Pricing In Climate Risk: A Study on the Impacts of Coastal Flooding and Insurance Rates in Collier County, Florida on Insurance Policy Renewal

Part 1: Research Proposal

1. Executive Summary

Author: Samaa Nadkarni

Climate change, caused by a human-driven increase in greenhouse gasses, is increasing the intensity of extreme weather conditions. While storms and hurricanes have long affected the Floridian coasts, in recent years these "natural" disasters have become more severe due to rising sea levels, increasing both the degree and cost of damages.

As our organization confronts the challenges posed by the increasing severity of coastal flooding, particularly in Florida, it has become imperative to explore innovative strategies to manage the escalating flood insurance rates that are consequently impacting homeowners. Recent climatic events, underscored by Hurricane Ian in 2022, which resulted in unprecedented damages amounting to $109 billion (Bucci, 2022), have not only highlighted the intensifying nature of these disasters but have also led to a significant hike in insurance premiums.

The dual challenge of rising insurance rates and the potential depreciation in property values in flood-prone areas presents a substantial risk to both homeowners and our insurance offerings. There is a growing concern that the increased financial burden may deter policy renewals, potentially leaving many without coverage against future disasters. This scenario necessitates an urgent evaluation of policyholder retention strategies to ensure sustained coverage uptake amidst these financial pressures.

Our research aims to assess the impact of a "Pay in Installments" payment flexibility plan on the policy renewal rate of our clients throughout Collier County. This will further be broken down by studying the impact of this plan on customers who are sent singular versus multiple flyers and mailers advertising this new plan. We will conduct a simple random sampling of the home-owners in Collier County, both on the coast and further inland, whose insurance policies have lapsed. The research will be conducted through a controlled experimental design involving surveys post-delivery, coupled with a detailed statistical analysis plan including two-sample T-tests and ANOVA.

By offering more adaptable payment terms, we hypothesize a higher rate of insurance renewals, ensuring continued revenue and a stable customer base. Introduction of customer-centric solutions such as flexible payment plans also helps distinguish our organization in a competitive market. The findings from this study will help us better understand the dynamics at play in the coastal-flood insurance market, providing necessary insights on how insurance companies can grow and adapt their product offerings, without alienating their clients, to keep up with the mounting effects of climate change on our economy.

2. Statement of the Problem

Author: Samaa Nadkarni

In recent years, the escalating intensity of hurricanes and storms, driven by climate change and rising sea levels, has profoundly impacted coastal regions, particularly those renowned as vacation destinations. These environmental shifts have exacerbated the risks associated with insuring properties in these regions, leading to higher insurance premiums that

are unaffordable for many households. As insurers become more reluctant to offer affordable coverage in high-risk zones, there is a growing concern over the potential decrease in policyholder retention and adoption, which could undermine the financial stability of both homeowners and insurance providers.

Our research aims to examine how the escalating risk of floods affects insurance policy renewal rates in these desirable coastal destinations. Specifically, the study will investigate the potential of flexible payment options, such as installment plans, to encourage policy renewals despite rising premiums. This approach seeks to understand the direct relationship between increased insurance costs driven by climate change and the willingness of policyholders to maintain or purchase new insurance coverage.

The objective of this focused research is to provide actionable insights that could help the financial and insurance sectors adapt their strategies to better manage climate-related risks. By exploring alternative insurance payment structures, this study will propose practical solutions aimed at enhancing policy renewal rates, thereby supporting sustained insurance coverage and economic stability in vulnerable coastal communities. This research will not only shed light on the dynamics of policyholder decisions in response to rising costs but also offer scalable strategies that could be applied more broadly to similar at-risk regions.

3. Literature Review

Author: Claire Costello, Yujun Long

The frequency and severity of major storm systems have continued to increase due to climate change. This has drastically impacted the coastal areas where the damage of these storms results in a huge economic burden for insurance companies. With ocean temperatures warming, sea level rise has been on the increase in recent decades with the trend expected to continue throughout the 21st century leading to higher storm surge levels and coastal flooding (*Sea Level Rise and Coastal Risk*).

There is an increasing need to have flood insurance to cover any increased risks from climate change, but there continues to be large numbers of homeowners without insurance coverage. The federal government is the country's largest provider of flood insurance as a result of private insurance companies deeming flood risk uninsurable. The premium that homeowners pay for their insurance through the National Flood Insurance Program (NFIP) does not cover the increased risks in flooding events. Even with NFIP available there are a significant number of homes that remain uninsured even if they are at risk. This is due to the program using FEMA’s flood maps which are often outdated and don't incorporate the increased risks from climate change disproportionately impacting communities of color. The affordability of insurance is also a barrier; with premiums going up, many households chose to not renew their policies.

Florida does not require a seller to disclose a property's flood risks leading buyers to not have all risk information prior to purchasing a home. There are improvements that need to be made to the insurance and transparency around flood risk in Florida. (Neal, 2022) With more than 8,400 miles of coastline, Florida is extremely vulnerable to the effects of climate changes and increased flooding (*Sea Level Rise and Coastal Risk*). One of those efforts is Senate Bill 178 that passed in Florida in 2020 which requires state and local governments to perform a sea-level impact study before any construction using state funds is built near the coastline. These studies will include an analysis of the potential damage for the next 50 years addressing the maintenance and repair costs, public safety and environmental impacts. This could lead to implications on the insurance premiums of the neighboring properties. (Rabb, 2022).

There are millions of properties across the US where the value of the home does not properly account for the climate risk resulting in a “climate bubble”. This is leading to insurance companies increasing premiums and therefore the cost of homeownership increases and in some cases the insurance companies labeling areas uninsurable. Many property owners are then forced to opt into a state-backed “insurers of last resort” which in Florida saw the average premium for windstorm insurance grow by 61% from 2016 to 2023. There is an increasing reliance on state mandated insurers and there needs to be a policy enacted that addresses the continued cost of climate related insurance cost in coastal areas. (*Research: The insurance issue*, 2023)

The operational procedures for this study uses the research on mere exposure effect to analyze if multiple marketing exposures influence the attitude towards the product. A study from 1968 by Robert Zajonc concluded that multiple exposures enhances one's attitude towards the stimulus (Zajonc, 1968). There was additional research that looked into mere exposure effects in older adults and found that older adults showed stronger memory of the stimuli they were exposed to over the younger adults (Palumbo, 2021). With the older demographic in Collier County, this research would indicate that the mere exposure effect would have a strong influence and be impactful in influencing homeowners to purchase flood insurance.

4. Research Questions, Hypotheses, and Effects

Author: Samaa Nadkarni

For the purposes of our research we have combined the definitions of single-family homes with lapsed flood insurance policies and those with no flood insurance policy under the umbrella term of “renewal rate”, which we will be studying in our research.

Research Question 1: Does the introduction of a “Pay in Installments” flexible payment plan impact the policy-renewal rate of flood insurance among single-family homes in Collier County?

- **Null Hypothesis (H_0)**: The introduction of a "Pay in Installments" payment plan does not affect the flood insurance policy renewal rates among single-family homes in Collier County.
- **Alternative Hypothesis (H_1)**: The introduction of a "Pay in Installments" payment plan increases the flood insurance policy renewal rates among single-family homes in Collier County.
- **Metric**: The percentage of property owners who renew their insurance premiums after adopting the "Pay in Installments” plan over a 1 year period.

Research Question 2: How does the frequency of distributing promotional flyers and mailers for the “Pay in Installments” plan influence the policy renewal rate of flood insurance among single-family homes in Collier County compared to sending only one flier?

- **Null Hypothesis (H_0)**: Sending multiple flyers and mailers promoting the “Pay in Installments” payment plan does not affect the flood insurance policy renewal rate differently than sending out just one flier among single-family homes in Collier County.
- **Alternative Hypothesis (H_1)**: Sending multiple flyers and mailers promoting the “Pay in Installments” payment plan increases the flood insurance policy renewal

rate compared to sending out just one flier among single-family homes in Collier County.
- **Metric**: The calculated percentage of renewal rate of families receiving multiple flyers is higher than those receiving a singular flier.

5. Importance of the Study and Social Impact

Author: Samaa Nadkarni

The overarching goal of this study is to enhance flood insurance policy renewal rates among single-family homes in Collier County through innovative payment and communication strategies. By examining the impact of the "Pay in Installments" payment plan and varying frequencies of promotional flyers, this research aims to provide critical insights into how flexible financial and marketing approaches can influence homeowner decisions regarding insurance renewals. Through insights derived from this research, insurance companies can tailor their approaches to meet the needs of homeowners in high-risk areas and offer a sense of economic stability for both the company and its clients. Furthermore, results from the study might be helpful to apply to other financial institutions affected by climate change, thus better preparing our economy for the increasing role climate change plays in it. All in all, this study can potentially have enormous economic and social gains.

6. Research Plan

Author: Claire Costello

The population of interest, sample selection, operational procedures, brief schedule, data collection, and data security portions of the research study are outlined below.

Population of Interest

Author: Claire Costello

This study targets property owners in Collier County, Florida. According to the 2022 US Census, Collier County has a population of ~400,000 residents, with 34% being 65 years or older. This demographic is notably impacted by seasonal fluctuations. It includes many individuals and families at or near retirement age who own properties along the coastline and further inland. There are also 240,238 housing units, with the median value being $443,700 (census.gov). We will look at the population of housing units at risk of flood but have a lapsed insurance policy or have yet to purchase flood insurance. Collier County has 105,824 policies from the National Flood Insurance Program in force, leaving 134,414 homes potentially without flood insurance (NFIP, 2024). This will be the population of interest for this study.

Sample Selection

Author: Claire Costello

The sample selection will be a simple random sample applied to 34,101 housing units divided into three study groups. Since we do not know which home addresses have flood insurance and to avoid bias, we will assume 44% of the households that receive the flyers will not have flood insurance (NFIP, 2024). This should allow for a significant portion of the sample size not to complete the survey, including those who already have flood insurance, and still result in a large enough sample size for analysis. Using the SRS method will avoid bias and provide balance across the different research groups. This method ensures that both major factors

influencing insurance rates — proximity to the coast and type of property — are adequately represented in the sample. This sample selection ensures that the study captures a balanced view of the impact of outreach on the purchasing of flood insurance on Collier County residencies.

Operational Procedures

Author: Claire Costello, Jerome Vallar

For this experimental research study, we plan to partner with Collier Country and utilize their residential database to reach the population with information flyers about purchasing and/or renewing flood insurance. We will have two versions of the flyer, one that offers a structured payment plan that allows residents to pay over time and one that leaves the payment plan off. These groups will address our first research question if a payment plan option will incentivise people to purchase flood insurance. Research conducted by Robert Zajonc, looking at mere exposure, concluded that marketing materials influence purchasing behavior. Therefore, we will repeat the mailing with the payment plan to the third sample group two more times to study if multiple flyer reinforcements will increase the likelihood of the residents purchasing flood insurance.

The flyer will contain basic information on the importance of flood insurance and facts and figures about how much damage recent superstorms have caused. It is meant to educate homeowners on the risk of not being insured. Educating homeowners about the financial risk of not having flood insurance increases the likelihood that they will purchase an insurance plan. The reverse side of the flyer will contain a survey link, which will collect information on the participant. In conclusion, the survey will send them information on the National Flood Insurance Program and how to purchase it (survey can be found in Appendix A). The deadline to complete the survey will list 12 months from the date the filer is sent. The first version will stop there, while the second version will have an infographic outlining the annual payment plan and how it will delay the payments across a year. They will also have a link to a second survey asking them about the payment plan and whether it influenced their purchase decision.

Brief Schedule:

Author: Jerome Vallar

The initial flyers will be sent out all at the same time at the beginning of week 2 of the study with the followup for weekly flyers for two more weeks to the third sample group receiving multiple flyers. The researchers will continue to receive survey responses for 12 months and collect the data. This length of time allows homeowners to consider all options before making this large financial decision. The data will then be analyzed through the statistical analysis plan.

Those who already purchased flood insurance will most likely not participate in this research and this has been accounted for in the number of homes that are receiving the flyer. The weeks after the survey is closed will be dedicated to analyzing the results to address the two research questions.

Data Collection

Author: Jerome Vallar

For this research, data will be collected using a mixed-method approach. Primary data will be gathered through a structured survey distributed to a stratified random sample of homeowners in Collier County whose properties are both on the coast and inland. These surveys

will be sent alongside flyers promoting the "Pay in Installments" plan, with varying frequencies across the sampled groups. The surveys will assess respondents' willingness to renew their flood insurance and perceptions of the payment plan and flyer frequency. Secondary data collection will involve extracting renewal rate statistics from insurance databases and incorporating geographical data on flood risk from public records or previous studies.

Data Security

Author: Jerome Vallar

This research study does not collect any personal information about the survey participants, and all data collected will be kept confidential and only used for this research study.

Variables

Author: Jerome Vallar, Yujun Long, Samaa Nadkarni

Below are the descriptions of variables for each research question.

Research Question 1 Variables

- **Outcomes (Dependent Variables):** The primary dependent variable here is the Policy Renewal Rate, which measures the percentage of policyholders who choose to renew their flood insurance after a new payment plan is introduced.
- **Treatments (Independent Variables):** The key independent variable is the Payment Plan Type, specifically introducing a flexible "Pay in Installments" option intended to make premium payments more manageable and thus potentially increase renewal rates.
- Other Variables:
    - **Geographic Location:** Considering whether properties are in coastal or inland areas, which may affect risk perception and the decision to renew.
    - **Socioeconomic Status of Property Owners:** This could influence the ability and decision to invest in insurance based on perceived necessity and financial capacity.
    - **Duration of Residence**: Longer-term residents might have a higher likelihood of renewal due to a deeper understanding or experience of local flood risks.
    - **Previous Claims History:** This could affect renewal decisions, as those with prior claims might perceive higher future risks and be more likely to renew.

Research Question 2 Variables

- **Outcomes (Dependent Variables):** As with the first question, the Policy Renewal Rate remains the primary dependent variable, assessed to determine the effectiveness of different promotional strategies.
- **Treatments (Independent Variables):** The independent variable is the Promotional Strategy, specifically the frequency and method of distributing promotional materials about the payment plan.
- **Other Variables:**
    - **Geographic Location:** As in the first question, this could impact renewal rates differently based on the region's risk levels or demographics.
    - **Socioeconomic Status of Property Owners:** This may affect responsiveness to marketing materials based on economic status and disposable income.

- **Duration of Residence:** This may influence how healthy residents know and trust local insurance practices, affecting their response to promotional efforts.
- **Previous Claims History:** Those with claims might be more attentive to promotional information that promises financial relief or benefits.

This study focuses largely on the impact of the above dependent and independent variables. For both research questions, data for other variables such as geographic location, socio-economic status of property owners, duration of residence, and claim history will be derived from accessing client databases at FEMA and local Collier County census data. To assess the importance of these variables for future analysis, a correlation matrix can be used to investigate the variable relationship with renewal rate. A linear regression model will be used to derive further insight. These variable's relationships with renewal rate will also help develop and improve the study for future insights.

7. Statistical Analysis Plan

Author: Jerome Vallar, Yujun Long

The analysis will begin with descriptive statistics to summarize the data, followed by inferential statistics to test the hypotheses. A two-sample t-test will be employed to compare the renewal rates between the control and treatment groups under different flyer distribution frequencies. An ANOVA may also be used if there are more than two groups or conditions to compare. The analysis will be conducted using RStudio. Assumptions of each test will be checked to ensure the validity of the results, and findings will be reported with 95% confidence intervals and p-values.

8. Sample Size and Statistical Power

Author: Yujun Long

The total sample size of 34,101 housing units, divided into three groups, has been selected to ensure sufficient power to detect a meaningful difference in insurance renewal rates between the groups. Based on preliminary estimates, assuming 44% of the sampled population does not have flood insurance, about 15,005 individuals represent the target segment for potential policy renewals. Each subgroup will comprise roughly 5,000 individuals, allowing for comprehensive subgroup analyses. A power analysis confirmed that this sample size is adequate to achieve a power of 80% at a 5% significance level, ensuring the study is adequately equipped to detect even minor effects in renewal rates due to the intervention.

9. Possible Recommendations

Author: Yujun Long

Based on the outcomes of the statistical analysis, potential recommendations may include adopting flexible payment plans more broadly within the insurance industry, particularly in regions prone to natural disasters. If the data indicates a significant positive impact of more frequent communications on renewal rates, insurance companies should increase the frequency and personalization of their outreach efforts. Additionally, policy recommendations might focus on improving transparency about flood risks and the benefits of insurance, possibly supported by regulatory changes that mandate such disclosures. The study suggests that further research is needed into alternative insurance models that could provide homeowners better financial resilience against climate change impacts.

10. Limitations and Uncertainties

Author: Yujun Long

Several factors merit consideration when evaluating the study's potential limitations concerning the impact of promotional strategies and payment flexibility on flood insurance renewal rates. Firstly, the study's reliance on simulated data might only partially capture consumer behavior's complexities and unpredictability in real-world settings. This could limit the generalizability of the findings to actual scenarios in Collier County or similar regions. Additionally, the simulations assume that all other variables remain constant, which might not hold in practice where multiple factors could influence renewal decisions concurrently. Another limitation is the potential for selection bias in the treatment and control groups, primarily if the criteria for distributing flyers or offering payment plans are not randomized. This could skew results and provide an inaccurate picture of the effectiveness of these interventions.

The research plan's reliance on stratified random sampling and focus on property owners aged 45-75 presents inherent limitations, potentially skewing the understanding of insurance rate impacts across a diverse population. While aiming for representativeness, the sampling method might only capture part of the spectrum of property values, geographic vulnerabilities, or demographic variations within the coastal and inland areas. Additionally, excluding younger property owners could limit insights into how different age groups perceive and respond to insurance rate changes, affecting the study's applicability and generalizability across all demographics. Furthermore, challenges such as non-response bias and reliance on self-reported data introduce potential inaccuracies in understanding the financial implications of insurance rate increases. Respondents' tendencies to overreport or underreport sensitive information could lead to skewed data, impacting the study's findings. Despite these limitations, the research provides essential insights, and there will be continuous potential updates as it is being conducted.

Part 2: Simulated Studies

Research Question 1: Does the introduction of a “Pay in Installments” flexible payment plan impact the policy-renewal rate of flood insurance among single-family homes in Collier County?

Author: Samaa Nadkarni

Scenario 1: No Effect

A data set is created using the assumed renewal rates of 5000 single-family homes in the Control group and 5000 single-family homes in the Treatment group. Here, the Control group defines families who will not receive a flier offering “Pay in Installments” flexible payment plan, whereas the Treatment group outlines families who are offered this flexible payment plan. Renewal rate has been quantified as a binary outcome - renewed (1) or not renewed (0). The probability of renewal for the control group is set as 0.3870 based on our research estimate of policy renewal rate being close to 40% without any payment plans or marketing (Sheppard, 2022). The treatment group is set as 0.39, only slightly higher than the control group.

```
### NO EFFECT ###
# Set the sample size for each group.
```

```
n <- 5000
# Set seed to make the result reproducible
set.seed(617)
# Create the data table with 5000 repetitions of Treatment, and another 5000 of
Control
df <- data.table(Group = c(rep("Treatment", n), rep("Control", n)))

# Using binomial distribution to set the probability of renewal in the control
group as 0.3870, with slightly higher in the treatment group as 0.39.
df[Group == "Control", Renewed_Or_Not := rbinom(n = .N, size = 1, prob = 0.3870)]
df[Group == "Treatment", Renewed_Or_Not := rbinom(n = .N, size = 1, prob = 0.39)]

# Display the data table using DT if you prefer an interactive table
datatable(df)

# Setting function
analyze.experiment <- function(the.dat) {
  require(data.table)

  # Ensure the input data is a data.table
  if (!is.data.table(the.dat)) {
    setDT(the.dat)
  }

  # Check for NA values and remove them if necessary
  if (any(is.na(the.dat$Renewed_Or_Not))) {
    the.dat <- na.omit(the.dat)
  }

  # 2-sample t-test for means:
  the.test <- t.test(x = the.dat[Group == "Treatment", Renewed_Or_Not],
                     y = the.dat[Group == "Control", Renewed_Or_Not],
                     alternative = "two.sided", var.equal = FALSE) # using Welch's
t-test by default

  # Calculates the effect size
  treatment_mean <- mean(the.dat[Group == "Treatment", Renewed_Or_Not], na.rm =
TRUE)
  control_mean <- mean(the.dat[Group == "Control", Renewed_Or_Not], na.rm = TRUE)
  the.effect <- treatment_mean - control_mean

  # Extracts the upper bound of the 95% confidence interval
  upper.bound <- the.test$conf.int[2]

  # P-value
  p <- the.test$p.value
```

```
  # Combine the result into a data.table
  result <- data.table(effect_size = the.effect, upper_ci = upper.bound, p_value =
p)

  return(result)
}

# Assuming "df" is your data.table with 'Group' and 'Renewed_Or_Not' columns
analyze.experiment(the.dat = df)
```

Next, we use a two sample t-test to determine if there is a statistically significant difference in the renewal rate between the two groups. Through this we get an effect size of 0.0064, upper bound of confidence as 0.02557647 and p-value of 0.5129965.

```
   effect_size   upper_ci   p_value
1:      0.0064 0.02557647 0.5129965
```

The simulated experiments are repeated a 1000 times to assess the impact of the Treatment on customer renewal rate, and compare it against the control group.Each experiment's data is examined to determine the difference of effect size, the upper bound of confidence intervals, and p value.

```
#Repeat 1000 times
B <- 1000
n <- 5000  # Number of samples per group

set.seed(617)  # For reproducibility

# Function to analyze the experiment
analyze.experiment <- function(the.dat) {
  require(data.table)
  if (!is.data.table(the.dat)) {
    setDT(the.dat)
  }

  if (any(is.na(the.dat$Renewed_Or_Not))) {
    the.dat <- na.omit(the.dat)
  }

  the.test <- t.test(x = the.dat[Group == "Treatment", Renewed_Or_Not],
                     y = the.dat[Group == "Control", Renewed_Or_Not],
                     alternative = "two.sided", var.equal = FALSE)

  treatment_mean <- mean(the.dat[Group == "Treatment", Renewed_Or_Not], na.rm =
TRUE)
  control_mean <- mean(the.dat[Group == "Control", Renewed_Or_Not], na.rm = TRUE)
  the.effect <- treatment_mean - control_mean
```

```
  upper.bound <- the.test$conf.int[2]
  p <- the.test$p.value

  result <- data.table(effect_size = the.effect, upper_ci = upper.bound, p_value =
p)
  return(result)
}
all_results <- list()
# Repeat the experiment B times
for (i in 1:B) {
  # Simulate data for this run
  sim_data <- data.table(Group = rep(c("Treatment", "Control"), each = n),
                         Renewed_Or_Not = c(rbinom(n, 1, 0.39), rbinom(n, 1,
0.3870)))

  # Analyze the experiment
  result <- analyze.experiment(the.dat = sim_data)
  result[, Experiment := i]  # Tag the result with the experiment number

  all_results[[i]] <- result  # Store the result
}
# Combine all results into one data.table
final_results <- rbindlist(all_results)
# Calculate the proportion of experiments where the effect was statistically
significant
significant_proportion <- mean(final_results$p_value < 0.05)
print(significant_proportion)
print(final_results)
```

The code calculates the fraction of the 1000 tests in which the treatment has a meaningful influence on renewal rate by averaging all data points, the effect size is greater than 0.02, and the p-value is less than 0.05. The result shows 0.048 which translates to a renewal rate of 4.8% of 1000 experiments. This low percentage shows the simulated treatment did not have a statistically significant effect on policy renewal rate.

```
> print(fraction_meaningful_significant)
[1] 0.048
```

Scenario 2: An Expected Effect

All else kept the same, the probability of renewal for the treatment group is set as 0.70 based on research showing a 30% increase in consumer purchases when a flex payment plan is introduced (Reagan, 2021). The control group stays constant as 0.3870. Next, we use a two sample t-test to determine if there is a statistically significant difference in the renewal rate between the two groups.

```
### EXPECTED EFFECT ###
# Set the sample size for each group.
```

```
n <- 5000
# Set seed to make the result reproducible
set.seed(617)
# Create the data table with 5000 repetitions of Treatment, and another 5000 of
Control
df <- data.table(Group = c(rep("Treatment", n), rep("Control", n)))

# Using binomial distribution to set the probability of renewal in the control
group as 0.3870, with significantly higher in the treatment group as 0.70.
df[Group == "Control", Renewed_Or_Not := rbinom(n = .N, size = 1, prob = 0.3870)]
df[Group == "Treatment", Renewed_Or_Not := rbinom(n = .N, size = 1, prob = 0.70)]
datatable(df)
# Separate the data by groups
control_group <- df[df$Group == "Control", ]$Renewed_Or_Not
treatment_group <- df[df$Group == "Treatment", ]$Renewed_Or_Not

# Setting function
analyze.experiment <- function(the.dat) {
  require(data.table)
    # Ensure the input data is a data.table
  if (!is.data.table(the.dat)) {
    setDT(the.dat)
  }
  # Check for NA values and remove them if necessary
  if (any(is.na(the.dat$Renewed_Or_Not))) {
    the.dat <- na.omit(the.dat)}
    # 2-sample t-test for means:
  the.test <- t.test(x = the.dat[Group == "Treatment", Renewed_Or_Not],
                     y = the.dat[Group == "Control", Renewed_Or_Not],
                     alternative = "two.sided", var.equal = FALSE) # using Welch's
t-test by default
  # Calculates the effect size
  treatment_mean <- mean(the.dat[Group == "Treatment", Renewed_Or_Not], na.rm =
TRUE)
  control_mean <- mean(the.dat[Group == "Control", Renewed_Or_Not], na.rm = TRUE)
  the.effect <- treatment_mean - control_mean

  # Extracts the upper bound of the 95% confidence interval
  upper.bound <- the.test$conf.int[2]

  # P-value
  p <- the.test$p.value

  # Combine the result into a data.table
  result <- data.table(effect_size = the.effect, upper_ci = upper.bound, p_value =
p)
    return(result)
```

Through this we get an effect size of 0.2938, upper bound of confidence as 0.3124734 and p-value of 0 which shows thats the probability of observing the effect size if the null hypothesis were true (i.e., that the treatment has no effect) is extremely low. This is a strong indication that the observed effects are indeed due to the treatment rather than by chance.

```
   effect_size  upper_ci       p_value
1:      0.2938 0.3124734 1.425545e-199
```

The simulated experiments are repeated a 1000 times to assess the impact of the Treatment on customer renewal rate, and compare it against the control group.

```
#Repeat 1000 times
B <- 1000
n <- 5000  # Number of samples per group

set.seed(617)  # For reproducibility

# Function to analyze the experiment
analyze.experiment <- function(the.dat) {
  require(data.table)
  if (!is.data.table(the.dat)) {
    setDT(the.dat)
  }

  if (any(is.na(the.dat$Renewed_Or_Not))) {
    the.dat <- na.omit(the.dat)
  }

  the.test <- t.test(x = the.dat[Group == "Treatment", Renewed_Or_Not],
                     y = the.dat[Group == "Control", Renewed_Or_Not],
                     alternative = "two.sided", var.equal = FALSE)

  treatment_mean <- mean(the.dat[Group == "Treatment", Renewed_Or_Not], na.rm =
TRUE)
  control_mean <- mean(the.dat[Group == "Control", Renewed_Or_Not], na.rm = TRUE)
  the.effect <- treatment_mean - control_mean
  upper.bound <- the.test$conf.int[2]
  p <- the.test$p.value

  result <- data.table(effect_size = the.effect, upper_ci = upper.bound, p_value =
p)
  return(result)
}
all_results <- list()
# Repeat the experiment B times
for (i in 1:B) {
  # Simulate data for this run
  sim_data <- data.table(Group = rep(c("Treatment", "Control"), each = n),
```

```
                        Renewed_Or_Not = c(rbinom(n, 1, 0.70), rbinom(n, 1,
0.3870)))

  # Analyze the experiment
  result <- analyze.experiment(the.dat = sim_data)
  result[, Experiment := i]  # Tag the result with the experiment number

  all_results[[i]] <- result  # Store the result
}
# Combine all results into one data.table
final_results <- rbindlist(all_results)
# Calculate the proportion of experiments where the effect was statistically
significant
significant_proportion <- mean(final_results$p_value < 0.05)
print(significant_proportion)
print(final_results)
```

The result shows 1, which translates to a renewal rate of 100% of 1000 experiments. This percentage shows the simulated treatment had a statistically significant effect on the policy renewal rate across all experiments.

```
> print(fraction_meaningful_significant)
[1] 1
```

Conclusion

Research Question	Scenario	Mean Effect in Simulated Data	95% Confidence Interval of Mean Effect	Percentage of False Positives	Percentage of True Negatives	Percentage of False Negatives	Percentage of True Positives
# 1	No Effect	0.002808	[-0.01461 , 0.0226]	0.8 %	50.4 %	43.9 %	4.9 %
# 1	Expected Effect	0.312627	[0.294395 , 0.33081]	0 %	0 %	0 %	100 %

Through this study, we see that the treatment group has a statistically significant effect on renewal rate through the implementation of a flexible payment plan. The “no effect” simulation had a 4.8% renewal rate, while the “expected effect” had a 100% renewal rate, showing a majority of p-values overall were less than 0.05. For scenario 1, the mean effect size is very small (0.002808), suggesting minimal to no natural effect, and the confidence interval ranges from -0.01461 to 0.0226, which includes 0, further supporting this conclusion. For scenario 2, the mean effect size is substantial (0.312627), indicating a strong effect supported by the confidence interval (0.294395 to 0.33081). The second scenario shows the beneficial effects of

having a flexible payment plan; giving the single-family homes in the treatment group a more manageable, more flexible schedule on which to pay the higher insurance rate increases the likelihood of then renewing their policy. This shows that introducing a "Pay in Installments" flexible payment plan helps increase renewal rates across the board for flood insurance policy renewal in single-family homes in Collier County.

Research Question 2: How does the frequency of distributing promotional flyers and mailers for the "Pay in Installments" plan influence the policy renewal rate of flood insurance among single-family homes in Collier County compared to sending only one flier?

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Scenario 1: Minimal Frequency Effect

The simulation aimed to evaluate the impact of a minimal frequency effect by comparing a control group (baseline renewal probability of 0.4) with a treatment group receiving the same frequent flyers (probability stayed at 0.4). Results from 1,000 simulations showed an average effect size of -0.0196, indicating a negligible difference in renewal rates between the two groups. The proportion of simulations resulting in statistically significant differences was only 14.6%, further underscoring that increasing flyer frequency minimally does not significantly affect policy renewals.

Scenario 2: Substantial Frequency Effect

In contrast, the substantial effect scenario involved a treatment group with a much higher renewal probability set at 0.85, while the control group remained at a 0.4 probability. It is noted that choosing an 85% significance level for Research Question 2 is aimed at enhancing the sensitivity of detecting potential effects of flyer frequency on policy renewal rates. This unconventional threshold, lower than the standard 95%, is particularly useful in exploratory research phases where capturing subtle influences is crucial. It allows for a broader exploration of marketing strategies, accepting a higher false positive rate to uncover valuable insights that could inform further, more targeted studies. This approach acknowledges the trade-off between precision and sensitivity, opting to prioritize the latter in the context of competitive insurance marketing. This scenario aimed to simulate the significant impact of increasing flyer distribution frequency. The simulation results were compelling, with an average effect size of -0.450, demonstrating a significant negative impact on renewal rates when flyer frequency was significantly increased. Remarkably, every simulation (100% proportion significant) indicated a statistically significant difference, suggesting that too frequent communications are counterproductive, potentially overwhelming, or annoying recipients.

```r
# Define parameters
n <- 1000      # number of observations per group
p_control <- 0.4  # probability of success in the control group
p_treatment <- 0.5  # probability of success in the treatment group
num_simulations <- 1000  # number of simulations

# Function to run a single simulation
run_simulation <- function() {
  control <- rbinom(n, size = 1, prob = p_control)
  treatment <- rbinom(n, size = 1, prob = p_treatment)
  test_result <- t.test(control, treatment)
  return(c(test_result$estimate[1] - test_result$estimate[2], test_result$p.value))
}
# Run multiple simulations
results <- replicate(num_simulations, run_simulation())
# Analyze results
results_df <- as.data.frame(t(results))
colnames(results_df) <- c("Effect_Size", "P_Value")
summary_results <- results_df %>%
  summarize(
    Average_Effect_Size = mean(Effect_Size),
    Proportion_Significant = mean(P_Value < 0.05)
  )
print(summary_results)
```

```
  Average_Effect_Size Proportion_Significant
1          -0.098634                   0.992
```

Conclusion

Research Question	Scenario	Mean Effect in Simulated Data	95% Confidence Interval of Mean Effect	Percentage of False Positives	Percentage of True Negatives	Percentage of False Negatives	Percentage of True Positives
# 2	No Effect	0.0206	[-0.024, 0.066]	Assuming 5% (typical error rate)	83.3%	16.7 %	16.7 %
# 2	Expected Effect	0.0994	[0.056, 0.140]	Assuming 5% (typical error rate)	0.7 %	99.3%	99.3 %

The table clearly distinguishes between the impacts of minimal and substantial frequency in distributing promotional flyers for the “Pay in Installments” plan on flood insurance renewal rates among single-family homes in Collier County. In the scenario with minimal frequency increase, the effect size is modest at 0.0206 with a wide confidence interval that spans negative and positive values, indicating a weak and non-significant impact. This is further supported by only 16.7% of the simulations producing statistically significant results, which is close to the typical false positive rate of 5%, suggesting that minimal increases in flyer frequency may not effectively enhance policy renewals.

Conversely, the substantial frequency scenario shows a more pronounced effect size of 0.0994 with a narrower confidence interval, reflecting a robust and statistically significant influence on policy renewals in 99.3% of simulations. This demonstrates a clear benefit from increasing the frequency of flyers, suggesting that more aggressive marketing efforts can significantly boost policy renewals. The data underscores the importance of tailored communication strategies in insurance marketing, especially in regions susceptible to climate risks where maintaining coverage is crucial for financial stability.

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Appendix A:

Survey 1

1. Are you a full-time resident of Collier County? Y/N
2. Do you have existing flood insurance on your home? Y/N
3. Are you aware if you are in a flood zone? Y/N
4. Are you interested in purchasing flood insurance? Y/N
5. Why had you not purchased flood insurance previously? Short answer

Survey 2

1. Are you a full-time resident of Collier County? Y/N
2. Do you have existing flood insurance on your home? Y/N
3. Are you aware if you are in a flood zone? Y/N
4. Are you interested in purchasing flood insurance? Y/N
5. If yes, are you interested in the payment plan option? Y/N
6. Why had you not purchased flood insurance previously? Short answer