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A Study of the Role Played by Past Experiences

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Introduction

With the proliferation of disasters that have occurred recently and the rising damages they have brought with them, investment in protection is a growing concern. Individuals, businesses, and governments have difficult decisions to make when it comes to investing in measures aimed at mitigating damages. One might think that these parties would choose to invest optimally in protecting themselves from loss. "Optimal" in this context is explained as the systematic calculation of risk and potential losses balanced with the cost and predicted benefits of total investment in protective measures. Thus, the decision-making process in this case would take into account the probability of an event occurring and the amount of damages that such an event would cause. It would then evaluate the economic benefits that a particular protective measure might provide and examine the probability that the measure will be effective. The total value of the expected benefit would then be discounted at the discount rate and compared with the total discounted value of the expected costs. Those with benefits greater than costs would be chosen. However, research shows that optimal investment often is not the case.[1],[2],[3] Numerous factors, including budget constraints, short term goals, difficulties assessing risk, and uncertainty of future benefits may change the approach that these parties take toward making their decisions.[4]

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[1] Lawless, Edward W. Technology and Social Shock. New Brunswick, New Jersey: Rutgers University Press, 1977.

[2] Shanmugam, Bala, and Philip Bourke. "Biases in Appraising Creditworthiness." The International Journal of Bank Marketing 10.3 (1992): 10-16. ProQuest. Lippincott Library, Philadelphia, PA. 23 Apr. 2004. <http://www.il.proquest.com/proquest/>.

[3] Agans, Robert P., and Leigh S. Shaffer. "The hindsight bias: The role of the availability heuristic and perceived risk." Basic and Applied Psychology. 15.4 (1994): 439-449. 23 Apr. 2004. <http://md1.csa.com/htbin/ids65/procskel.cgi>.

[4] Kleindorfer, Paul R., Howard C. Kunreuther, and Paul J. H. Schoemaker. "Societal decision making." Decision Sciences: An Integrative Perspective. Cambridge University Press. pp. 344-383.

In particular, this paper focuses on those situations in which parties are affected by a disaster of some sort and must then make decisions about future investment. Rather than examining the investment decision in a vacuum, this paper seeks to explore the role of past experience in causing investment levels to change. Past experiences in this case are defined as a prior instance in which the party was affected by a situation from which it is seeking to protect itself. Thus the occurrence of this instance must have caused the party to suffer a loss. Additionally, the instances considered are ones in which the party is able to mitigate the amount of damages caused by the event but cannot change the probability of the event occurring.

This paper will explore three case studies to address the role of past experience in changing decisions to invest in protective measures. In the first, hurricane protection will be considered. The damages caused by Hurricane Andrew will be explained and will be shown to have caused changes in protective measures taken to mitigate future losses from hurricanes. A similar case study on wildfires will be examined, with the Aspen Wildfire being shown to have provoked increased investment in wildfire protection. The final case study will examine IT security and will demonstrate the changes brought about by the SoBig.F virus.

To further test the hypothesis that past experience has an effect on increasing investment in protection, a simulation game will be examined. The game is designed to simulate decisions to invest in hurricane protection for a hypothetical home located in a hurricane-prone region. The data gathered from the game will then be analyzed to see if past hurricanes cause players to invest in greater levels of protection.

Additionally, implications and policy recommendations will be offered to help avoid the problem in the future. Finally, this paper will close with conclusions that can be drawn from the material presented.

Existing Literature

Much research has previously been done on the topic of past experience and its role in decision-making. One example is *Technology and Social Shock,* by Edward W. Lawless. In his book, Lawless reports on a series of forty-five case studies, each one based on a particular adverse event related to technological progress. For each case, Lawless gives a chronological depiction of the happenings leading up to and surrounding the particular event, as well as an account of what changes occurred as a result of the event. One particular case study concerns botulism, a rare and deadly poison to which humans can be exposed due to the improper processing of canned goods. Lawless describes the death of one man in 1971. This death was determined to have been caused by botulism from a can of Bon Vivant soup. Lawless discusses the large volume of press coverage and increasingly widespread fear caused by the botulism scare. As a result of this case, Bon Vivant was forced to declare bankruptcy, the government increased its scrutiny of factory canning processes, and companies imposed their own stricter guidelines to follow in processing canned foods.[5]

The role of past experience in investment decisions also is closely related to existing literature on the availability bias. The availability bias was first defined in 1973 by Kahneman and Tversky as one of the heuristics people use when making estimates of probability (along with representativeness and anchoring and adjustment). According to

[5] Lawless. 103-111.

this theory, people use their own recall of instances to estimate the probability of their occurrence. Thus, they will tend to overestimate the probability of instances that are easily recalled and vice versa for those that are difficult to bring to mind.[6]

Agans and Shaffer conducted another study to test the availability heuristic. They designed an experiment in which they gave participants a scenario to read that involved lung cancer, a car accident, or a homicide. They then tested the subjects' ability to accurately predict probabilities of the events occurring. They found that priming participants with information about one of these misfortunes increased the participant's evaluation of the probability that the event would occur, giving weight to Kahneman and Tversky's theory of the availability bias.[7]

Investment in Hurricane Protection

Both firms and individuals in coastal areas are faced with decisions regarding how much to spend on protection from hurricanes. Hurricane protection is interesting to consider, because while a strong storm may result in destroyed property regardless of its owners' foresight, making investments ahead of time will often bring benefits in terms of mitigated damages. In addition, hurricanes represent an event in which people may try to lessen the consequences, but have no control over the probability of the storm occurring.

A wide range of measures is available for those seeking to protect themselves from damages. For instance, the property owner may engage in such simple activities as buying plywood and sizing it to fit over each window. According to USA Today, a plan must be in place beforehand in order for this strategy to be successful. Otherwise, the

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[6] Shanmugam. 10-16.
[7] Agans.

limited amount of time between the knowledge of an impending storm and its arrival may not be sufficient for it to be carried out.[8] Similarly, damages may be mitigated by easily accomplished activities. These activities include carrying loose items into the house to keep them from turning into hazards by the heavy winds, and keeping shrubs trimmed and loose branches cleaned up. These measures have relatively low costs and can help protect the homes of owners and their neighbors.

On the other hand, some investments require a greater amount of foresight, time, and capital expenditure. For mitigating the damages of hurricanes, protecting windows is most important, and significant protection can be obtained from installing sturdy shutters and impact-resistant windows. Sturdy shutters are less likely to break off in the wind and crash into windows; impact-resistant windows are designed to endure strong blows if items of any sort are knocked into them.[9] These measures tend to be more expensive, and can range from $3,000 to $8,500 for a 1,500-square-foot home.[10] However, they can offer large benefits as they protect the most vulnerable part of the house. Investing in these "home improvement" measures requires more than a last minute effort at protection. Likewise, the decision to invest in hurricane insurance is not one that can be made with a storm on the horizon.

In analyzing the role that prior experience plays in making investments in hurricane protection, it is useful to examine a particular event. In this case, the chosen event is Hurricane Andrew due to its extensive reach and particularly damaging consequences. Hurricane Andrew hit several states around the Gulf of Mexico, but its

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[8] Williams, Jack. "Protect your home against a hurricane, without wasting time." USATODAY.com. 27 Oct. 2003. USA Today. 23 Apr. 2004. <http://www.usatoday.com/weather/whurprep.htm>.
[9] Williams.
[10] "Protecting Windows." Tampa Bay Online. 30 Apr. 2004. <http://hurricane.weathercenter.com/guide/windows.htm>.

wrath was felt most harshly in southern Florida and south-central Louisiana. It was classified as a category 4 storm (the second highest rating) and lasted from August 16-28, 1992.[11] With winds reaching up to 175 mph, it caused over $25 billion in total damages with $15.5 billion in insured losses.[12] This makes Hurricane Andrew the most expensive natural disaster in history. To give a more detailed picture of the wreckage cause by Hurricane Andrew, it was responsible for 26 deaths[13] and the destruction of over 25,000 homes, with another 101,000 that were damaged.[14] Additionally, many insurance companies did not have sufficient funds to cover losses sustained by their customers, leading to another crisis and the bankruptcy of nine insurers.[15] Even more striking, however, was the Dade County Grand Jury's estimate that many of these damages could have been prevented had it not been for "noncompliance with building codes, faulty structural designs, and the scarcity of building material and tradesmen to make repairs."[16]

The question then becomes, how did the parties that suffered this loss respond? Did they subsequently increase their investment in protective measures in order to mitigate the damages from future hurricanes? Or did they react in the opposite manner, believing that any measures they could have taken would have been ineffective? Significant evidence shows that they tended to do the former rather than the latter. As a result of Hurricane Andrew, Florida and other states adopted more stringent building

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[11] Rappaport, Ed. "Preliminary Report: Hurricane Andrew." 10 Dec. 1993. National Hurricane Center. 23 Apr. 2004. < http://www.nhc.noaa.gov/1992andrew.html>.

[12] Lecomte, Eugene and Karen Gahagan. "Hurricane Insurance Protection in Florida." Paying the Price. Ed. Howard Kunreuther and Richard J. Roth, Sr. Washington, DC: Joseph Henry Press, 1998.

[13] Rappaport.

[14] "Florida remembers Hurricane Andrew after 10 years." Caymen Net News. 232 (30 Aug. 2002). 23 Apr. 2004. <http://www.caymannetnews.com/Archive/Archive%20Articles/August%202002/Issue%20230/Florida%20Remembers.html>.

[15] Lecomte.

[16] Lecomte.

codes as defined by the International Building Code. Materials used for windows now have to endure a "large missile" test, or the force of a nine pound 2x4 hurled at 34 miles per hour, a "small missile" test, or the force of two grams of steel moving at 80 feet per second, and a cyclical pressure test, designed to make windows endure the usual pressure changes observed inside and outside the home during hurricanes.[17] Hotlines and newspapers now offer tips on preparing for hurricanes so that people know to take easy steps such as covering windows with plywood and carrying all loose items inside.[18],[19]

Moreover, the insurance crisis was addressed by both insurers themselves and by the state of Florida. Insurers, shocked by the unexpectedly high amount of losses, began to invest in catastrophic modeling techniques that use technology to better estimate their risk and allow them to adjust premiums accordingly.[20] Along with this, they have raised home insurance premiums to create larger pools of money should such an event occur again. According to Florida's Department of Insurance, "the top 10 hurricane insurance writers in the state have increased their rates an average of 137 percent since Hurricane Andrew."[21] Coastal areas of Florida have suffered the brunt of these rate increases, as other regions are at lower risk and less willing to pay significant increases.[22] The state reacted to the insurance crisis by creating the Residential Property and Casualty Joint Underwriting Association to offer insurance to those homeowners who are unable to

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[17] Randall, Brett. "From shutterless to blast." Buildings. 97.6 (Jun. 2003): 28. ProQuest. Lippincott Library, Philadelphia, PA. 23 Apr. 2004. <http://www.il.proquest.com/proquest/>.
[18] Williams.
[19] Though evidence shows that such hotlines have been established, I have been unable to find data concerning their use by homeowners or the amount of people adopting measures they have suggested.
[20] Roberts, Sally. "Cat modeling evolving as risks, technology change." Business Insurance. 37.45 (10 Nov. 2003): 32. . ProQuest. Lippincott Library, Philadelphia, PA. 23 Apr. 2004. <http://www.il.proquest.com/proquest/>.
[21] Torres, John A. "Check insurance policy before a storm develops." Florida Today. 22 May 2002. 23 Apr. 2003. <http://www.floridacapitalnews.com/hurricane/stories/052202insurance.htm>
[22] Torres.

afford it in the private market.[23] They also created the Florida Hurricane Catastrophe Fund as a reinsurance fund able to offer up to $11 billion should the state's insurance companies face another crisis.[24] These changes were implemented directly after the devastation caused by Hurricane Andrew, supporting the hypothesis that past experience tends to draw increased attention to a potential problem and, subsequently raise the level of investment in preventing the damages it causes.

Investment in Wildfire Protection

Another investment decision that must be made is that by those living in western forested states when choosing how much to invest in protection against the threat of wildfires. Contrary to popular belief, wildfires represent a natural disaster whose consequences may be mitigated by taking certain measures taken beforehand. For instance, processes such as forest thinning and prescribed burning can slow the spread of wildfires. These processes involve purposely cutting down trees or burning them in a controlled manner in order to eliminate some of the fuel that would otherwise burn once a forest fire breaks out.[25] In addition, buildings can be constructed with fire-resistant materials. These materials are made to endure flames for a certain amount of time and can help to slow the spread of fires between buildings.[26] Aside from constructing their

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[23] Lectome.
[24] Sainz, Adrian. "Ten years after Hurricane Andrew, effects are still felt." Sun-Sentinel. 23 Apr. 2004. <http://www.sun-sentinel.com/news/weather/hurricane/sfl-1992-ap-mainstory,0,913282.story>
[25] Davis, Tony. "A threat remains." Arizona Daily Star. 4 Aug. 2003. 23 Apr. 2004. <http://www.azstarnet.com/wildfire/30804FIRERISK2fmai2fmst2f.html>
[26] Beal, Tom. "Community rebuilds: 1 mountain, many voices." Arizona Daily Star. 13 July 2003. 23 Apr. 2004. <http://www.azstarnet.com/wildfire/30713wildfire2fphnxrising2f2f.html>.

homes to be safer, residents also can help to protect themselves and their neighbors by clearing their yards of flammable materials such as trees and pine needles.[27]

An interesting wildfire episode to look at when considering its impact on protection decisions is that of the recent Aspen Wildfire. The Aspen Wildfire began on June 17, 2003, and was concentrated in the Coronado Forest in Arizona. It covered an area of 84,750 acres and was particularly damaging to Mount Lemmon.[28] Like many forest fires in this area, it was caused by intense wind and dry heat and exacerbated by draught and an abundance of fuel. The Aspen Wildfire lasted approximately one month and devastated the town of Summerhaven. It destroyed 335 homes and businesses, damaged 5 others, and cost $16.3 million to fight.[29] "Damage to electric lines, phone lines, water facilities, streets, and sewers" alone amounted to $4.1 million.[30] In addition, runoff of ash occurred when the rains finally began to put out the flames. This brought about another $2.7 million in expenses aimed at preventing soil loss, and caused damages in Sabino Canyon even though the flames from the fire never reached the area.[31] As was the case with Hurricane Andrew, experts estimated that approximately 60% of Summerhaven residents had taken steps to make their homes safer from the spread of fires.[32] Had more people engaged in such activities, the total damages could have been much lower.

In reaction to the Aspen Wildfire and other summer wildfires, President Bush enacted the Healthy Forest Initiative, raising federal funding for firefighting by 55% and

[27] Davis, Tony. "A valuable lesson: Keep clear space around home." Arizona Daily Star. 21 June 2003. 23 Apr. 2004. <http://www.azstarnet.com/wildfire/30621WILDFIRELESSONS.html>.
[28] "Smoke, Flames, and Ash: The story of the Aspen Fire." Arizona Daily Star. 17 Aug. 2003. 23 Apr. 2004. <http://www.azstarnet.com/wildfire/part3.html>.
[29] "Smoke."
[30] "Smoke."
[31] "Smoke."
[32] Davis. "A Valuable Lesson."

promising $760 million in fiscal year 2005, a significant portion of which will be used for prescribed burning and forest thinning to eliminate some of the hazardous fuel that helps fires spread quickly.[33] According to the plan, an additional 3.7 million acres will be treated for fuel reduction.[34] Residents are pushing for even greater funds. In the meantime, outreach groups have begun to offer seminars on how to make homes more "fire-wise" by telling residents how to clear space around their homes to slow the spread of fires.[35] In addition, local governments have adopted tougher building codes requiring the exteriors of new homes to be built of materials that can withstand flames for up to an hour and roofs to be made of Class A material that resists flames.[36],[37] These laws have been adhered to during the rebuilding process of Summerhaven. New zoning laws require residents to be responsible for creating more "defensible space" around buildings, or space that is not filled with trees and other flammable materials, to slow down the spread of fires.[38],[39] Therefore the same reaction to past experience that was witnessed in the case of Hurricane Andrew appears with the Aspen Wildfire as well.

Investment in IT Security

A final decision to invest in protection is one made by both individuals and businesses when choosing how they will engage in IT security. One of the most common

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[33] United States Dept. of the Interior. Secretary Norton Announces Implementation of Hungry Valley Wildfire Project: Touts President's FY 2005 Budget Request. Office of the Secretary. 7 Feb. 2004. < http://www.doi.gov/news/040210a>.
[34] United States Dept. of the Interior.
[35] Davis. "A Valuable Lesson."
[36] Beal.
[37] "Pima County Adopts/Revises Codes." Code Wise: Pima County Building Codes. 8 Mar. 2004. 23 Apr. 2004.< http://www.pimaxpress.com/BCodes/Codewise/2004/Vol-6-Mar1-04.pdf>.
[38] Davis, Tony. "Lemmon debate is smooth." Arizona Daily Star. 31 Jul. 2003. < http://www.azstarnet.com/wildfire/30731codes.html>.
[39] "Pima County Adopts/Revises Codes."

threats to IT security, and the one on which this paper will focus, is the spread of viruses over the Internet. There exist a plethora of methods to protect from these viruses, but each works by mitigating the damages the viruses cause, rather than the probability that they will hit. That is, one cannot stop the virus from being sent to a computer but protection measures can keep the virus from being downloaded and infecting the system. Due to the technical complexity of the various options available for protection, this paper will look primarily at the decision to invest in antivirus software.

While the technical workings of antivirus software are complicated, they can be summarized as follows. Antivirus software typically works by scanning files that are coming in and out of a computer. These files may come from various sources, but they commonly arrive through e-mail or downloads. Antivirus software employs one or more methods to ensure the safety of these files. First of all, it may use its own virus definitions to search out files that fit these descriptions. Thus the antivirus software will scan files and compare them to the virus definitions to find the ones that are corrupted. File scanning is generally performed on a selection of files that are already on the computer. Antivirus software also engages in the scanning of emails and attachments. This works in one of two ways: either the program will scan files from the e-mail server before passing them to the computer or it will scan files on the computer before passing them to the e-mail program. Additionally, some antivirus programs will scan files as they are downloaded (download scanning), try to detect code in emails that appears to be like past viruses (heuristic scanning), or scan what is called active code that is common in web pages and may be potentially damaging (active code scanning).[40] As these

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[40] "Antivirus Software: How does Antivirus Work?" SolutionsReview.com. 23 Apr. 2004. <http://www.solutionsreview.com/Antivirus_how_do_antivirus_software_work.asp>.

descriptions suggest, antivirus software provides benefits both to you and to others. By catching viruses before they are spread to your system, to other users on your network, and to your personal e-mail contacts, antivirus software serves to mitigate the damages viruses cause. Typical antivirus software packages cost anything from $30 to $50 for individuals and include a yearly fee, usually around $20, to continue upgrading virus definitions.[41]

Of particular interest to the decisions to invest in antivirus software are the recent virus outbreaks during the summer of 2003, especially the SoBig.F variant of the SoBig virus. SoBig.F was one of the biggest and most damaging viruses in recent history. It struck on August 18 and spread rapidly. At the time, it was the world's fastest spreading virus (until the Mydoom virus took over this title in January 2004).[42] It was formatted as an e-mail attachment that activated itself when opened by the user. Because many users thought the e-mail came from a secure source, they mistakenly opened it. However, the e-mail actually comes from a "spoofed address" or one compiled by the virus through searching files on previous senders' computers. Once opened, it installs itself onto the user's hard drive and searches through the computer's files for e-mail addresses. It then uses these e-mail addresses and its built-in e-mail program to send itself on.[43] The damages the SoBig.F virus causes come from the volume of messages it sends. It is responsible for bogging down servers with e-mails and slowing down networks. This has caused a range of problems for users, including Air Canada, which had to ground its

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[41] Geroski, Ray. "Evaluating the true cost of client-side antivirus software." Tech Republic. 11 Jul. 2002. 30 Apr. 2004 <http://techrepublic.com.com/5100-6264-5033051.html?tag=viewfull>.
[42] "SoBig.F breaks virus speed records." CNN.com. 22 Aug. 2003. 24 Apr. 2004. <http://www.cnn.com/2003/TECH/internet/08/21/sobig.virus/>.
[43] Koffler, Daniel. "Email under attack: How the SoBig.F virus works." Domino Power Magazine. 24 Apr. 2004. <http://www.dominopower.com/issuesprint/issue200308/00001084.html>.

flights until the computer problem was solved.[44] In a scan of 40.5 million e-mails sent, AOL found the virus to be present in over half of them.[45] An estimate of its economic damages, both from system downtime at infected sites and from the volume of e-mails it sends to users who remain uninfected, was around $7 billion, despite the fact that it was discovered before it had started to spread rapidly and antivirus definitions were made available quickly.[46]

Similar to the other events, investment in IT security showed a significant incline after the outbreak of the SoBig.F virus. As a result of the SoBig.F virus, in addition to other viruses seen this past summer, sales of antivirus software have surged, even when sales of other software products have been falling.[47] A *Business Week* article reported that "due to a midsummer outbreak of computer viruses, spending on security software for both consumers and businesses grew an estimated 9.6%, to $5.62 billion, in 2003."[48] Antivirus software sales for 2004 are predicted to rise another 10.2%.[49] Along with the antivirus software spending increase, the 2003 Global Security Survey of financial institutions around the world conducted by Deloitte Touché Tohmatsu found that 47% of respondents have increased IT security staffing and 63% either have installed or plan to install a Chief Security Officer or Chief Information Security Officer within the next 2 years in order to address security concerns.[50] In addition, Ernst & Young's Global Information Security Survey 2003, given to 1,400 organizations worldwide, showed that

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[44] "SoBig.F breaks virus speed records."
[45] "SoBig.F breaks virus speed records."
[46] Naraine, Ryan. "The ABC's of the SoBig Virus." eSecurityPlanet.com. 20 Sep. 2003. 24 Apr. 2004. <http://www.esecurityplanet.com/trends/article.php/3075171>.
[47] Rupley, Sebastian. "Tales of Woe for Software." ABC News. 10 Feb. 2004. 23 Apr. 2004. <http://abcnews.go.com/sections/scitech/ZDM/software_sales_2003_pcmag_040210.html>.
[48] "Software: Pay-As-You-Go Is Up and Running." Business Week Online. 12 Jan. 2004. <http://www.businessweek.com/magazine/content/04_02/b3865607.htm>.
[49] "Software: Pay-As-You-Go Is Up and Running."
[50] "Global Security Survey 2003." Deloitte Touche Tohmatsu. <www.deloitte.com/gfsi>.

risk reduction was a major reason for investing in protection in 78% of organizations, in comparison to legislative or regulatory compliance affecting only 48% and reputation or trust affecting 47%.[51] Thus the evidence points toward the fact that both consumers and businesses are responding to the threats to which they have recently been subjected by increasing their focus and their spending on a greater investment in protection.

Data Analysis

In order to quantitatively test the results seen in the case studies, a data analysis was conducted. The data set was derived from a hurricane simulation game given to approximately 200 undergraduate marketing students at the University of Pennsylvania's Wharton School. In the game, students are told that they are moving to a hypothetical hurricane-prone country and that they must make decisions to invest in protective measures. They are randomly assigned a housing location and initial home value (ranging from $15,000 to $65,000) and given information about the typical hurricane season and the relative probabilities of storms hitting each location. They are also provided with information about the effectiveness of the different hurricane protection measures. The students are then told to maximize their total score, which is equal to the initial value of the home minus any damages they sustain from storms minus their spending on protection. The game lasts for forty weeks, split into two years of five months each. Once the individual invests in protection, he will not lose it until a storm occurs (although he may choose to add more protection at any point). The level of protection ranges from 0 to 100. The hypothesis being tested was that players will tend to invest in more protection during the period after they have sustained a loss.

[51] "Ernst & Young Global Information Security Survey 2003." Ernst & Young. <www.ey.com/global>.

Several different studies were run in order to test this hypothesis. First of all, a regression was run on the entire population. The regression equation evaluated was:

$$Y = \text{Intercept} + \beta_1\text{Lag(Loss)} + \beta_2\text{Month} + \beta_3\text{Lag(Miss)} + \beta_4\text{Total Loss} + €$$

In this equation, the dependent variable Y represents the protection level purchased by each individual. The factors evaluated for their influence on protection level were: (1) Lag(Loss), or the magnitude of the loss sustained in the period before, (2) Month, which was tested for a linear relationship since the game begins in June and progresses further into the severe hurricane season in the later months, (3) Lag(Miss), which is a binary variable representing whether or not the person lived close to an area that was hit by a storm the period before and sustained damages greater than $20,000, [52] and (4) Total Loss to see if there was a cumulative effect aside from the recency effect, or the effect caused by the period before and represented by the Lag(Loss) variable. In this original analysis, the intercept coefficient was 22.7, the Lag(Loss) coefficient was -.00022, the Lag(Miss) coefficient was -7.6, and the Total Loss coefficient was .000026 (Appendix A shows a chart of the coefficients and their p-values). Of these coefficients, all except Total Loss were statistically significant at the 95% confidence level. From this analysis, the hypothesis that Lag(Loss) will tend to increase investment in protection does not hold.

The data was then evaluated at the individual level to correct for an aggregation bias in which some percentage of individuals might show a positive effect in future investment due to the Lag(Loss) variable whose effect would be diluted when combined with the total population. This also served to control for individual differences in baseline protection investment levels. Forty randomized individual regressions were run

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[52] Homes are assigned to an area numbered 0 to 5. A storm that hits close to a home hits an area one number away in either direction.

using the same model as was used with the aggregate data. The results showed that the loss sustained in the period before, represented by the Lag(Loss) variable, did not significantly increase protective measures. Out of the 40 observations examined, only 28 showed a positive correlation between Lag(Loss) and investment in protection. (Appendix E shows the direction of the coefficients for all variables of all observations regardless of statistical significance). Of these 28, only one was statistically significant at the 95% confidence level. An additional four observations were significant but negative. (Appendix B shows a chart of the five regressions in which Lag(Loss) had a significant effect, Appendix C shows the correlations of all observations and the p-values for Lag(Loss), and Appendix D shows a chart of the statistical significance and direction of the coefficients for all variables of all observations).

Even though most of the regressions did not show Lag(Loss) to be statistically significant, there still could have been a smaller effect if the p-values tended to be in the lower range. Under the null hypothesis that Lag(Loss) does not have an effect on protection level, the p-values should show a uniform distribution. To test for a relative significance of the Lag(Loss) variable in comparison to the uniform distribution, its p-values were plotted. The histogram shows that the p-values do not seem to be skewed toward the low end (Appendix F shows the histogram). Although a greater quantity of p-values appears in the range of 0 to .33, at least four of these values represent those coefficients that were significant at the 95% confidence level but negative. Thus, there is a slightly higher concentration of p-values in this range, but it does not support the theory that Lag(Loss) has an effect on increased investment because some of these values represent coefficients in the opposite direction. With this taken into account, the chart depicts a fairly uniform distribution of p-values.

Thus it seems that the data does not strongly support the hypothesis that Lag(Loss) has an effect on increasing the protection level. There are several reasons why this might be the case. First of all, several difficulties were encountered in analyzing the data set. One problem is the fact that participants can invest each period but they cannot uninvest. The chosen protection level stays in place until a storm hits some location. Therefore, we may see several periods in a row where the participant's level of investment does not change. These data points, however, cannot be excluded because the participant still has the opportunity to invest in more protection during every period. Additionally, there may be a constraint on the participant's ability to invest in greater levels of protection. That is, if the participant has already invested in a protection level of 100, he may still sustain a loss but be unable to raise that level during the next period. Thus, this constraint may cause the effect of Lag(Loss) to be mitigated. Of the 40 participants studied, 6 or 15% may have been constrained by this fact, as they chose to invest in protection of 100 more than one time.

Another explanation for the lack of clear results may be that Lag(Loss) had some effect, but that it was small. This point is supported by the evidence showing that 28 observations were positive. The 28 positive observations represent a statistically significant increase above the expected mean value:

$$\text{Z value} = (28/40 - 20/40) / (\sqrt{((1/2 * 1/2) / 40)}) = 2.5 > 1.96$$

Furthermore, the small coefficients may have a large effect depending on the value of the loss sustained. Consider the individual with the following coefficients as an example:

Intercept	Lag(Loss)	Month	Lag(Miss)	Total Loss
1.46	0.001	2.937	16.16	-0.00037

According to the regression, the individual would increase his protection level on average 1.46 * Intercept + .001 *Lag(Loss) + 2.937 * Month + 16.16 * Lag(Miss) + (-.00037) * Total Loss. This person also sustained an average Lag(Loss) of $1,384.62. This shows that the person would on average be expected to increase protection by 1.38 (on a scale of 0-100). While this is a small number on average, so is the average of losses sustained. If the Lag(Loss) value is higher, so will be the expected increase in investment. In fact this is exactly what we see. When this person sustained a loss of $12,000, the level of protection was increased by 15 (or $50 in spending on protection out of a possible $310), slightly greater than the 12 that the regression would predict.

Furthermore, the results of the simulation may not match those predicted by the case studies due to the nature of the game. The decision-making process is likely to be more involved in real life situations where people have more to lose from having their property destroyed. Therefore, in the real world, people might be risk averse and enjoy utility from investing in protective measures. This may not be captured in the game atmosphere where utility is derived from a higher score alone.

On the other hand, it is possible that losses must reach a threshold level above which we will see increased investment in protection. Perhaps losses in the simulation were not widespread enough to encourage more investment. In addition, players may have doubts about the effectiveness of different protection measures, a hypothesis supported by the fact that the actual protection value is unobserved by the player and differs from what he thinks he is getting. Moreover, participants may simply underestimate their likelihood of being hit by another storm. Due to the nature of the game, they are unable to research and seek out information on these two factors to give a more comprehensive picture of the benefits they might receive from investing in protection. While it is perhaps naïve to believe that people consistently do this in the real world, numerous sources exist with this type of information already compiled and readily available as recommendations to people faced with investment decisions.

Policy Recommendations

Aside from proving the importance of past experience in investment decisions, one of the main goals of this paper has been to show that many damages can be prevented if only investment in protective measures is engaged in ahead of time. There are several possible means for encouraging increased investment, some of which are already in place for certain problems. First of all, increased governmental action, such as enacting and enforcing stricter building codes, might be a possible solution. Government-sponsored task forces to study potential problems and evaluate risks, with the goal of suggesting future paths to avoid them, also might be useful. One track that could be particularly effective for encouraging individual action is to have greater media focus on preventable dangers and ways to keep them from happening. This, of course, has to be worthwhile for the media company. Subsidies are a possible solution for encouraging such coverage. While these subsidies could certainly come from the public sector, they also could be obtained through the private sector. For instance, companies that insure media entities could offer premium discounts if the entities engage in campaigns to encourage protective measures. Thus, if the media entities sponsor segments detailing the importance of protection and how to go about doing it, insurance agencies could lower their rates. As an example, a news company might offer to include a ten-minute segment on protecting your home from hurricanes during the nightly news broadcast in exchange for lower premiums given by insurers. The insurance companies then would benefit through lowered future claims from other clients who begin to invest in greater protection. This same strategy could be, and at least occasionally is, followed by insurers for their other clients. For instance, if a client engages in risk-reducing behavior such as constructing buildings with a safer structure, the client may receive lower premiums than others. This gives individuals the necessary incentive to invest in protection themselves.

Conclusions

In conclusion, it seems that past experiences do have an effect on future decisions to invest in protection. Moreover, these effects appear to be greatest when the magnitude of loss is high and when media coverage is present to spread news about the event. This is strongly supported by the results of the case studies, which show greatly increased protective measures in response to damages that were often unprecedented in nature and highly reported in the news. Additionally, we tend to see stronger reactions by individuals versus the government where it is easier to prevent damages. Thus, for instances such as wildfires where cases will exist in which no possible action by an individual could prevent their spread, we see a government action as the primary source of investment changes. On the other hand, virus protection is primarily engaged in by individuals and businesses since viruses are relatively easy to prevent given a commitment to investment in updated antivirus software. Thus far, government has played a relatively small role in enforcing protective measures in IT security.

Furthermore, the results of the simulation game may suggest the need for incentives to encourage investment by individuals where government involvement is lacking.

In terms of future research questions, much could be looked at when trying to alleviate the problem of underinvestment beforehand and to prevent large scale losses. A future research project might focus on which of a group of benefits is most worthwhile for a particular event. The costs and benefits of each type of investment could be studied in more detail, and recommendations could be published for people to follow when choosing their own protection. Such a project might involve either a case study with a firm that is making investment decisions or with the help of an expert in the field, as benefits in particular are very difficult to estimate without an in-depth knowledge of the type of event against which one is protecting.

Appendix A: Chart of Aggregate Regression Analysis Coefficients and P-values

Intercept	P-value	Lag(Loss)	P-value	Month	P-value	Lag(Miss)	P-value	Total Loss	P-value
22.7	<.001	-0.00022	0.0328	3.02	<.001	-7.6	0.0002	0.000026	0.186

Appendix B: Chart summarizing the effects of variables where Lag(Loss) was statistically significant at the 95% confidence level

ID	Intercept	Lag(Loss)	Month	Lag(Miss)	Total Loss
10179403	+	-	0	0	0
10179836	0	+	0	+	0
10179948	+	-	-	0	+
10207196	+	-	0	0	+
10207330	0	-	0	-	0

* + represents positive coefficient, - negative, and 0 not statistically significant

Appendix C: Chart of Individual Regression Analyses Showing Coefficients of each variable and P-value of Lag(Loss) Variable

ID	Intercept	Lag(Loss)	P-value Lag(Loss)	Month	Lag(Miss)	Total Loss
10148976	41.83	0.004	0.1021	-3.53	-3.7	-0.0001
10157237	-16.49	0.0067	0.1149	14.6	-23.3	-0.005
10157340	-0.79	0.00056	0.1715	4.18	-6.19	-0.00029
10178576	6.027	0.0001	0.7545	-0.59	-3.04	-0.00002
10178611	-9.79	0.00126	0.5194	7.15	-29.49	0.0017
10179200	8.23	0.000000076	0.9995	3.08	-13.28	-0.00028
10179403	21.68	-0.00064	0.0124	0.959	-0.947	0.0000015
10179836	1.46	0.001	0.0257	2.937	16.16	-0.00037
10179948	45.02	-0.0028	0.0132	-15.07	-4.29	0.0033
10186209	56.4	-0.0004	0.4858	-11.16	X	0.0002
10186755	12.9	0.00014	0.841	-0.67	-6.59	-0.00016
10205855	0.11	0.00027	0.5593	0.54	21.1	-0.0008
10205859	34.7	-0.00038	0.7607	-9.75	13.45	0.0011
10206096	20.66	0.00045	0.3013	7.23	-0.5	-0.0003
10206249	40.1	-0.00053	0.4308	10.34	-17.46	-0.0008
10206423	25.22	-0.0009	0.0865	-1.42	-22.2	0.00008
10206902	52.74	-0.00042	0.8095	2.02	-14.24	0.00006
10207149	22.63	0.00007	0.9241	-1.98	-17.4	0.0001
10207196	36.7	-0.001	0.018	-15.6	13.87	0.001
10207222	7.39	0.0002	0.2821	-0.67	-5.38	0.0005
10207330	21.8	-0.002	0.0032	4.43	-45.5	0.00029
10207434	28.8	0.004	0.2809	17.7	-25.4	-0.004
10207862	18.26	0.0005	0.663	19.4	-6.6	-0.0005
10207957	-9.01	0.009	0.0944	8.24	0.728	0.0015
10207964	34.7	0.0047	0.5855	-1.03	15.4	0.0069
10208060	-7.4	0.00008	0.8789	6.8	22.7	-0.00068
10264553	25.7	0.001	0.5085	10.67	-11.25	-0.0003
10265444	2.611	0.000017	0.9828	19.96	30.61	-0.0006
10265446	53.15	0.001	0.2889	-5.9	-20.1	-0.00058
10265540	16.68	0.0009	0.802	17.21	-27.57	-0.0031
10265549	8.49	0.0004	0.774	5.05	20.85	0.000027
10265727	-9.54	-0.000015	0.9842	26.09	11.18	-0.003
10266029	69.21	-0.001	0.2482	3.68	X	0.00076
10266665	49.62	0.001	0.4786	-4.38	-11.9	-0.00056
14645136	-1.931	0.0007	0.6456	8.29	-10.6	-0.001
22648689	50.03	0.0008	0.578	-13.91	11.51	0.001
40765333	32.6	0.001	0.2505	-3.69	-17.86	0.000062
40804826	56.99	0.001	0.4874	0.92	X	-0.001
40860692	3.466	-0.00026	0.615	-0.06	-3.21	0.00006
93683569	51.9	0.0001	0.8761	0.448	X	-0.00035

* X represents unavailable data

Appendix D: Chart summarizing those variables that were statistically significant at the 95% confidence level

ID	Intercept	Lag(Loss)	Month	Lag(Miss)	Total Loss
10148976	+	0	0	0	0
10157237	0	0	+	0	-
10157340	0	0	+	0	0
10178576	+	0	0	0	0
10178611	-	0	0	0	0
10179200	0	0	0	0	0
10179403	+	-	0	0	0
10179836	0	+	0	+	0
10179948	+	-	-	0	+
10186209	+	0	-	X	0
10186755	0	0	0	0	0
10205855	0	0	0	+	0
10205859	+	0	-	0	0
10206096	+	0	+	0	-
10206249	+	0	+	0	-
10206423	+	0	0	0	0
10206902	+	0	0	0	0
10207149	+	0	0	0	0
10207196	+	-	0	0	+
10207222	0	0	0	0	+
10207330	0	-	0	-	0
10207434	+	0	+	0	0
10207862	0	0	+	0	0
10207957	0	0	0	0	0
10207964	+	0	0	0	0
10208060	0	0	0	0	0
10264553	+	0	+	0	0
10265444	0	0	+	0	-
10265446	+	0	-	0	0
10265540	0	0	+	0	0
10265549	0	0	0	0	0
10265727	0	0	+	0	-
10266029	+	0	0	X	0
10266665	+	0	0	0	0
14645136	0	0	+	0	0
22648689	+	0	-	0	0
40765333	+	0	0	0	0
40804826	+	0	0	X	0
40860692	0	0	0	0	0
93683569	+	0	0	X	0

* + represents significantly positive coefficient, - negative, and 0 no significance

Appendix D: Chart summarizing the direction of coefficients for each variable regardless of whether or not they are statistically significant

ID	Intercept	Lag(Loss)	Month	Lag(Miss)	Total Loss
10148976	+	+	-	-	-
10157237	-	+	+	-	-
10157340	-	+	+	-	-
10178576	+	+	-	-	-
10178611	-	+	+	-	+
10179200	+	+	+	-	-
10179403	+	-	+	-	+
10179836	+	+	+	+	-
10179948	+	-	-	-	+
10186209	+	-	-	X	+
10186755	+	+	-	-	-
10205855	+	+	+	+	-
10205859	+	-	-	+	+
10206096	+	+	+	-	-
10206249	+	-	+	-	-
10206423	+	-	-	-	+
10206902	+	-	+	-	+
10207149	+	+	-	-	+
10207196	+	-	-	+	+
10207222	+	+	-	-	+
10207330	+	-	+	-	+
10207434	+	+	+	-	-
10207862	+	+	+	-	-
10207957	-	+	+	+	+
10207964	+	+	-	+	+
10208060	-	+	+	+	-
10264553	+	+	+	-	-
10265444	+	+	+	+	-
10265446	+	+	-	-	-
10265540	+	+	+	-	-
10265549	+	+	+	+	+
10265727	+	-	+	+	-
10266029	+	-	+	X	+
10266665	+	+	-	-	-
14645136	-	+	+	-	-
22648689	+	+	-	+	+
40765333	+	+	-	-	+
40804826	+	+	+	X	-
40860692	+	-	-	-	+
93683569	+	+	+	X	-
		28	/40		

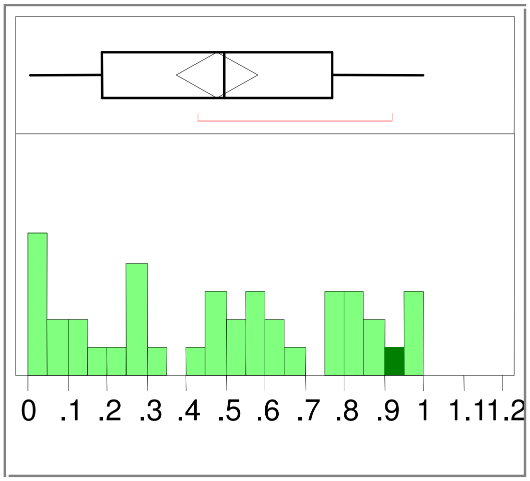
* + represents positive coefficient, - negative

* For the Lag(Loss) variable, 28 out of 40 observations showed positive coefficients

Appendix F: Histogram depicting the p-values of the Lag(Loss) variable for individual regressions

Distributions

Significance



Quantiles

100.0%	maximum	0.99950
99.5%		0.99950
97.5%		0.99912
90.0%		0.91958
75.0%	quartile	0.77068
50.0%	median	0.49795
25.0%	quartile	0.19068
10.0%		0.01877
2.5%		0.00343
0.5%		0.00320
0.0%	minimum	0.00320

Moments

Mean	0.48095
Std Dev	0.3201158
Std Err Mean	0.0506148
upper 95% Mean	0.583328
lower 95% Mean	0.378572
N	40
Sum Wgts	40
Sum	19.238
Variance	0.1024741
Skewness	-0.008573
Kurtosis	-1.276939

* P-values in the first segment, 0 - .33, represent both those values that are significant but negative and the value single value that is significant and positive. This accounts for the relatively higher number of p-values observed in this range in comparison to other ranges.

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