tag{5.5}$$

$$= f(probability\ change1_{it}, probability\ change2_{it}, probability\ change3_{it}) + \varepsilon_{it}$$

Table 5.9 Definitions and Summary Statistics for Variables Used in Probability Regression in Game Two

Variable Name	Definition	Sample Mean (s.d.)	Min	Max
probability change	The difference of reported probability between the current period t and the previous one period $t-1$; $prob_{i,t} - prob_{i,t-1}$	-0.04(26.90)	-100	100
probability change1	The difference of reported probability between the period $t-1$ and the period $t-2$; $prob_{i,t-1} - prob_{i,t-2}$	-0.15(27.01)	-100	100
probability change2	The difference of reported probability between the period $t-2$ and the period $t-3$; $prob_{i,t-2} - prob_{i,t-3}$	-0.51(26.92)	-100	100
probability change3	The difference of reported probability between the period $t-3$ and the period $t-4$; $prob_{i,t-3} - prob_{i,t-4}$	-0.26(27.04)	-100	100

There are two persons who reported the same probability of loss across the periods. Due to the lack of sufficient variation in dependent variable, 94 samples in the end are used in the regression for Game Two. The regression results are following in Table 5.4.

Table 5.10 Results of Probability Regression in Game Two

Variable Name	The number of significant samples out of all used samples [**94**]	Positive Sign/ Negative sign
probability change1	92	0
		92
probability change2	89	0
		89
probability change3	45	0
		45

Note: at a 10% significance level

Game Two is similar to Game One in regards to the regression results: subjects changed their probability of loss up and down frequently. This is, however, reasonable in Game Two where subjects were experiencing randomly selected series of revenues in every round and started over to perceive the loss probability in the next round. Changing reported probability could be just a reflection of changing fundamental risk information.

Demand regression

Demand regression model for Game One[15]

I utilized the logistic function to analyze the insurance demand. The regression model is represented as

$$prob_{it}(purchase\ choice = c) = f(prob_{it}, goodyear_{it}, badyear_{it}, period_{it}) + \varepsilon_{it} \quad (5.6)$$

[15] I have also investigated a model including square terms of streak variables for a check a quadratic relationship between purchase choice and streak variable. But no evidence of it was found in estimation results.

where the choice δ is equal to 1 for purchasing insurance and 0 for no insurance and ε_{it} is an error term subject to a normal distribution.

In the function above, $probt_{it}$ is the subject i's reported probability that revenue in current period will be less than $90 per area. The variables *goodyear* and *badyear* are created to accounts for the effect of streaks of good and bad revenue years on insurance purchase choice, in order to test the hypothesis of gambler's fallacy and hot hand effect. The values of *goodyear* were generated in this manner: if the previous period is the third year in row when the revenue is larger than 90, the current period of *goodyear* would be set to 3; if the previous period is the fourth consecutive year when the revenue is larger than 90, the current period of *goodyear* would be set to 4, etc. The minimum and maximum value of *goodyear* is 0 and 6 respectively (See Table 5.7). Likewise, the variable *badyear* was generated in the same fashion. As its maximum value is 4 (See Table 5.7), it just has three levels, 0, 3 and 4. Since the maximum value of good streak variable is 6, the first 6 observations of *goodyear* were set to be missing for each individual. The first 4 observations of *badyear* were missing for each individual as well for the same reason. As to variable *period* , it refers to the cumulative amount of periods the subjects have been experiencing, in order to capture the learning process—see whether or not subjects were learning to purchase crop insurance as more rounds of the game were running along. Obviously it has 50 values, 0 through 49.

Table 5.11 Definitions and Summary Statistics for Variables Used in Demand Regression without Square Term in Game One

Variable Name	Definition	Sample Mean (s.d.)	Min	Max
purchase choice	The purchase choice made by subjects, one for buying, zero for not buying	0.55(0.50)	0	1
prob	The reported probability that revenue will fall below $90 per area in the current period	46.61(22.40)	0	100
goodyear	The amount of consecutive bad years (>2) that subjects have been experiencing before the current period	1.18(1.92)	0	6
badyear	The amount of consecutive bad years (>2) that subjects have been experiencing before the current period	0.39(0.97)	0	4
period	The cumulative amount of periods that subjects have been experiencing	24.50(14.43)	0	49

4 samples in the pool have the same choice across the rounds. Due to a lack of sufficient variation in dependent variable in some samples, it ends up using 88 samples in the regression. The regression results are following in Table 5.8.

Table 5.12 Results from Demand Regression without Square Term in Game One

Variable Name	The number of significance out of all used samples [**88**]	Positive Sign / Negative sign
prob	45	42
		3
goodyear	9	3
		6
badyear	8	7
		1
period	19	15
		4

Note: at 10% significance

From the estimate results we can see that the reported probability variable is significant in over half of samples in most of which it is positive. It means that the probability of purchasing choice will increase as the probability of perception of loss rises, which makes sense. Neither of two streak variables looks statistically significant since no more than 10 are significant at 10% level for both of them, thereby rejecting the hypotheses of gambler's fallacy and hot hand effect: the subjects in Game One did not exhibit the behaviors of gambler's fallacy and hot hand effect when making decision to buy insurance. It is interesting to find that there are 15 samples out of 88, where there is a positive and significant *period* factor which indicates that subjects were learning to buy more insurance contracts in Game One as they had been experiencing more rounds.

Demand regression model for Game Two

The demand regression in Game Two has similar factor variables as in Game One -- probability of loss, period, and streak variables (good streak and bad streak) to explain the insurance purchase choice. Since the two games have distinctive experimental settings, the creations of streak variables were different. In Game Two, A new series of 20 observations was provided in each period for subjects to observe and their probability perception would start over in the next period; while the histogram remained constant throughout the game and subjects updated their perceptions only by the new drawn revenue observation. Therefore, the streak variables are based upon the given 20 observations in each round: if the 20th observation is the third consecutive good year that revenue is larger than 90, the value of *goodyear* would be set to 3; if the 20th is the fourth consecutive good year when the revenue is larger than 90, the current period of *goodyear* would be set to 4, etc. Likewise, the variable *badyear* was created in the same fashion. Additionally, the reported auto-correlation probability in Game Two was included in explanatory variables, just for a curiosity about its effect on purchase decision. Therefore, the demand regression model for Game Two is formulating as follow,

$$prob_{it}(purchase\ choice = \delta) = f(prob_{it}, goodyear_{it}, badyear_{it}, proba_{it}, period_{it}) \quad (5.7)$$

Table 5.13 Definitions and Summary Statistics for Variables Used in Demand Regression in Game Two

Variable Name	Definition	Sample Mean (s.d.)	Min	Max
Purchase choice	The purchase choice made by subjects, one for buying, zero for not buying	0.54(0.50)	0	1
prob	The reported probability that revenue will fall below $90 per area in the current period	46.12(23.29)	0	100
goodyear	The amount of consecutive good years (>2) that subjects have been experiencing before the last observation in the series shows up	2.76(4.11)	0	16
badyear	The amount of consecutive bad years (>2) that subjects have been experiencing before the last observation in the series shows up	0.22(1.08)	0	6
proba	The reported probability that the revenue series in the period is correlated	46.44(25.11)	0	100
period	The cumulative amount of periods that subjects have been experiencing	24.50(14.43)	1	49

Since there are 3 subjects choosing either buying or not buying all the rounds, the lack of sufficient variation in dependent variable caused 92 samples to be used in the regression. The regression results are following in Table 5.12.

Table 5.14 Results from Demand Regression in Game Two

Variable Name	The number of significance out of all used samples [**92**]	Positive Sign / Negative sign
prob	63	61
		2
goodyear	2	1
		1
badyear	1	1
		0
proba	10	2
		8
period	16	7
		9

Note: at 10% significance

Both streak variables have no explanatory power in this model as well as in the regression of Game One. The fact of insignificance of streak variables rejects the hypotheses of gambler's fallacy and hot hand effect: the subjects did not exhibit the behaviors of gambler's fallacy and hot hand effect when making decisions to buy insurance. The reported probability of loss is significant for nearly two thirds of samples and its positive sign implies that an increase in perceived probability of loss leads to a rise in the probability of demand for insurance policy. On the other hand, the probability of series being correlated is not statistically significant. Variable *period* is statistically significant in some samples but they split the amount of positive and negative signs which makes it unreliable to explain the demand model.

CHAPTER VI

SUMMARY AND CONCLUSION

Summary

The study set out to explore how two cognitive biases, gambler's fallacy and hot hand effect, exert an effect on crop insurance purchase decision. I used experimental methods to accomplish this objective and designed two financially incentive games that represented distinct experimental situations. Subjects were assigned to participate in two subsequent games. Game One, providing an overall revenue histogram at the beginning of the game, allowed subjects to update risk information and make purchase decision before a random revenue draw in each period. Game Two showed a new-drawn series with 21 revenue observations in each round which could be uncorrelated or correlated with a correlation coefficient of 0.7. Each of the two series had 50-50 chance of being chosen. Subjects made to purchase insurance after evaluating the risk separately in each period. In the analysis, I created streak variables that account for the effect of consecutive good and bad revenue years on demand for insurance. The streak variables in both games did not show desirable explanatory power to decipher subjects' purchase behavior; thereby the hypotheses concerning hot hand effect and gambler's fallacy were rejected.

In the analysis of probability perception, it is found that subjects changed the loss probability up and down frequently according to statistically significant probability change variables in both games. This is consistent with a phenomenon of "mean reversion" which is widely used in finance. But the mean is reverting to an upward biased probability level in Game One because the mean of probability of loss is 46% while the true loss probability is 33%.

Another important influencing factor, the probability of loss is statistically significant among most samples; the positive sign of loss probability reported by subjects strongly demonstrates that subjective probability of risks indeed influences individual's crop insurance purchase decision positively. It is also interesting to find that the experience variable in Game One is statistically significant in some samples to successfully explain the individual demand for crop insurance. Its positive sign provides evidence to argue that in a random situation, the longer the exposure to risky events subjects have, the more willing to engage in insurance protection they are.

Conclusion

Even though the hypotheses of hot hand effect and gambler's fallacy failed to be supported, the interesting findings mentioned above still enable me to offer some constructive suggestions. Concerning the significant effect of subjective probability of loss risks on purchase decision and the experimental fact that subjects were bouncing up and down to update the loss probability, seemingly seeking the equilibrium, the farm bureau or crop insurance companies should establish education programs that are aimed to train farmers to understanding the principles of probability theory and fundamentals of risk managements. The finding that the longer subjects were exposed to risks the more likely they became to buy insurance in the random environment confirms the significance and necessity of this education program. From the perspective of farmers, a better understanding of probability would enable them to discover the risks in the real world and seek reliable protections.

For future work, this laboratory experiment can be extended to a field study providing an insightful look into cognitive operations within individual farmers. A lab experiment with revisions, nevertheless, needs to be tested for a few times before taken into field due to some shortcomings in my experiment.

Given that some subjects who are very well-educated junior/senior undergraduate or graduate students showed insufficient understanding of probability theory knowledge in experiments, it is reasonable to question that farmers without higher education can be able to understand and apply the knowledge into the problem solution. So I would suggest that two treatments be created—one with a probability education before experiment and one without. It needs to test the effect of education program on demand for crop insurance.

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APPENDIX A

IRB APPROVAL AND EXPERIMENT INSTRUCTIONS

IRB Approval

The following is the email containing the approval information:

“Dear Mr. Qian:

This email serves as official documentation that the above referenced project was reviewed and approved via administrative review on 3/11/2014 in accordance with 45 CFR 46.101(b)(2). Continuing review is not necessary for this project. However, in accordance with SOP 01-03 Administrative Review of Applications, a new application must be submitted if the study is ongoing after 5 years from the date of approval. Additionally, any modification to the project must be reviewed and approved by the HRPP prior to implementation. Any failure to adhere to the approved protocol could result in suspension or termination of your project. The HRPP reserves the right, at any time during the project period, to observe you and the additional researchers on this project.

Please note that the MSU HRPP accreditation for our human subjects protection program requires an approval stamp for consent forms. The approval stamp will assist in ensuring the HRPP approved version of the consent form is used in the actual conduct of research. Your stamped consent form will be attached in a separate email. **You must use the stamped consent form for obtaining consent from participants.**

Please refer to your HRPP number (#14-048) when contacting our office regarding this application.

Thank you for your cooperation and good luck to you in conducting this research project. If you have questions or concerns, please contact me at jroberts@orc.msstate.edu or call 662-325-

2238.

Finally, we would greatly appreciate your feedback on the HRPP approval process. Please take a few minutes to complete our survey at http://www.surveymonkey.com/s/YZC7QQD.

Sincerely,

Jodi Roberts, Ph.D.

IR! B Officer"

Project Title: **Experimental Analysis of Crop Insurance Purchase--Cognitive Bias in Decision Making**

PRINCIPAL INVESTIGATOR'S ASSURANCE

As Primary Investigator I have ultimate responsibility for the performance of this study, the protection of the rights and welfare of the human subjects, and strict adherence by all co-investigators and research personnel to all Institutional Review Board (IRB) requirements, federal regulations, and state statutes for human subjects research. I hereby assure the following:

The information provided in this application is accurate to the best of my knowledge.

All named individuals on this project have been given a copy of the protocol and have acknowledged an understanding of the procedures outlined in the application.

All experiments and procedures involving human subjects will be performed under my supervision or that of another qualified professional listed on this protocol.

I understand that, should I use the project described in this application as a basis for a proposal for funding (either intramural or extramural), it is my responsibility to ensure that the description of human subjects use in the funding proposal(s) is identical in principle to that contained in this application. I will submit modifications and/or changes to the IRB as necessary to ensure concordance.

I and all the co-investigators and research personnel in this study agree to comply with all applicable requirements for the protection of human subjects in research including, but not limited to, the following:

- Obtaining the legally effective informed consent of all human subjects or their legally authorized representatives, and using only the currently approved, consent form with the IRB approval stamp (if applicable), and
- Obtaining written notification of approval from the IRB before implementation of any changes to the project (except when necessary to eliminate apparent immediate hazards to the subject); and
- Reporting via the Problem Report any unanticipated problem; and
- Promptly providing the IRB with any information requested relative to the project; and
- Promptly and completely complying with an IRB decision to suspend or withdraw its approval for the project; and
- Obtaining continuing review prior to the date approval for this study expires; and
- Granting access to any project-associated records to the IRB to ensure compliance with the approved protocol.

Name of Principal Investigator / Researcher: Peng Qian

Signature:

ADVISOR'S ASSURANCE (if applicable)

I assume responsibility for ensuring the competence, integrity and ethical conduct of the investigator(s) for this research project. The investigator(s) is/are fully competent to accomplish the goals and techniques stated in the attached proposal. Further, I certify that I have thoroughly reviewed this application for readability and accuracy and the study is clearly described herein.

I have reviewed the proposed research and concluded that the following apply:

- The research uses procedures consistent with sound research design.
- The research design is sufficiently sound to yield the expected knowledge.

Name of Advisor: Dr. Keith H. Coble

Signature:

Approval Document

Mississippi State University
Informed Consent Form for Participation in Research

Title of Research Study: Experimental Analysis of Crop Insurance Purchase—Cognitive Bias in Decision Making
Study Site: Computer Lab Room 010, Lloyd-Watson-Ricks Building

Researchers: Dr. Keith Coble, Dr. Ardian Harri and Dr. Kalyn Coatney, and Mr. Peng Qian, Mississippi State University, Department of Agricultural Economics

Purpose
The purpose of this research is to investigate whether and how cognitive perceptions affect the crop insurance purchase decisions.

Procedures

You must be 18 years old to participate this experiment. At the beginning, you will fill in a form to make lottery choices. Then you will be shown an Excel spreadsheet on the computer and answer several probability questions and whether to buy insurance contracts. The experimenter will present you additional information to help you complete the mission round by round. You are about to finish two experiments one after the other. At the end of the session, you will be paid according to a combination of your performances and results of random revenue outcomes. The experiment as a whole is expected to last no more than two hours.

Risks or Discomforts

The researchers expect that discomfort to you will be minimal to non-existent. You will be asked to sit in front of a computer and record responses on spreadsheet on that computer.

Benefits

Subjects participating in experimental sessions benefit directly from participation fees; furthermore, each subject has a chance to earn more based on the performances assessing risk probability and insurance choices.

Incentive to participate

For showing up to the experiment today, you are guaranteed a $5.00 show-up fee regardless of your participation in the experiment. During the purchase procedure which 50 rounds are to be run in each section (you will have 2 sections in total), revenues will be realized and an amount of net return will be received in each round. At the end of two sections, net returns of each round in two sections will be aggregated, and exchanged for cash at a certain rate and paid to you. If you withdraw before the purchase phase are completed or if any physical or verbal communication between subjects is detected by the researchers during the experiment, all subjects will be dismissed, and subjects will only receive their $5.00 show-up fee.

Page 1 of 3
Version: 03/03/2014

Confidentiality

Please note that these records will be held by a state entity and therefore are subject to disclosure if required by law. Research information may be shared with the MSU Institutional Review Board (IRB) and the Office for Human Research Protections (OHRP).

All records of this research project may be inspected by the Food and Drug Administration (FDA).

Questions

If you have any questions about this research project, please feel free to contact Peng Qian at 662-312-9287 in office 330 Lloyd-Watson-Ricks Bldg, Dr. Keith H. Coble at 325-6670 in office 320B Lloyd-Watson-Ricks Bldg., or Dr. Kalyn T. Coatney at 325-7983 in office 365 Lloyd-Watson-Ricks Bldg., or Dr. Ardian Harri at 325-5179 in office 318 Lloyd-Watson-Ricks Bldg.

For questions regarding your rights as a research participant, or to discuss problems, express concerns or complaints, request information, or offer input, please feel free to contact the MSU Research Compliance Office by phone at 662-325-3994, by e-mail at irb@research.msstate.edu, or on the web at http://orc.msstate.edu/humansubjects/participant/.

Voluntary Participation

Please understand that your **participation is voluntary.** Your **refusal to participate will involve no penalty or loss** of benefits to which you are otherwise entitled. You **may discontinue your participation** at any time without penalty or loss of benefits.

Options for Participation

Please initial your choice for the options below:

___The researchers may contact me again to participate in future research activities.

___The researchers may NOT contact me again regarding future research.

Please take all the time you need to read through this document and decide whether you would like to participate in this research study.

If you agree to participate in this research study, please sign below. You will be given a copy of this form for your records.

______________________________ __________

Participant Signature Date

MSU HRPP Approved: 03.11.2014 Expires: 03.11.2019 IRB # 14-048

Page 2 of 3
Version: 03/03/2014

Economic Experiment General Announcement

Who?

All math, statistics, economics, finance and agricultural economics students with a senior or graduate standing who have not yet participated this semester are eligible to sign up for an **economic experiment** sponsored by the Department of Agricultural Economics.

What?

Don't pass up this excellent opportunity to try out your economic decision skills in an experimental market while earning a considerable amount of real $money$. Earnings are expected to range from **$20 to $50 plus a $5 show-up bonus**.

When?

Sessions run on Monday, Wednesday, Thursday and Friday at 4:00 pm and last roughly 2 hours.

Where?

Sessions will be held in Room 010, Lloyd-Ricks-Watson Building.

If you have any questions or wish to inquire about available sessions please do not hesitate to contact:

Peng Qian

pq17@msstate.edu

Lloyd-Ricks-Watson, Room 330

Dear Student,

Recently you are invited to participate in an **economic experiment** sponsored by the Department of Agricultural Economics. All students who have not yet participated this semester are eligible to sign up for this experiment.

Don't pass up this excellent opportunity to try out your economic decision skills in an experimental market while earning a considerable amount of real $money$. Earnings are expected to range from **$20 to $50 plus a $5 show-up bonus**.

Sessions run on Monday, Wednesday, Thursday and Friday at 4:00 pm and last roughly 2 hours and will be in Room 010, Lloyd-Ricks-Watson Building. If you are interested in this experiment, please send an email to the following email address, pq17@msstate.edu, and you will receive a reply with a URL in which you can sign up for the sessions.

If you have any questions or wish to inquire about available sessions please do not hesitate to contact:

Peng Qian

pq17@msstate.edu

Lloyd-Ricks-Watson, Room 330

Sincerely,

MSU HRPP Approved: 03.11.2014 Expires: 03.11.2019 IRB # 14-048

MISSISSIPPI STATE UNIVERSITY HUMAN RESEARCH PROTECTION PROGRAM	Protocol Submission Form *Version 12-06-2013*

This form should be used by Principal Investigators to request IRB review of research involving human subjects that does not qualify for Administrative Review (i.e., protocols that will undergo Expedited or Convened IRB review).

This form is locked; however, you may unlock the form for features such as spell checking if you wish. If you change the form in any way, you will be required to resubmit the protocol.

Investigator's Checklist for Submission

Before submitting your protocol for IRB review, make sure you have included the following (if applicable):

☒ Survey, Questionnaire or Interview Questions
☒ Consent and Assent forms
☒ Recruiting materials
☐ Permission letters from participating institutions
☒ Signed Investigator Assurance form
☐ For non-student researchers - Completed Scientific or Scholary Validity Review Form signed by the appropriate individual. Note this can be submitted separately from the Protocol Submission Form, but it is required prior to approval
☒ Clear, concise description of procedures to be used (Feel free to also attach any proposals that may further explain your project. However, the study must be fully described within the application.)
☒ All personnel listed must have completed IRB/Human Subjects Training. If not, your application cannot be approved until the training has been completed. Information regarding training options can be found at Training. You can check your training records from the "Check your training records" link from http://orc.msstate.edu/humansubjects/ .

PLEASE NOTE:

The determination of the IRB will be communicated to you in writing. Submission of an application to the IRB does not equal IRB approval. You may not begin this research until you have received written notification of IRB approval.

MSU Campus Mail: Mailstop 9563	**US Mail:** PO Box 6223 MS State, MS 39762	**Physical Location:** 53 Morgan Avenue MS State, MS 39762
Fax: 662-325-8776	E-mail: irb@research.msstate.edu	
If you have any questions, please feel free to contact our office at 325-3294 or by e-mail at irb@research.msstate.edu		

Project Title: **Experimental Analysis of Crop Insurance Purchase--Cognitive Bias in Decision Making**

PRINCIPAL INVESTIGATOR'S ASSURANCE

As Primary Investigator, I have ultimate responsibility for the performance of this study, the protection of the rights and welfare of the human subjects, and strict adherence by all co-investigators and research personnel to all Institutional Review Board (IRB) requirements, federal regulations, and state statutes for human subjects research. I hereby assure the following:

The information provided in this application is accurate to the best of my knowledge.

All named individuals on this project have been given a copy of the protocol and have acknowledged an understanding of the procedures outlined in the application.

All experiments and procedures involving human subjects will be performed under my supervision or that of another qualified professional listed on this protocol.

I understand that, should I use the project described in this application as a basis for a proposal for funding (either intramural or extramural), it is my responsibility to ensure that the description of human subjects use in the funding proposal(s) is identical in principle to that contained in this application. I will submit modifications and/or changes to the IRB as necessary to ensure concordance.

I and all the co-investigators and research personnel in this study agree to comply with all applicable requirements for the protection of human subjects in research including, but not limited to, the following:

- Obtaining the legally effective informed consent of all human subjects or their legally authorized representatives, and using only the currently approved, consent form with the IRB approval stamp (if applicable); and
- Obtaining written notification of approval from the IRB before implementation of any changes to the project (except when necessary to eliminate apparent immediate hazards to the subject); and
- Reporting via the Problem Report any unanticipated problem; and
- Promptly providing the IRB with any information requested relative to the project; and
- Promptly and completely complying with an IRB decision to suspend or withdraw its approval for the project; and
- Obtaining continuing review prior to the date approval for this study expires; and
- Granting access to any project-associated records to the IRB to ensure compliance with the approved protocol.

Name of Principal Investigator / Researcher: Peng Qian

Signature:

ADVISOR'S ASSURANCE (if applicable)

I assume responsibility for ensuring the competence, integrity and ethical conduct of the investigator(s) for this research project. The investigator(s) is/are fully competent to accomplish the goals and techniques stated in the attached proposal. Further, I certify that I have thoroughly reviewed this application for readability and accuracy and the study is clearly described herein.

I have reviewed the proposed research and concluded that the following apply:

- The research uses procedures consistent with sound research design.
- The research design is sufficiently sound to yield the expected knowledge.

Name of Advisor: Dr. Keith H. Coble

Signature:

I. Project Information

Type of submission:

☒ Original Submission
☐ Revisions pending approval under Study # _____
☐ Requesting Developmental Approval* only
Include a timeline for development of the project. Estimated date for submission of a revised IRB application: _____
☐ Revision to previous Developmental Approval
If you already have developmental approval, list the docket number assigned to the first submission of the study: _____

**Also referred to as "118 designation" - see Developmental Approval or "118 Designation" for more details. No human subjects (including use of identifiable data) may be involved in the research prior to final IRB approval.*

Project Period: **from** Upon IRB Approval **to** 5/30/14
Includes both data collection and data analysis

- *Start date cannot predate IRB approval date; may be "upon IRB approval"*

Study Funding:

☐ External Funding
Agency: _____
SPA Proposal or Fund/Account Number: _____
PI of Award (if different than Principal Investigator/Researcher listed above): _____
☒ Department Funds
☐ Other, specify: _____

Graduate Students:

- All graduate (thesis or dissertation) committee members should be listed on the application using the Student Committee Form, and must have IRB training.

II. Personnel & Qualifications

- In the table below, describe the role and responsibilities of all research personnel and describe their qualifications as they relate to their abilities to perform responsibilities associated with the study.
- As principal investigator, it is your responsibility to ensure that all individuals conducting procedures described in this application are adequately trained prior to involving human participants.
- All personnel listed on this application are required to successfully complete the MSU IRB & Human Subjects training course or an IRB-approved alternative. Training will be verified by IRB staff before approval is granted.

Names of all research personnel involved in the design, conduct, or reporting of the research - *Use additional copies of this page as needed.*
Complete and attach a Contact Information Form for all new individuals and individuals with updated information.

Name	Institutional Affiliation[1] (Choose only one for each individual)	Does this person or an immediate family member have a financial interest related to the research? [2] Yes***	No
Principal Investigator: Peng Qian Net ID: pq17 MSU Department: Agricultural Economics Student: Thesis ☒, Dissertation ☐ Preferred phone number: 662-312-9287 Email: pq17@msstate.edu	☒ MSU Student ☐ MSU Faculty or Staff ☐ MSU Adjunct or Visiting Faculty* ☐ Other:**	☐	☒
Role, responsibilities and qualifications: Peng Qian is a graduate student in the Department of Agricultural Economics, and will be the principal investigator in the experiment and his thesis is primarily based on the data and results from the experiment. Peng Qian will design and oversee the experiment, collect and analyze the data, and then construct his own thesis based on the experiment results.			
Advisor (if applicable): Dr. Keith H. Coble Net ID: khc3	☒ MSU Faculty, Staff, or Student ☐ MSU Adjunct or Visiting Faculty* ☐ Other:**	☐	☐
Role, responsibilities and qualifications: Dr. Coble will oversee the experiment design, collection of data and analysis of data. Dr. Coble has a Ph.D. from Texas A&M University and is a W.L. Giles Distinguished Professor of agricultural economics. Dr. Coble has conducted a vast amount of experimental research on human subjects and he is experienced in human subject experiments.			
Name: Ardian Harri Net ID: ah333	☒ MSU Faculty, Staff, or Student ☐ MSU Adjunct or Visiting Faculty* ☐ Other:**	☐	☒
Role, responsibilities and qualifications: Dr. Ardian Harri will assist with the design of the experiment, help conduct the experiment, and have access to the data and confidential information. Dr. Harri has a Ph.D. from Oklahoma State University and has been involved in experimental research for years and has published an amount of papers on experimental study.			
Name: Kalyn Coatney Net ID: ktc76	☒ MSU Faculty, Staff, or Student ☐ MSU Adjunct or Visiting Faculty* ☐ Other:**	☐	☒
Role, responsibilities and qualifications: Dr. Kalyn T. Coatney will assist with the design of the experiment, help conduct the experiment, and have access to the data and confidential information. Dr. Coatney has a Ph.D. from the University of Wyoming and has previously conducted experimental research on human subjects. Dr. Coatney has been involved in and published experimental economics research since 1999.			
Name: Net ID:	☒ MSU Faculty, Staff, or Student ☐ MSU Adjunct or Visiting Faculty* ☐ Other:**	☐	☒
Role, responsibilities and qualifications:			
Name: Net ID:	☐ MSU Faculty, Staff, or Student ☐ MSU Adjunct or Visiting Faculty* ☐ Other:**	☐	☐
Role, responsibilities and qualifications:			
☐ Check here to indicate additional investigator(s) are listed on a separate form.			
[1]Individuals not classified as regular MSU Faculty, Staff, or Students may only be covered by the MSU IRB under limited circumstances.			

*MSU Adjunct or Visiting Faculty** may be covered by the MSU IRB for activities conducted in association with their MSU appointment. Confirmation of Adjunct or Visiting status must be conveyed to the IRB by the appropriate department head, the individual's MSU offer letter, or current listing in the MSU Employee Directory.
Non-MSU affiliates may only be covered at the discretion of the MSU IRB. The Individual Investigator Agreement (IIA) must be completed for each non-affiliate whose activities the MSU IRB is being petitioned to cover. The IIA is not necessary for individuals who will receive approval of their activities from an IRB at another institution.

(2)Financial interest

- "Immediate Family" means spouse and dependent children.
- "Financial Interest Related to the Research" means any of the following interests in the sponsor, product or service being tested, or competitor of the sponsor held by the individual or the individual's immediate family:
  - Ownership interest of any value including, but not limited to stocks and options exclusive of interests in publicly-traded, diversified mutual funds.
  - Compensation of any amount including, but not limited to honoraria, consultant fees, royalties, or other income.
  - Proprietary interest of any value including, but not limited to, patents, trademarks, copyrights, and licensing agreements.
  - Board or executive relationship, regardless of compensation.
  - The occurrence of any reimbursed or sponsored travel (i.e., that which is paid on behalf of the individual and not reimbursed to the individual so the exact monetary value may not be readily available) related to the institutional responsibilities. This does not apply to travel that is reimbursed or sponsored by a Federal, state, or local government agency, an institution of higher education as defined at 20 U.S.C. 1001 (a), an academic teaching hospital, or a research institute that is affiliated with an institution of higher education.

***If yes, submit a Financial Interest Disclosure Form.**

III. Research Protocol

1. Site of work:
   List each MSU site where the research procedures will be performed. Please be as descriptive as possible (e.g., building, room number, Drill Field).

   Computer Lab, Room 010, Lloyd-Risks -Watson Building

   If any of the research activities will be conducted at a performance site that is geographically separate from MSU or at a site that does not fall under the MSU HRPP's authority, please provide information below about that site For additional sites, use the External Site Form.

Site	Has the site given permission for the research to be conducted?	Will the site receive federal funding passed through from your grant?	Will the site's IRB review the research?	Will the site rely on MSU's IRB to review the research?
Site name: Address:	☐Yes ☐No ☐N/A	☐Yes ☐No	☐Yes ☐No	☐Yes* ☐No
Site name: Address:	☐Yes ☐No ☐N/A	☐Yes ☐No	☐Yes ☐No	☐Yes* ☐No
Site name: Address:	☐Yes ☐No ☐N/A	☐Yes ☐No	☐Yes ☐No	☐Yes* ☐No
Site name: Address:	☐Yes ☐No ☐N/A	☐Yes ☐No	☐Yes ☐No	☐Yes* ☐No
☐ Check here to indicate additional site(s) listed on separate form.				
*Not allowed for Veterans Affairs research.				

For multi-site research in which MSU is the lead, applications must include information that is relevant to the protection of participants, such as: unanticipated problems involving risks to participants or others, interim results, and/or protocol modifications.

2. Description of the project and Scientific or Scholarly Validity review.
   a. Brief description of the general purpose of the project (to include the scientific or scholarly rationale for the study).

      Experimental economics is an increasingly popular tool used by economists to study decision making. Experimental markets provide a controlled setting in which specific market behaviors can be isolated and assessed. Laboratory experiments are used to assess the outcomes of decision making and behavior in markets ex ante, that is, "before the event". Laboratory can be also used to assess the outcomes of markets where adequate real-world data does not exist.

      This experiment is mainly to investigate whether people would make cognitive errors when making decisions to buy crop insurance through specific experimental settings. During this experiment , two different machenisms will be used and we would like to see what different results would come from them. One experiment is just a dichotomous choice and the other one is stemmed from an experimental setting created by Offerman and Sonnemans (2004). We are to investigate how subjects behave in a series of purchase decisions in a dynamic market environment, in order to test hypotheses.

      This applied research will assist crop insurance policy maker or insurance companies in identifying how they reconsider demand and look into deeply how farmers make decisions to buy crop insurance.

      Citation:

      Offerman, T., Sonnemans, J. 2004. "What's Causing Overreaction? An Experimental Investigation of Recency and the Hot-hand Effect" Scand. J. of Economics 106(3), 533-553.

   b. For research where the PI is not a student, be sure to submit the Scientific or Scholarly Validity Review Form signed by the appropriate individual. The review for student research is documented on the Investigator's Assurance page of this document.

3. In your view, what benefits (individual and/or societal) may result from the study that would justify asking the subjects to participate?

   Indirect benefits. General benefits of this research include a better understanding of decision making in market purchases. This information is used to test hypotheses related to human behavior in economics settings. Resulsts are used for policy maker and insurance companies.
   Direct benefits to subjects. Subjects participating in experimental sessions benefit directly from show-up fees and participation fees, which are paid to them

in the real cash; they may potentially be provided additional financial incentive in order to motivate them take it seriously based on their performance during the experiments. The payment will be also in the real cash. Participants learn more about how they decide what they will be performing in the market.

4. Give details of the procedures that relate to the subjects' participation.
   - *If the procedures are in an existing document (for example, a grant or dissertation proposal), you may attach the document or the pertinent parts of the document that further explain your project. However, the study must be fully described within the application. Be sure to reference any attachment.*
   - *Append a copy of all questionnaires or test instruments. If the procedures involve observation, please include the type of behavior or action you expect to observe and record. If the procedures involve an interview, attach a sample of questions you plan to ask.*
   - *Describe all interactions (contacts, interventions, observations, etc.) between the researchers and participants.*
   - *Describe procedures being performed already for diagnostic or treatment purposes, if any.*

1) Upon arrival, subjects pick up one consent form first and assign a subject ID number. Subject ID number is to be entered on all data collection materials.
2) Sign consent form and hand to Front Door Moderator
3) Subjects pick up experiment instruction from Experiment Moderator, a $5 cash is given before they sign the receipt
4) Subjects read the instructions of the first experiment while the Experiment Medorator is reading the instructions word by word.
5) A few practice rounds will be run and subjects will decide to purchase crop insurance contracts on the computer, letting subjects be familiar with the rules before the real rounds.
6) The real rounds of the first experiment are going on after a couple of practice rounds. Subjects are asked two questions under specific experimental settings.
7) Subjects take a short break between the two separate experiments
8) Subjects read the instructions of the second experiment while the Experiment Medorator is reading the instructions word by word.
9) A few practice rounds will be run just like in the first experiment and subjects will decide to purchase crop insurance contracts on the computer, letting subjects be familiar with the instructions before real rounds.
10) The real rounds of the second experiment are going on after a few practice rounds.
11) Subjects are required to answer two probability questions and one question whether to purchase the insurance policy in each round when the Experiment Moderator is showing them the additional important information with the help of projector.
13) After subjects finish all the rounds of questions, the second experiment is done, which means the whole experiment is over as well.
14) Upon subjects' completion of the whole experiments, Experiment Moderator saves each of the spreadsheets.
15) At the end of the whole experiment, subjects come to a private area

to receive the payment in real cash which is based on the purchase performances during the experiments and sign the consent form again. Participation procedure: participation is voluntary Research information: participants are told that the experiment is used to study the economics of decision making. Data collection. Data from spreadsheets are captured via participant responses via computers.

5. Indicate any of the following populations that are to be included in the study.

☐ Pregnant women/Fetuses	☒ Students and/or employees of MSU
☐ Prisoners	☐ Substance abusers
☐ Children (under age 18)	☐ Non-english speaking people
☐ Adults with cognitive impairments	☐ Other population(s) vulnerable to coercion or undue influence (specify):
☐ No vulnerable populations	

a. Describe whether any prospective participants will be in a subordinate position to or otherwise vulnerable to coercion or undue influence of anyone involved in the study (e.g, students in an investigator's class or employees supervised by one of the researchers).

It is possible that some participants have been enrolled or will be enrolled in the investigators' courses. However, participation is voluntary and will not impact the grade of those who participate.

b. Indicate additional precautions being taken to ensure protection of the populations indicated above.

To protect those participants all instructions are formally presented by the investigator. Sessions are conducted in facilities that meet the Mississippi State University safety guidelines.

6. Describe selection (inclusion/exclusion) criteria for participation (i.e., salient characteristics of subjects such as age range, gender, diagnosis, institutional affiliation, and/or other pertinent characterizations).

Potential subjects will be MSU students, faculty, and staff.

7. How many individuals will participate in the study?

We expect about 100 participants

8. Describe the recruitment and enrollment procedures. Include a final copy of any recruitment letter, advertisement, e-mail, transcript of verbal recruitment announcement, audio/video recording, etc., and state the mode of its communication.

Subjects will be recruited via posters or leaflets throughout the campus or emails sent by Department of Agricultural Economics

9. Describe any inducement or incentive that will be offered, including the amount and timing of payments to participants. *Provide justification for any inducement other than those of trivial benefit.*

Incentives. Participants will be provided opportunities, in rounds, to choose whether to buy crop insurance to keep from potential risks. In each round, there will be realized revenues according to each year's actual revenes which keep change every time. In the end of the experiment, revenues of all rounds will be aggregated and tranlated into the real cash based on a certain exchange rate. The payment records (one for the show-up fee and one for the participation fee) are attached at the end of this document, and a copy of each is provided to the participants.

10. Will the research involve obtaining records from either of the following sources?
☐ Educational records – Please note there may be specific requirements for accessing educational records for research purposes for compliance with FERPA.

☐ Medical records – Please note there may be specific requirements for accessing medical records for research purposes for compliance with HIPAA.

11. Informed Consent and Assent
A. Check the appropriate box(es) below to indicate whether you intend to (i) obtain participants' consent (or assent/parental permission) and/or (ii) request a Waiver or Alteration of Consent. It is appropriate to check boxes (i) and (ii) if you will not obtain consent for a subset of participants (e.g., you will not consent participants that only complete a screening questionnaire but participants entering the study will give consent).
i. ☒ Participants will be asked to provide consent (or, if participants are minors, they will be asked to provide their assent in addition to parental/guardian permission). Consent and assent form templates that include all required elements can be found on the IRB website at Consent and Assent Process.
a. ☒ Written signed consent/assent – consent/assent forms attached.
b. ☐ Oral consent/assent or an unsigned form - include a written transcript of what is to be said or the form that will be given to the participant(s), and attach the Request to Waive Documentation of the Consent Process form to justify the reason that signed consent will not be obtained.

ii. ☐ Investigator requests a waiver or alteration of consent. Please attach the Request to Waive or Alter the Consent Process form. An exclusion of one or more of the required elements of consent (such as omission of the true purpose in a study involving deception) would be considered an alteration of consent.

B. If you indicated in item 11.A.i. above that consent (or assent/parental permission) will be solicited, describe the consent process below.
i. Who will conduct the consent interview (e.g., name of a specific individual or description of individuals from the research team who will be obtaining

consent)? Any individual obtaining consent must be listed in the Personnel & Qualifications section (section II) of this application.

Dr. Coble, Dr. Coatney, Dr. Harri and Peng Qian

ii. Who will be asked to provide consent or permission (e.g., will participants be adults who will consent to their own participation, or will participants be minors from whom assent and parental permission will be sought)?

Participants are adults and consent is on their own behalf.

iii. Does the nature of the research (considering associated risks) warrant any waiting period between informing the prospective participant of the nature of the research and obtaining consent (i.e., to allow the participant time to consider whether to participate in the research)?

No

iv. Describe any information that will be communicated to the participants during the consent process that is not included in the written document(s) or oral script(s).

All information to be communicated to the participants is included in the consent letter and instructions. The only foreseable information that is not included, is a response by the moderator to a participant's question regarding the experiment.

v. What steps will be taken to minimize the possibility of coercion or undue influence?

Participants are informed that they may discontinue participating in the experiment without giving up benefits due them at that time.

vi. What language(s) will be understood by the prospective participant(s) or legally authorized representative(s)?

English

vii. What language will be used by those obtaining consent (member(s) of the research team indicated in item 11.B.i. above)?

English

12. Assessment of risk to participants

a. Describe any physical risks associated with the research:

Minimal risk. Participants are asked to sit in front of computers and record responses on computers. Sessions are conducted in facilities that meet the Mississippi State University safety guidelines, therefore foreseeable physical risks are no higher than those originally encountered in a campus setting. Experimental sessions generally last roughly two hours. Participants generally are asked to not attent more than one session.

b. Describe any psychological risks (e.g., feeling demeaned, embarrassed, worried, or upset):

Minimal risk. Participants are given detailed instructions of the purchase process. All subjects are informed that there are no right or wrong

decisions, only those that they deem they are in their own interest.

c. Describe any social risks (e.g., possible loss of status, privacy, or reputation):

Minimal risk. Responses to purchase decisions on computers are concealed by participants and submitted to the researchers. Information regarding the amount of allowance kept and how much other participants actually realize will not be availble to other participants

d. Describe any risks to participants' employability or insurability:

None

e. Describe any deception of participants (include the Waiver/Alteration of Consent form requested in item #11.A.ii above):

None

f. Do you see any other chance that subjects might be harmed in any way?

No

g. Describe how you will control for the risks you've identified (e.g., confidentiality procedures, emergency response plan, referral for medical care, counseling resources, data and safety monitoring plan):

Payment will be inl cash, and participants make decisions based on self interest during the experiment.

Subject identification. Subjects are identified by number only in stored data. Subjects are asked to sign on the consent and payment forms and provide their University ID for proof of participation to the funding source. ID numbers are not stored with the data.

Privacy and confidentiality. Individual information during the experiment is protected using adequate spacing of individuals during the purchase process. Show-up fees and incentives are paid privately immediately after the experiment with each subject coming up individually to receive earnings in a private area.

Data storage. All consent forms, payment records or data is kept confidential and will be maintained in the department of Agricultural Economics. Data are stored electronically in Excel files on computers and disks. These data are stored for use in current and future analysis. Consent forms that include participants' signitures will be maintained in a locked file carbinet in primary investigator's office. Payment forms will be maintained during the life of the project.

Access to the data. The data will be accssible to the primary and co-investigators and any graduate students related to the project.

Access to the consent forms. Consent forms will be only accessible to the primary and co-investigator.

Access to payment forms. Other than primary and co-investigator, payment records may be provided to funding sources to account for funds used for participation fees and experiment earnings.

13. Will the sponsor or another outside agency bear responsibility for overseeing the progress of the research study?

☐ Yes - Provide a copy of the plan or agreement that requires the outside agency to promptly report findings detected during the monitoring process that could affect the safety or medical care of participants or influence the conduct of the study. The plan should also describe the steps to be followed to communicate results to participants when those results directly affect their safety or medical care. If no plan exists, please attach the Data and Safety Monitoring Plan form.

☒ No

For international research, will a local IRB provide oversight of the research? If so, how will documents, including but not limited to: initial review, continuing review, review of modifications, post-approval monitoring, handling of complaints, non-compliance, and unanticipated problems involving risk to participants or others, be coordinated and communicated to the MSU HRPP?

☐ Yes - Please explain:

☐ No

14. Describe provisions to protect the privacy of participants during the course of the study, including recruitment and data collection activities. Please address the following questions in your response.

a. Will the research involve gathering private information without participants' consent (if so, include the Waiver/Alteration of Consent form requested in item #11.A.ii above)?

No

b. Will participants be asked intrusive questions for which they have not given consent (if so, include the Waiver/Alteration of Consent form requested in item #11.A.ii above)?

No

c. Will participants be subjected to any physical intervention or manipulation of their environment for which they have not given consent (if so, include the Waiver/Alteration of Consent form requested in item #11.A.ii above)?

No

d. During the conduct of the study (including the process of recruitment and follow-up) might participants be publicly identified or embarrassed (i.e., "outed"), or might participants' responses be overheard or observed by individuals outside the research team (e.g., might participants see other participants' responses on a survey in a crowded classroom or interview responses be overheard)?

No

e. Is the research being conducted in a setting (e.g, international research) in which the cultural norms of the participants might affect expectations of privacy (e.g., interaction among different religious or ethnic groups, or genders)? Might participants otherwise feel their privacy is violated in the conduct of the research?

No

15. How do you ensure confidentiality of information collected?
<u>At a minimum, provide the following information</u>:

a. Who will have access to the data?

Investigators: Dr. Coble. Dr. Coatney, Dr. Harri and Peng Qian

b. Where will data be stored?

Data storage. All consent forms, payment records and data is kept confidential and will be maintianed in the Department of Agricultural Economics. Data are stored electronically in Excel files in computers and disks. These data are stored in use for current and future analysis

c. What provisions are in place to protect the confidentiality of the data (e.g., physical measures such as locked offices and filing cabinets, and/or electronic measures such as secured networks, data encryption, password protection) during storage, use, and transport/transmission (if applicable) of data?

Data will be stored on the password-protected office computers of the investigators, in locked office.

d. Where will signed consent forms be stored (be specific regarding location)?

Consent forms that include participants' signitures will be maintained in a locked file carbinet in primary investigator's office.

e. What <u>direct identifiers</u> (such as name, student ID number, Net ID, etc.) or <u>indirect identifiers</u> (such as demographics sufficient to identify individual participants considering the study population) will be collected?

Subjects are asked to sign on the consent and payment forms and provide their University ID for proof of participation to the funding source. ID numbers are not stored with the data. Payment forms will be maintained in the same fashion as the consent forms during the life of project.

f. What purpose do the identifiers serve?

Subjects are identified by an Experimental Identification number only in stored data.

g. When will identifiers be removed or "de-linked" from the data? (Identifiers include a code number, which may be linked to another document containing names or other identifying information.)

No linking between personal information and data is maintained.

h. Will the data be retained indefinitely or destroyed?

Retained

i. If the data will be destroyed, how and at what point in time (be as specific as possible)?

N/A

16. Are approvals needed from another MSU regulatory committee (i.e. IACUC for animals or IBC for infectious agents or recombinant DNA)? If so, please attach approval letter(s) from appropriate committee(s). If approval has not yet been obtained, where are you at in the approval process?

No

17. Is there any additional information you would like to provide?

No

Experiment Instructions

Crop Insurance Purchase Experiment

Thank you for attending today, you will be participating in an economic experiment where you can earn a payment for participating. To begin, read and sign the disclosure statement; and you will earn a payment as your show-up fee in Holt-Laury Choice Task. You will be able to earn more money in this experiment. I will first explain the experiment and then tell you how you will be able to earn more.

Holt-Laury Lottery Choice Task

- The sheet of paper shows ten rows of questions and each question needs a decision which is a paired choice between "Option A" and "Option B".
- You will make ten choices and record these in the final column, but only one of them will be used in the end to determine your earnings
- Here is a ten-sided die that will be used to determine payoffs; the faces are numbered from 1 to 10 (the "0" face of the die will serve as 10.)
- After you have made all your choices, we will throw this die twice, once to select one of the ten decisions to be used, and a second time to determine what your payoff is for the option you chose, A or B, for the particular decision selected.
    - For example, look at Question 1 at the top. In Question 1, for the second throw, the higher prize is paid if the throw of die is 1 and the lower prize is paid when any other throw appears. For question 2, the higher prize is paid when the throw is 1 or 2 while the lower prize is paid for 3 through 10.
- The other Questions are similar, except that as you move down the table, the chances of the higher payoff for each option increase.
- Even though you will make ten decisions, only one of these will end up affecting your earnings.
    - You will not know in advance which decision will be used. Obviously, each decision has an equal chance of being used in the end.

To summarize, you will make ten choices: for each Question row you will have to choose between Option A and Option B. You may choose A for some Question rows and B for other rows and you may change your decisions and make them in any order.

- When you are finished, we will throw the ten-sided die to select which of the ten Questions will be used.
- Then we will throw the die again to determine your money earnings for the Option you chose for that Question. At last, you write your earnings in the blank at the top of the page.

Are there any questions? Now you may begin making your choices. Please do not talk with anyone while we are doing this; raise your hand if you have a question.

Subject No. ___________ Date ___________ Total Earning ____________

Question	Option A	Option B	Which Option Is preferred?
1	10% chance of $10.00, 90% chance of $8.00	10% chance of $19.00 90% chance of $1.00	
2	20% chance of $10.00, 80% chance of $8.00	20% chance of $19.00 80% chance of $1.00	
3	30% chance of $10.00, 70% chance of $8.00	30% chance of $19.00, 70% chance of 1.00	
4	40% chance of $10.00, 60% chance of $8.00	40% chance of $19.00, 60% chance of $1.00	
5	50% chance of $10.00, 50% chance of $8.00	50% chance of $19.00, 50% chance of $1.00	
6	60% chance of $10.00, 40% chance of $8.00	60% chance of $19.00, 40% chance of $1.00	
7	70% chance of $10.00, 30% chance of $8.00	70% chance of $19.00, 30% chance of $1.00	
8	80% chance of $10.00, 20% chance of $8.00	80% chance of $19.00, 20% chance of $1.00	
9	90% chance of $10.00, 10% chance of $8.00	90% chance of $19.00, 10% chance of $1.00	
10	100% chance of $10.00, 0% chance of $8.00	100% chance of $19.00, 0% chance of $1.00	

Game 1

- In this game you will be playing the role of a farmer growing a crop. Like most crop farmers you do not control either the weather which affects the yield of your crop or the market price you will receive at harvest time which occurs approximately six months after you plant the crop.
- You are planning to grow 100 acres of the new crop. On average the revenue from this crop is $100/acre/year but it costs $90/acre/year to grow it. So in total you will generate $1000 profits on average in each year. There is only one harvest per year. If yields or harvest prices are low you lose money that year.
- To help you understand the revenue risk of this crop we will show you the following histogram of the revenue for the crop, which are *1000 observations from the true distribution*, on your own computer. You can assume that these 1000 observations are the past 1000 years' historical revenues and we are going to have a new 50 years to grow crop. The histogram will **NOT change** throughout this game.
- However you may purchase an insurance product that protects you from low revenue. The insurance will work in this manner. If your revenue falls below $90/acre in a year, the insurance will make up the difference with an indemnity to you. So

  Indemnity=90-revenue, if revenue is less than 90, else indemnity=0

  - For example, if revenue is $60 per acre the insurance would pay you $30 per acre or if revenue was $10 per acre the insurance would pay $80 per acre. However, if revenue is over $90 per acre, the insurance pays nothing. The cost of this insurance is [$4 per acre].
- Then you will be asked to state "**what is the probability of collecting insurance (the probability that revenue falls below $90 per acre) do you think it would be in the next year**".
  - Note you need to input your answer that may fall between 0% meaning there is no chance you will receive an indemnity in the next period and

100% meaning you are certain revenue will fall below $90 per acre next period.

- You will be asked "**whether or not you are willing to buy an insurance"** to protect you from potential loss from revenue, or not if you think it is too expensive.
    - Noted that this is just a yes-or-no question, and you need to input in the respective cell, "1" meaning "willing to buy" and "0" meaning "not willing to buy".
- Please raise your red card to indicate your completion of this question. After everybody raises their cards, an observation of revenue will be **randomly** drawn from *the true revenue distribution from which the 1000 historical data observations were drawn*, and shown on the monitor. You need to input the revenue in the cells by yourself and the net return in this round will be shown up automatically. To summarize, the average revenue is $100 per acre but the cost to grow the crop is $90. So you would expect to cost $9000 and make $1000/year by planting 100 acres of the crop on average. The payoff are coming as follow,

$$\text{Net return} = \text{crop revenue} - \text{cost} + \text{insurance indemnity} - \text{premium}, \text{ if insured,}$$

$$\text{Net return} = \text{crop revenue} - \text{cost}, \text{ if not insured.}$$

- You will receive one dollar for every $5000 of net return in the game.
- The last thing to be noted: the cell will be locked after your input and you CANNOT go back to edit it. So you've just got one chance to input your answer. Be careful and cherish it!

Game 2

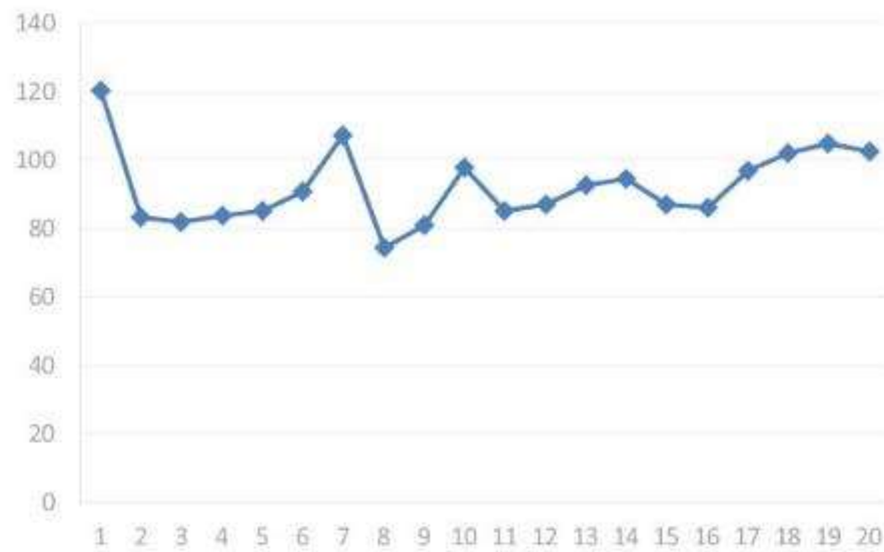
- In this game you will still be playing the role of a farmer growing a crop. Like most crop farmers you do not control either the weather which affects the yield of your crop or the market price you will receive at harvest time which occurs approximately six months after you plant the crop.
- You are planning to grow 100 acres of the new crop. On average the revenue from this crop is \$100/acre/year but it costs \$90/acre/year to grow it. So in total you will generate \$1000 profits on average in each year. There is only one harvest per year. If yields or harvest prices are low you lose money that year
- However you may purchase an insurance product that protects you from low revenue. The insurance will work in this manner. If your revenue falls below \$90/acre in a year, the insurance will make up the difference with an indemnity to you. So

$$\text{Indemnity} = 90 - \text{revenue}, \text{if revenue is less than } 90, \text{else indemnity} = 0.$$

  - For example, if revenue is \$60 per acre the insurance would pay you \$30 per acre or if revenue was \$10 per acre the insurance would pay \$80 per acre. However, if revenue is over \$90 per acre, the insurance pays nothing. The cost of this insurance is \$4 per acre.
- You will look at **21** observations instead of one in each period. You also need to know that there is a 50/50 chance that the **21** revenues from one year to the next are either <u>independent or correlated</u>. That is, if revenues are independent across time, then the revenue for this year will have no relationship with next year's revenue. However, if revenues are correlated then if **<u>this year's revenue is above average</u>** there is a 70% chance **<u>next year's revenue will be above average</u>**. Conversely, if this year's revenue is **<u>below average</u>** there would be a 70% chance next year's revenue will be **<u>below average</u>**.

- To help you understand what *autocorrelation* really means. It can be defined as "correlation between members of series of observations ordered in time and space"[16]
- The following are some graphs to help you further understand correlation:

  - 90% Autocorrelation



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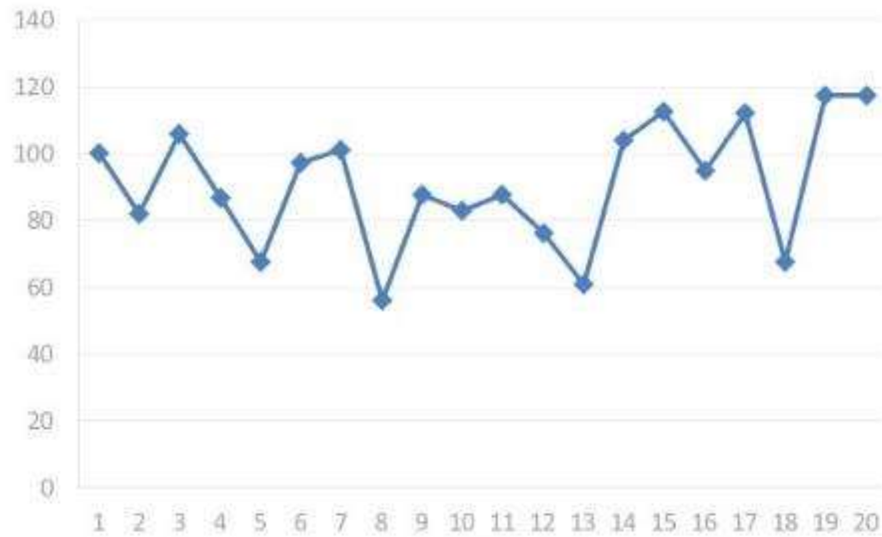
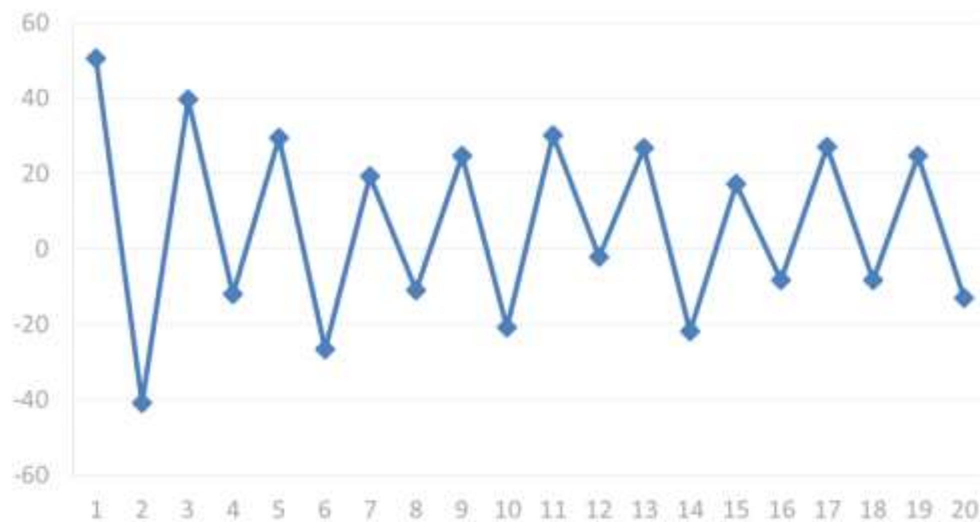
[16] Maurice G. Kendall and William R. Buckland, *A Dictionary of Statistical Terms,* Hafner Publishing Company, New York, 1971, p. 8.

- 0% Autocorrelation (Uncorrelated or Independent)



- -90% Autocorrelation



- With the help of the computer, in each round we will draw **21** observations of farm revenues, which have a **50/50** chance to be 70% correlated or uncorrelated, for you to observe. **First twenty** observations are shown to you before you make a decision. **The last** observation will be shown to you to determine your net return in this period after you answer the following three questions.

- Based on the twenty observations you were just given,

  What is the chance that this crop's revenue is correlated across time?

  [Note your answer may fall between 0% , meaning there is no chance crop revenue is correlated across time and 100% meaning you are certain revenue is correlated across time.] Remember there is 50/50 chance revenue is correlated across time or not.

  The next question is:

  Given the series you are observing, **what is the chance that you will collect an indemnity** if you purchase the insurance policy?

  [Note your answer may fall between 0% meaning there is no chance you will receive an indemnity in the next period and 100% meaning you are certain revenue will fall below $90 next period.]

  Then third question is:

  Are you willing to pay [4 $/acre] **for the insurance policy to protect your revenue**? Answer either yes or no, 1 for "YES" and 0 for "NO".

- Please raise your red card to indicate your completion of this question. After everybody raises their cards, the computer will show you the last observation from the series you observed. You need to input the drawn revenue into the cells by yourself.
  - So the actual revenue outcome, according to the explanations above, will be correlated with the last observation if drawn from the correlated revenue series; or it will be uncorrelated if the observation is from the uncorrelated series. This actual revenue will determine the net return from the farm and any insurance indemnity to be paid.

- Your second source of earning from this game will be based on the first question about whether you think revenues are correlated across time. **Remember**, the question asked you what the chances the crop's revenue is correlated across time. The payoff table below shows you that how many points you will obtain based on your reported probability if the revenues are "correlated' or "uncorrelated". (It does not mean you necessarily need to answer in increments of 10, you can put any number 0 -100 in percentage) The aggregate earnings from every period will be averaged and you will receive one dollar for 1000 points earned.

Points	Reported Probability (%)										
	0	10	20	30	40	50	60	70	80	90	100
Correlated	0	900	600	100	400	500	400	100	600	900	10000
Uncorrelated	10000	900	600	100	400	500	400	100	600	900	0

- Therefore, as you can discern, the best strategy here for you is to honestly tell us the true evaluation of probabilities.

- Finally, you will earn from the revenue for the farm. The average revenue per acre is $100 but it costs $90 to grow the crop. So you would expect to make $1000/year in 100 acres on average:

$$\text{Net return} = \text{crop revenue} - \text{cost} + \text{insurance indemnity} - \text{premium}, \text{ if insured,}$$

$$\text{Net return} = \text{crop revenue} - \text{cost}, \quad \text{if not insured.}$$

  - You will receive one dollar for every $5000 of net return in the game.
  - We will conduct 5-10 practice rounds to let you become familiar with the game and then play for 50 rounds.

- The last thing to be noted: the cell will be locked after your input and you CANNOT go back to edit it. So you've just got one chance to input your answer. Be careful and cherish it!

- After the completion of experiment, please leave your answer sheet and the instructions on the table and do not take them out of computer lab. Thank you.

APPENDIX B

SAS CODE FOR DATA ANALYSIS

```
dm log 'clear' output ;
dm output 'clear' output;
libname normal'C:\Users\pq17\Desktop\Experiment Data\Mass Data
Analysis\SAS Analysis\GAME1\normal';

dm log 'clear' output ;
dm output 'clear' output;
libname ROUNDS 'C:\Users\pq17\Desktop\Experiment Data\Mass Data
Analysis\SAS Analysis\GAME2\rounds';


/*scoring rule in Game One;/


data normal.game1;
      set normal.game1;
      dev_rp=(pi-33)**2; *deviation from real probability;
run;

proc sql;
      create table normal.game1_scoring as
      select sum(dev_rp) as sum_rp from normal.game1
      group by sub
      order by sub;

data normal.game1_scoring;
      set normal.game1_scoring;
      sqrt_rp=sqrt(sum_rp);
run;

proc sort data=normal.game1_scoring;
      by sub;
run;

data normal.game1_scoring (keep=sub sqrt_rp rename=(sqrt_rp = score));
      set normal.game1_scoring;
      by sub;
      if last.sub then output;
run;

/*scoring rule in Game Two;/

data rounds.qsr;
input sub qsr;
cards;
1     6790.5
2     7447
3     6823.5
4     6938.5
5     6845
6     6428.54
7     7289.04
8     6607.38
```

9	7039
10	7438
11	6760
12	7035.9
13	6433.5
14	6983
15	7306
16	7140.6
17	7069.5
18	7141.52
19	7651.32
20	6753.08
21	7152
22	7437
23	5976.92
24	6724
25	7353.12
26	7503.52
27	6760.44
28	6765.66
29	6575.86
30	7052.08
31	6517.42
32	7302
33	7480
34	7269.5
35	6789.5
36	6708.4
37	7228
38	7446
39	6295.8
40	6980
41	7245.16
42	7292
43	6127
44	7138.5
45	6527
46	7127.3
47	5316.918367
48	6708.52
49	7170
50	6804.5
51	7354
52	6810
53	6392
54	7515.5
55	7067
56	5855.7
57	6030
58	7359
59	7299.06
60	7289.56
61	6869.38
62	7422
63	7576.3

```
64    7134
65    7106
66    7145
67    7229.5
68    6705.8
69    7396
70    7250.44
71    6542
72    6794.26
73    6585
74    7094
75    6800
76    7001.92
77    6723.5
78    5914
79    7302.5
80    6217
81    6432
82    7364
83    7469
84    7504.92
85    7379.38
86    6627.5
87    7051.5
88    6593.42
89    6875.5
90    7241
91    7288.5
92    7404.96
93    7052.44
94    6936.32
95    5839
;
run;


data rounds.game2_scoring;
      merge rounds.game2 rounds.qsr;
      by sub;
run;

data rounds.game2_scoring (keep=sub qsr);
      set rounds.game2_scoring;
      score=qsr/1000;
      drop qsr
run;

/*purchase choice in Game One;/

data normal.game1_count;
      set normal.game1;
      if c=1 then count+1;
      if first.sub then do;
      if c=0 then count=0;
      if c=1 then count=1;
```

```
      end;
      by sub;
      if last.sub then output;
run;

/*perceived correlation compared to true correlation;/

data one;
      input period corr;
      datalines;
      1       0
2       0
3       0
4       1
5       0
6       0
7       1
8       1
9       1
10      0
11      1
12      1
13      0
14      1
15      0
16      0
17      1
18      1
19      1
20      0
21      0
22      0
23      1
24      1
25      0
26      1
27      1
28      1
29      0
30      1
31      0
32      0
33      0
34      1
35      1
36      0
37      0
38      1
39      1
40      1
41      0
42      0
43      1
44      0
45      0
```

```
46	1
47	0
48	1
49	0
50	0
;
run;

proc sql;
	create table rounds.corr as
	select one.period, sub, pa, one.corr
	from rounds.game2 as a, one
	where a.period=one.period
	order by period;

data rounds.corr1;
	set rounds.corr;
	if pa=50 then subcorr=1;else if pa<50 then subcorr=0; else
subcorr=99;
	if subcorr=99 then t=99;
	if corr=1 and subcorr^=99 then do;
		if subcorr=1 then t=1;
		if subcorr=0 then t=3;
	end;
	if corr=0 and subcorr^=99 then do;
		if subcorr=0 then t=4;
		if subcorr=1 then t=2;
	end;
	if t^=99 then output;
run;

proc freq data=rounds.corr1;
	table t;
run;


/*purchase choice in Game One;/

data normal.game1_count;
	set normal.game1;
	if c=1 then count+1;
	if first.sub then do;
	if c=0 then count=0;
	if c=1 then count=1;
	end;
	by sub;
	if last.sub then output;
run;



/*purchase choice in Game Two;/

data rounds.game2_count;
	set rounds.game2;
```

```
      if c=1 then count+1;
      if first.sub then do;
      if c=0 then count=0;
      if c=1 then count=1;
      end;
      by sub;
      if last.sub then output;
run;

/*test for the normality of purchase choices in two games;/

proc univariate data=normal.game1_count normal;
      var count_of_purchase;
run;

proc univariate data=rounds.game2_count normal;
      var count_of_purchase;
run;



/*test for the difference of purchase choices within individual in two

games;/

proc sql;
      create table normal.compare1 as
      select a.sub, (a.count_of_purchase-b.count_of_purchase) as diff
      from normal.game1_count as a, (select * from rounds.game2_count
                                                      group by sub
having count(*) not in (42, 43, 88)) as b
                  where a.sub=b.sub;

proc univariate data=normal.compare1;
      var diff;
run;

/*probability regression in Game One;/

data normal.game1_pc;
      set normal.game1 (drop = gy1--gy6 by1_--zg2
rename=(pichange=pch));
      pch1=lag(pch);
      pch2=lag2(pch);
      pch3=lag3(pch);
      do i=0 to 91;
      if _n_=1+50*i then do;
      pch1=.;
      pch2=.;
      pch3=.;
      end;
      if _n_=2+50*i then do;
      pch1=.;
      pch2=.;
      pch3=.;
```

```
        end;
        if _n_=3+50*i then do;
        pch2=.;
        pch3=.;
        end;
        if _n_=4+50*i then do;
        pch3=.;
        end;
        end;
run;

proc means data=normal.game1_pc maxdec=2;
        var pch pch1 pch2 pch3;
run;



proc reg data=normal.game1_pc;
        model pch = pch1 pch2 pch3;
        by sub;
        ods output ParameterEstimates=normal.pc_Est
FitStatistics=normal.pc_fit;

run;

%macro sign(set=, testvar = );
        %let k=1;
        %let var = %scan(&testvar, &k);
        %do %while (&var NE);
                data normal.&set;
                        set normal.&set;
                        if variable ="&var" then do;
                                if 0<probt<0.1 then
                                do;
                                        if estimate>0 then sig_&var=1;
                                        else if estimate<0 then sig_&var=-1;
                                end;
                        end;
                run;

                proc freq data=normal.&set;
                        tables sig_&var
                run;
                %let k=%eval(&k+1);
                %let var=%scan(&testvar, &k);
        %end;
%mend;

%sign(set=pc_est, testvar=pch1 pch2 pch3);




/*probability regression in Game Two;/
```

```
data rounds.game2_pc;
      set rounds.game2 (drop = gy1--gy6 by1_--zg2
rename=(pichange=pch));
      pch1=lag(pch);
      pch2=lag2(pch);
      pch3=lag3(pch);
run;

data rounds.game2_pc;
      set rounds.game2_pc;
      do i=0 to 91;
      if _n_=1+50*i then do;
      pch1=.;
      pch2=.;
      pch3=.;
      end;
      if _n_=2+50*i then do;
      pch1=.;
      pch2=.;
      pch3=.;
      end;
      if _n_=3+50*i then do;
      pch2=.;
      pch3=.;
      end;
      if _n_=4+50*i then do;
      pch3=.;
      end;
      end;
run;

proc means data= rounds.game2_pc maxdec=2;
      var pch pch1 pch2 pch3;
run;



proc reg data= rounds.game2_pc;
      model pch = pch1 pch2 pch3;
      by sub;
      ods output ParameterEstimates=rounds.pc_Est
FitStatistics=rounds.pc_fit;

run;

%macro sign(set=, testvar = );
      %let k=1;
      %let var = %scan(&testvar, &k);
      %do %while (&var NE);
            data rounds.&set;
                  set rounds.&set;
                  if variable ="&var" then do;
                        if 0<probt<0.1 then
```

```
                        do;
                              if estimate>0 then sig_&var=1;
                              else if estimate<0 then sig_&var=-1;
                        end;
                  end;
            run;

            proc freq data=rounds.&set;
                  tables sig_&var
            run;
            %let k=%eval(&k+1);
            %let var=%scan(&testvar, &k);
      %end;
%mend;

%sign(set=pc_est, testvar=pch1 pch2 pch3);

/*demand regression without square terms in Game One;/



data normal.game1_pc;
      set normal.game1_pc;
      do i=0 to 91;
      if 1+50*i<=_n_<=4+50*i then do;
      gy=.;
      by=.;
      end;
      if 5+50*i<=_n_<=6+50*i then gy=.;
      end;

run;

data normal.game1_pc;
      set normal.game1_pc;
      if 0<=gy<3 then gy=0;
      if 0<=by<2 then by=0;
      gysq=gy*gy;
      bysq=by*by;
run;

data normal.game1_pc;
      set normal.game1_pc;
      period1=lag(period);
      do i=0 to 91;
      if _n_=1+50*i then period1=0;
      end;
run;



proc means data=normal.game1_pc maxdec=2;
      var c pi gy by period1 gysq bysq;
run;
```

```
proc logistic data=normal.game1_pc ;
      model c (event='1') = pi gy by period1 / firth maxiter=99999;
      by sub;
      ods output ParameterEstimates=normal.choice_Est
FitStatistics=normal.choice_fit;
run;



%macro sign_chi(set=, testvar = );
      %let k=1;
      %let var = %scan(&testvar, &k);
      %do %while (&var NE);
            data normal.&set;
                  set normal.&set;
                  if variable ="&var" then do;
                        if 0<probchisq<0.1 then
                        do;
                              if estimate>0 then sig_&var=1;
                              else if estimate<0 then sig_&var=-1;
                        end;
                  end;
            run;

            proc freq data=rounds.&set;
                  tables sig_&var
            run;

            %let k=%eval(&k+1);
            %let var=%scan(&testvar, &k);
      %end;
%mend;



%sign_chi(set=choice_est, testvar=pi gy by period1)


/*demand regression without square terms in Game Two;/

proc logistic data=normal.game1_pc ;
      model c (event='1') = pi gy by gysq bysq period1 / firth
maxiter=99999;
      by sub;
      ods output ParameterEstimates=normal.choice_Est
FitStatistics=normal.choice_fit;
run;

%sign_chi(set=choice_est, testvar=pi gy by gysq bysq period1)



/*demand regression in Game Two;/
```

```
data rounds.one;
      input period goodyear badyear;
      datalines;
1          0          1
2          0          1
3          2          0
4          0          1
5          2          0
6          6          0
7          0          1
8          5          0
9          4          0
10         10         0
11         0          2
12         2          0
13         8          0
14         16         0
15         0          1
16         0          2
17         7          0
18         8          0
19         1          0
20         0          1
21         12         0
22         4          0
23         0          5
24         1          0
25         1          0
26         1          0
27         11         0
28         0          6
29         1          0
30         7          0
31         2          0
32         1          0
33         11         0
34         0          1
35         1          0
36         0          1
37         1          0
38         5          0
39         1          0
40         3          0
41         0          2
42         3          0
43         5          0
44         0          1
45         4          0
46         1          0
47         1          0
48         9          0
49         0          2
50         0          2
```

```
;
run;


proc sort data=rounds.game2;
      by sub;
run;

data rounds.game2;
      set rounds.game2;
      period+1;
      if first.sub then period=1;
      by sub;
run;

proc sql;
      create table rounds.g2 as
      select *
      from rounds.game2 as a,
             two as b
      where a.period=b.period
      order by sub, period;
quit;

data rounds.g2;
      set rounds.g2;
      period1=lag(period);
      do i=0 to 94;
      if _n_=1+50*i then period1=0;
      end;
      drop i;
run;

proc means data=rounds.g2 maxdec=2;
      var c pi pa goodyear badyear period1;
run;

proc logistic data=rounds.g2;
      model c (event='1') = pi pa goodyear badyear period1/ firth
maxiter=99999;
      by sub;
      ods output ParameterEstimates=rounds.est;
run;

%macro sign_chisq(set=, testvar = );
      %let k=1;
      %let var = %scan(&testvar, &k);
      %do %while (&var NE);
            data rounds.&set;
                  set rounds.&set;
                  if variable ="&var" then do;
                        if 0<probchisq<0.1 then
                        do;
                              if estimate>0 then sig_&var=1;
                              else if estimate<0 then sig_&var=-1;
```

```
                        end;
                  end;
            run;

            proc freq data=rounds.&set;
                  tables &var;
            run;

            %let k=%eval(&k+1);
            %let var=%scan(&testvar, &k);
      %end;
%mend;

%sign_chisq(set=est, testvar=pi pa goodyear badyear period1)
```