Libraries

```
#Libraries and api key

library(stringr)
library(openai)
library(mlogit)
```

```
Loading required package: dfidx
```

```

Attaching package: 'dfidx'
```

```
The following object is masked from 'package:stats':

    filter
```

```
library(tidyverse)
```

```
-- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
v dplyr     1.1.2     v purrr     1.0.2
v forcats   1.0.0     v readr     2.1.4
v ggplot2   3.4.2     v tibble    3.2.1
v lubridate 1.9.2     v tidyr     1.3.0
```

```
-- Conflicts ------------------------------------------ tidyverse_conflicts() --
x dplyr::filter() masks dfidx::filter(), stats::filter()
x dplyr::lag()    masks stats::lag()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to beco
```

```
Sys.setenv(
    OPENAI_API_KEY = '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'
)
```

Get_Responses

```r
# This function:
# 1) Queries the OpenAI API with chosen method and settings
# 2) Creates a vector then assigns each response to the vector.
# 3) Searches each string in the vector for given keywords, and returns the FIRST keyword


get_response <- function(n = 5, chat = FALSE, prompt, role, keywords){

  #Change formatting and model based on chat TRUE/FALSE
  if(chat == TRUE){
    model <- 'gpt-4'
    prompt <- list(list('role' = 'system', 'content' = role), list('role' = 'user', 'conte
  }

  if(chat == FALSE){
    model <- 'text-davinci-003'
  }


  #identify model and temperature wanted
  temp <- 1
  tokens <- 100


  #Use function based on chat argument
  if(chat == TRUE){
    response <- create_chat_completion(model = model, n = n, messages = prompt, temperatur
  }

  if(chat == FALSE){
  response <- create_completion(model = model, n = n, prompt = prompt, temperature = temp,
  }

  #Create choices object  to access the choices directly
  choices <- response$choices

  #Create a text vector to store the text in
  text_v <- c()

  #Loop through each choice with appropriate access path
  for (i in 1:n){
```

```
    if(chat == TRUE){
      text_v <- c(text_v, choices[[4]][[i]])
    }

    if(chat == FALSE){
      text_v <- c(text_v, choices[[1]][[i]])
    }
  }

  #Create vector to store true/false string comparisons
  answer <- c()


  #Loop through individual responses
  for (string in text_v){

    is_true <- c()

    #Loop through the keywords
    for(keyword in keywords){

      #Append the is_true vector with the result of keyword search
      is_true <- c(is_true, grepl(keyword, string, ignore.case = TRUE))
    }

    #If there is more than 1 keyword found, then return inconclusive. Else, return the key
    answer <- c(answer, ifelse(sum(is_true) > 1, 'Inconclusive', keywords[is_true]))
  }
  #Makes sure all elements are in a single vector
  answer <- unlist(answer, FALSE)

return(list(answer = answer, text_v = text_v))
#return(answer)
}
```

One Laptop

Prompt

```
one_prompt <- function(price = 1000,
                       income = 50000,
                       prompt_num = 1){

        role <- 'You are a customer taking part in a product survey. Make the most reasona


  #Originial prompt from the paper
    if(prompt_num == 1){

      prompt <- paste0('A customer is randomly selected while shopping for laptops. Their
income is $', income,'.
While shopping, the customer sees a Surface Laptop 3, Price: $', price,',
Processor: Intel Core i5, RAM: 8GB, Screen Size: 13.5in, SD: 128GB
The customer is asked, after they finish shopping: Did you purchase any lap-
top? If so, which one?
Customer: ')
    }


      #Excludes 'You:' or "Customer:' and makes the model the shopper instead of third per
    if(prompt_num == 2){

    prompt <- paste0('Pretend you are a customer who has been randomly selected while shop
    }

  #says 'any' instead of 'this' and 'includes 'You:'
  if(prompt_num == 3){

    prompt <- paste0('Pretend you are a customer who has been randomly selected while shop
  }


  #says 'this' instead of 'any' and drops 'If so, which one?'
  #Neither model likes this one. Primarily reports no.
  if(prompt_num == 4){
```

```
    prompt <- paste0('Pretend you are a customer who has been randomly selected while shop
  }

  #says 'If so, which one' after 'Did you purchase this laptop?'
  if(prompt_num == 5){

    prompt <- paste0('Pretend you are a customer who has been randomly selected while shop
  }

  if(prompt_num == 6){
    prompt <- paste0('Pretend you are a customer who has been randomly selected while shop
  }
#Notes and observations

    #Shocking difference between including "Pretend" and not including "Pretend" after adj

return( c(prompt, role) )
}
```

DF

```
#Model choice
chat <- FALSE

#Prompt number
prompt_num <- 1

#Set k to change in price
k <- 25

#Set j to number of prices
num_prices <- 20

#Max is 128
#Set n to number of iterations PER PRICE
n <- 128



#initiate starting price
```

```r
price <- 749



if(chat == TRUE){
#Identify keywords to look for in responses
  keywords <- c('Surface', 'No')
}

if(chat == FALSE){
  keywords <- c('Yes', 'No')
}


# Different incomes to use
income <- c(70000)

#Initiate variables used in loop
choice_v <- c()
income_v <- c()
price_v <- c()
text_v <- c()
#Loop through the prompts

#Prompt for each price at given income level
for(inc in income){

  new_price <- price

  for(i in 1:num_prices){



    #Identify the prompt
    prompt_func <- one_prompt(price = new_price, income = inc, prompt_num = prompt_num)

    #Split it into role / prompt
    prompt <- prompt_func[1]
    role <- prompt_func[2]

    #Append the choice vector with newest choice
```

```
    response <- get_response(n = n, chat = chat, prompt = prompt, role = role, keywords =
    choice_v <- c(choice_v, unlist(response[1]))
    text_v <- c(text_v, unlist(response[2]))
    #Append income and price vectors to match the choice vector
    income_v <- c(income_v, rep(inc, n))
    price_v <- c(price_v, rep(new_price, n))

    new_price <-  new_price + k

  }

}

#Create dynamic variable based on model and prompt
if(chat == TRUE){
  var_name <- paste('one_', 'chat_p', prompt_num, '_inc', length(income), sep = '')
}

if(chat == FALSE){
  var_name <- paste('one_', 'comp_p', prompt_num, '_inc', length(income), sep = '')
}

#Assign dataframe appropriate name
assign(var_name, data.frame(choice = choice_v, income = income_v, price = price_v, text =

# Perform cleaning on the dynamically named dataframe
df <- get(var_name)
df_nn <- drop_na(df)
df_clean <- subset(df_nn, choice != 'Inconclusive')
df_binary <- df_clean |>
  mutate(choice = recode(choice, "Yes" = 1, "No" = 0))
df_mean <- df_binary |>
  group_by(price, income) |>
  summarise(avg_choice = mean(choice, na.rm = TRUE))
```

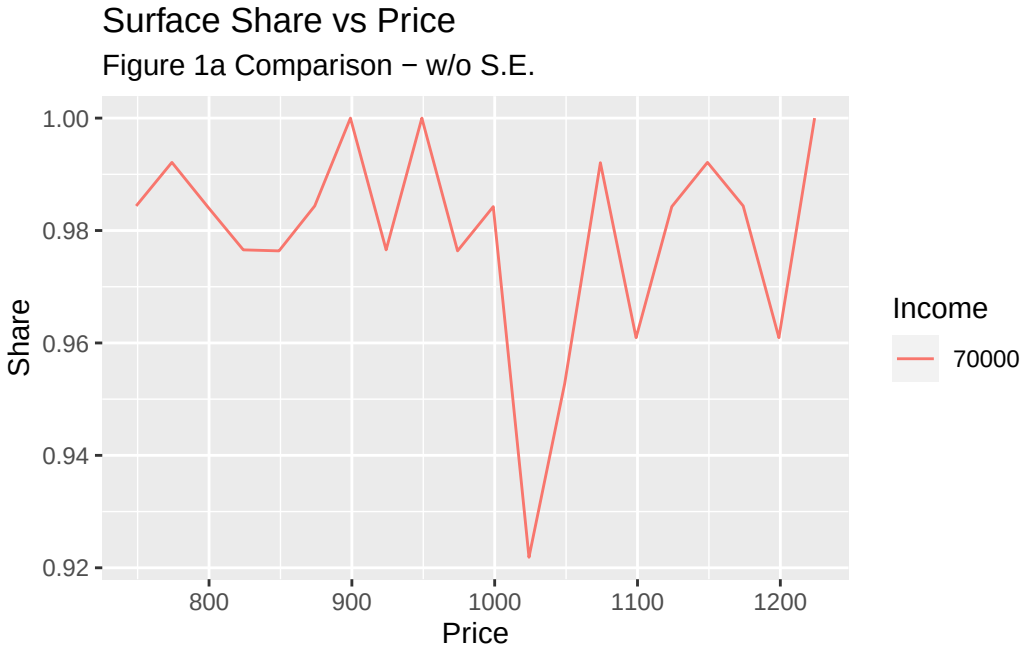
```
`summarise()` has grouped output by 'price'. You can override using the
`.groups` argument.
```

```
# If you want to save the cleaned dataframes back to dynamically named variables, you can
```

```
assign(paste0(var_name, "_mean"), df_mean)
```

Fig 1a Plots

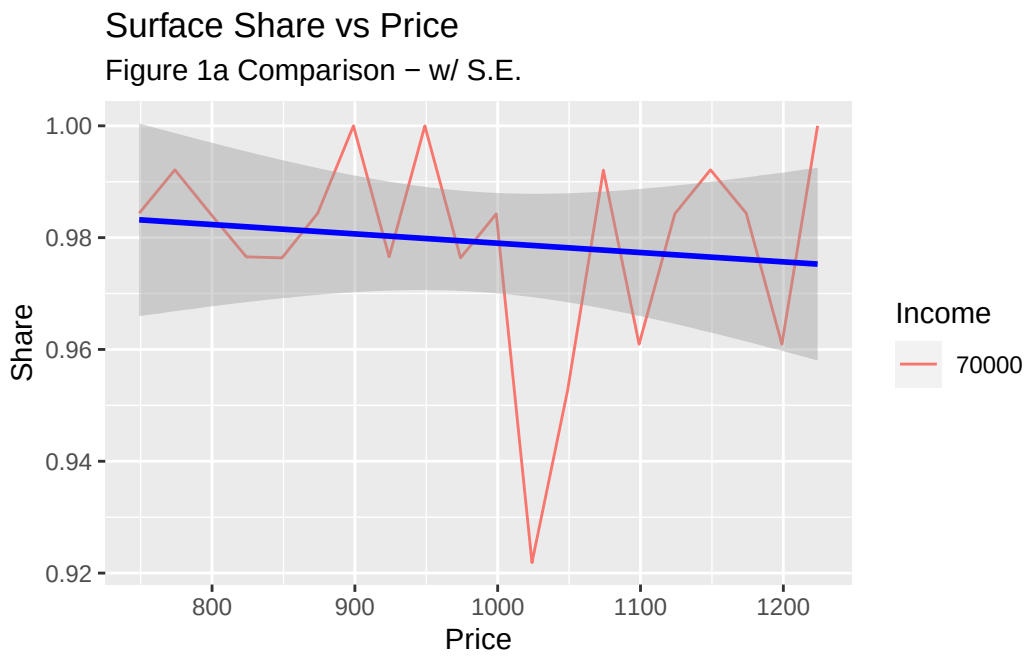
```
ggplot(data = one_comp_p1_inc1_mean, aes(x = price, y = avg_choice, color = as.factor(inco
  geom_line() +
  labs(title = "Surface Share vs Price",
       subtitle = "Figure 1a Comparison - w/o S.E.",
       y = "Share",
       x = "Price",
       color = "Income")
```




```
ggplot(data = one_comp_p1_inc1_mean, aes(x = price, y = avg_choice, color = as.factor(inco
  geom_line() +
  geom_smooth(method = "lm", se = TRUE, color = "blue") +  # Add smoothed line with SE sha
  labs(title = "Surface Share vs Price",
       subtitle = "Figure 1a Comparison - w/ S.E.",
       y = "Share",
       x = "Price",
```

```
        color = "Income")
```

```
`geom_smooth()` using formula = 'y ~ x'
```




```
#Model choice
chat <- FALSE

#Prompt number
prompt_num <- 1

#Set k to change in price
k <- 25

#Set j to number of prices
num_prices <- 20

#Max is 128
#Set n to number of iterations PER PRICE
n <- 128
```

```r
#initiate starting price
price <- 749



if(chat == TRUE){
#Identify keywords to look for in responses
  keywords <- c('Surface', 'No')
}

if(chat == FALSE){
  keywords <- c('Yes', 'No')
}


# Different incomes to use
income <- c(50000, 120000)

#Initiate variables used in loop
choice_v <- c()
income_v <- c()
price_v <- c()
text_v <- c()
#Loop through the prompts

#Prompt for each price at given income level
for(inc in income){

  new_price <- price

  for(i in 1:num_prices){



    #Identify the prompt
    prompt_func <- one_prompt(price = new_price, income = inc, prompt_num = prompt_num)

    #Split it into role / prompt
    prompt <- prompt_func[1]
    role <- prompt_func[2]
```

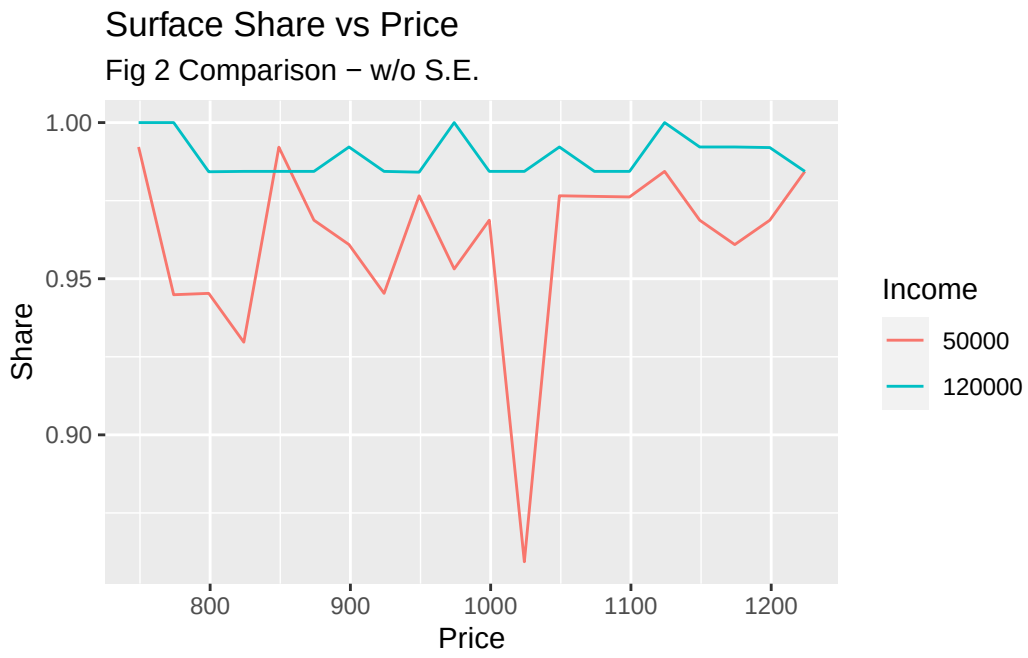
```
    #Append the choice vector with newest choice
    response <- get_response(n = n, chat = chat, prompt = prompt, role = role, keywords =
    choice_v <- c(choice_v, unlist(response[1]))
    text_v <- c(text_v, unlist(response[2]))
    #Append income and price vectors to match the choice vector
    income_v <- c(income_v, rep(inc, n))
    price_v <- c(price_v, rep(new_price, n))

    new_price <-  new_price + k

  }

}

#Create dynamic variable based on model and prompt
if(chat == TRUE){
  var_name <- paste('one_', 'chat_p', prompt_num, '_inc', length(income), sep = '')
}

if(chat == FALSE){
  var_name <- paste('one_', 'comp_p', prompt_num, '_inc', length(income), sep = '')
}

#Assign dataframe appropriate name
assign(var_name, data.frame(choice = choice_v, income = income_v, price = price_v, text =

# Perform cleaning on the dynamically named dataframe
df <- get(var_name)
df_nn <- drop_na(df)
df_clean <- subset(df_nn, choice != 'Inconclusive')
df_binary <- df_clean |>
  mutate(choice = recode(choice, "Yes" = 1, "No" = 0))
df_mean <- df_binary |>
  group_by(price, income) |>
  summarise(avg_choice = mean(choice, na.rm = TRUE))
```

```
`summarise()` has grouped output by 'price'. You can override using the
`.groups` argument.
```

```r
# If you want to save the cleaned dataframes back to dynamically named variables, you can


assign(paste0(var_name, "_mean"), df_mean)
```

Fig 2 Plots

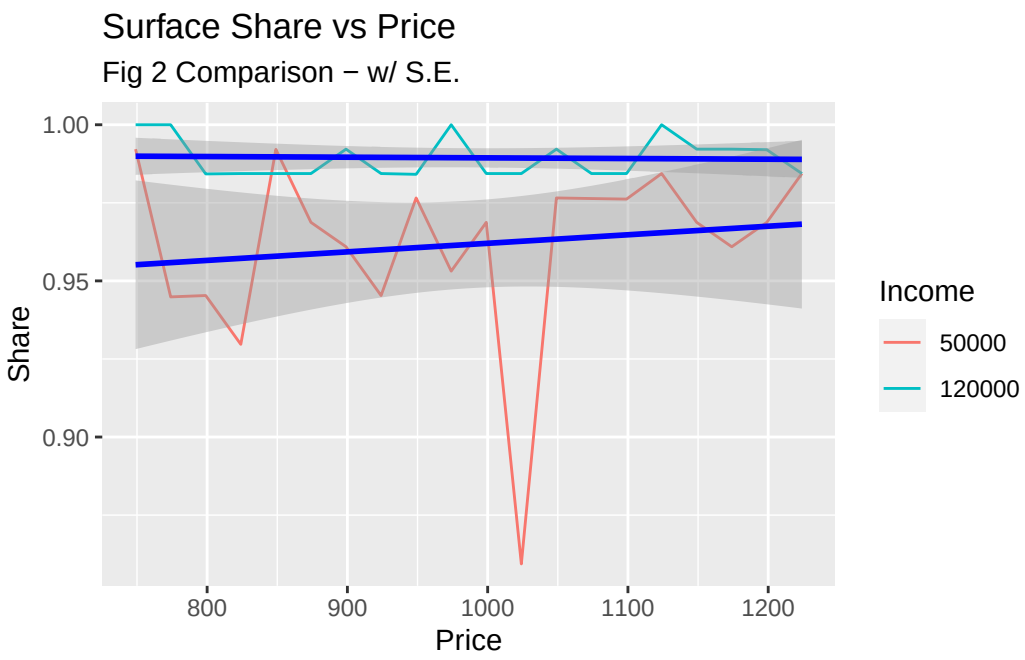
```r
ggplot(data = one_comp_p1_inc2_mean, aes(x = price, y = avg_choice, color = as.factor(inco
  geom_line() +
  labs(title = "Surface Share vs Price",
       subtitle = 'Fig 2 Comparison - w/o S.E.',
       y = "Share",
       x = "Price",
       color = "Income")
```




```r
ggplot(data = one_comp_p1_inc2_mean, aes(x = price, y = avg_choice, color = as.factor(inco
  geom_line() +
  geom_smooth(method = "lm", se = TRUE, color = "blue") +  # Add smoothed line with SE sha
  labs(title = "Surface Share vs Price",
```

```
        subtitle = 'Fig 2 Comparison - w/ S.E.',
        y = "Share",
        x = "Price",
        color = "Income")
```

```
`geom_smooth()` using formula = 'y ~ x'
```



Two Laptops

Prompt

```
two_prompt <- function(income = 50000,
                       surface_price = 999,
                       prompt_num = 1){
  role <- 'You are a consumer taking part in a product survey. Make the most reasonable pu

  #Prompt 1 is the paper's prompt
  if(prompt_num == 1){
  prompt <- paste('A customer is randomly selected while shopping for laptops. Their annua
```

```
income is $',income,'.
While shopping, the customer has three options:
- Surface Laptop 3, Price: $', surface_price,' Processor: Intel Core i5, RAM:8GB,
Screen Size: 13.5in, SD: 128GB
- Macbook Air (2019), Price: $999, Processor: Intel Core i5, RAM: 8GB,
Screen Size: 13.3in, SD: 128GB
They also have the option not to purchase a laptop. The customer is asked,
after they finish shopping: Which laptop, if any, did you purchase? Customer: ', sep = "")
  }

  if(prompt_num == 2){
    prompt <- paste('Pretend you are a customer who has been randomly selected while shopp
    While shopping, you have three options:
    - Surface Laptop 3, Price: $', surface_price,' Processor: Intel Core i5, RAM:
8GB, Screen Size: 13.5in, SD: 128GB
- Macbook Air (2019), Price: $999, Processor: Intel Core i5, RAM: 8GB,
Screen Size: 13.3in, SD: 128GB

You also have the option not to purchase a laptop. Which laptop, if any, did you purchase?
  }

      return( c(prompt, role))
}
```

DF

```
#model
chat = FALSE

#Set k to price change
k = 25

#Set j to number of prices
num_prices = 20

#Set n to number of iterations PER PRICE
n <- 128

# Different incomes to use
income <- c(70000)
```

```r
#Surface Price
surface_price <- 749

#keywords to search for in the response
keywords <- c('surface', 'macbook')

#Prompt 1 is the paper's prompt
prompt_num <- 1


choice_v <- c()
income_v <- c()
price_v <- c()

#Loop through the prompts

#Prompt for each price at given income level
for(inc in income){

  new_price <- surface_price

  for(i in 1:num_prices){



    #Identify the prompt
    prompt_func <- two_prompt(surface_price = new_price, income = inc, prompt_num = prompt

    #Split it into role / prompt
    prompt <- prompt_func[1]
    role <- prompt_func[2]

    #Append the choice vector with newest choice
    response <- get_response(n = n, chat = chat, prompt = prompt, role = role, keywords =
    choice_v <- c(choice_v, unlist(response[1]))
    text_v <- c(text_v, unlist(response[2]))

    #Append income and price vectors to match the choice vector
    income_v <- c(income_v, rep(inc, n))
    price_v <- c(price_v, rep(new_price, n))
```

```
    new_price <-  new_price + k

  }

}

#Create dynamic variable based on model and prompt
if(chat == TRUE){
  var_name <- paste('two_', 'chat_p', prompt_num, '_inc', length(inc), sep = '')
}

if(chat == FALSE){
  var_name <- paste('two_', 'comp_p', prompt_num, '_inc', length(inc), sep = '')
}

#Assign dataframe appropriate name
assign(var_name, data.frame(choice = choice_v, income = income_v, price = price_v))


# Perform cleaning on the dynamically named dataframe
df <- get(var_name)
df_nn <- drop_na(df)
df_clean <- subset(df_nn, choice != 'Inconclusive')
df_binary <- df_clean |>
  mutate(choice = recode(choice, "surface" = 1, "macbook" = 0))
df_mean <- df_binary |>
  group_by(price, income) |>
  summarise(avg_choice = mean(choice, na.rm = TRUE))
```

```
`summarise()` has grouped output by 'price'. You can override using the
`.groups` argument.
```

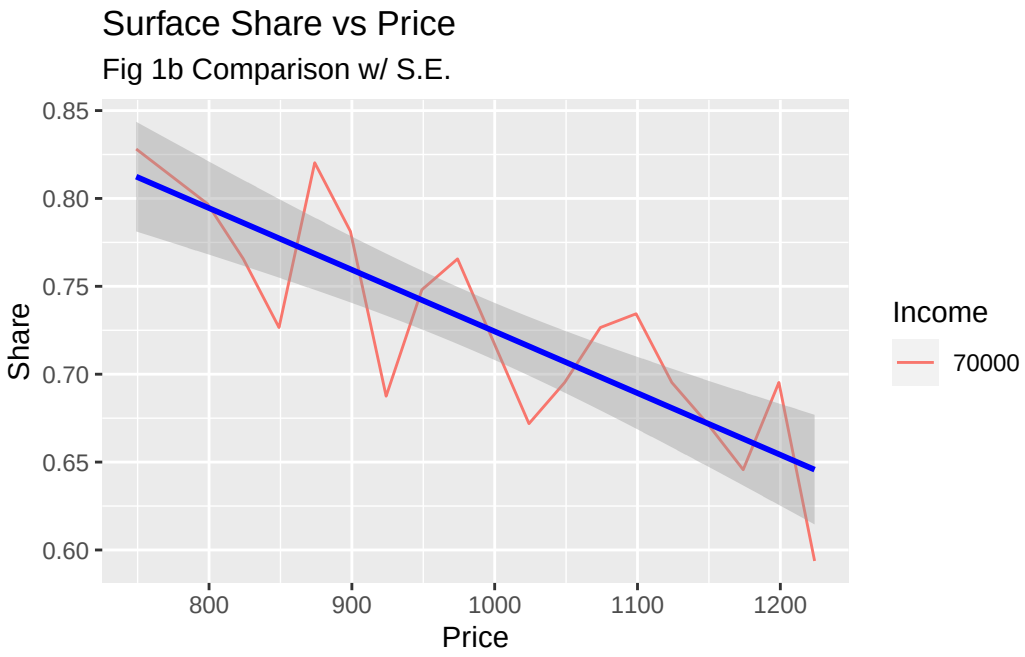
```
# If you want to save the cleaned dataframes back to dynamically named variables, you can

assign(paste0(var_name, "_mean"), df_mean)
```

Fig 1b Plots

```
ggplot(data = two_comp_p1_inc1_mean, aes(x = price, y = avg_choice, color = as.factor(inco
  geom_line() +
  labs(title = "Surface Share vs Price",
       subtitle = 'Fig 1b Comparison w/o S.E.',
       y = "Share",
       x = "Price",
       color = "Income")
```


```
ggplot(data = two_comp_p1_inc1_mean, aes(x = price, y = avg_choice, color = as.factor(inco
  geom_line() +
  geom_smooth(method = "lm", se = TRUE, color = 'blue') +
  labs(title = "Surface Share vs Price",
       subtitle = 'Fig 1b Comparison w/ S.E.',
       y = "Share",
       x = "Price",
       color = "Income")
```

```
`geom_smooth()` using formula = 'y ~ x'
```



Toothpaste

Prompt

```
#Create prompt with income, colgate price and crest price.
tp_prompt <- function(colgate_price = 2,
                      crest_price = 4,
                      income = 50000,
                      prompt_num = 1){

  #prompts 1-3 are from the paper.

  if(prompt_num == 1){
    option <- ''
  }

  if(prompt_num == 2){
    option <- ' The customer says that
last time they shopped for toothpaste they purchased the Colgate whitening
toothpaste.'
```

```
  }

  if(prompt_num == 3){
    option <- ' This customer bought
the Colgate whitening toothpaste last time they shopped for toothpaste.'
  }

  prompt <- paste('A customer is randomly selected while shopping in the supermarket. Thei
annual income is $',income,'.
While shopping, the customer passes by the toothpaste aisle and sees two op-
tions:
- Colgate whitening toothpaste with fluoride, price $',colgate_price,'.
- Crest whitening toothpaste with fluoride, price $',crest_price,'.
They also have the option not to purchase toothpaste.',option,' The customer is asked,
after they finish shopping: Which toothpaste, if any, did you purchase?
Customer: ', sep = "")

  return(prompt)
}
```

DF

```
choice_v <- c()
income_v <- c()
price_v <- c()
text_v <- c()
#Option 1 is Colgate
#Option 2 is Crest
#Option 3 is No Purchase

#Choose Model
chat = FALSE

#Choose prompt num
prompt_num <- 1

#Set k to increase in price change
k <- .25

#Set j to number of prices
```

```r
num_prices <- 17

#Set n to number of iterations PER PRICE
n <-128

colgate_price <- 2

keywords <- c('crest', 'colgate')

income <- c(70000)

#Prompt for each price at given income level
for(inc in income){

  new_price <- colgate_price

  for(i in 1:num_prices){



    #Identify the prompt
    prompt_func <- tp_prompt(colgate_price = new_price, income = inc, prompt_num = prompt_

    #Split it into role / prompt
    prompt <- prompt_func[1]
    role <- prompt_func[2]

    #Append the choice vector with newest choice
    response <- get_response(n = n, chat = chat, prompt = prompt, role = role, keywords =
    choice_v <- c(choice_v, unlist(response[1]))
    text_v <- c(text_v, unlist(response[2]))

    #Append income and price vectors to match the choice vector
    income_v <- c(income_v, rep(inc, n))
    price_v <- c(price_v, rep(new_price, n))

    new_price <-  new_price + k

  }

}
```

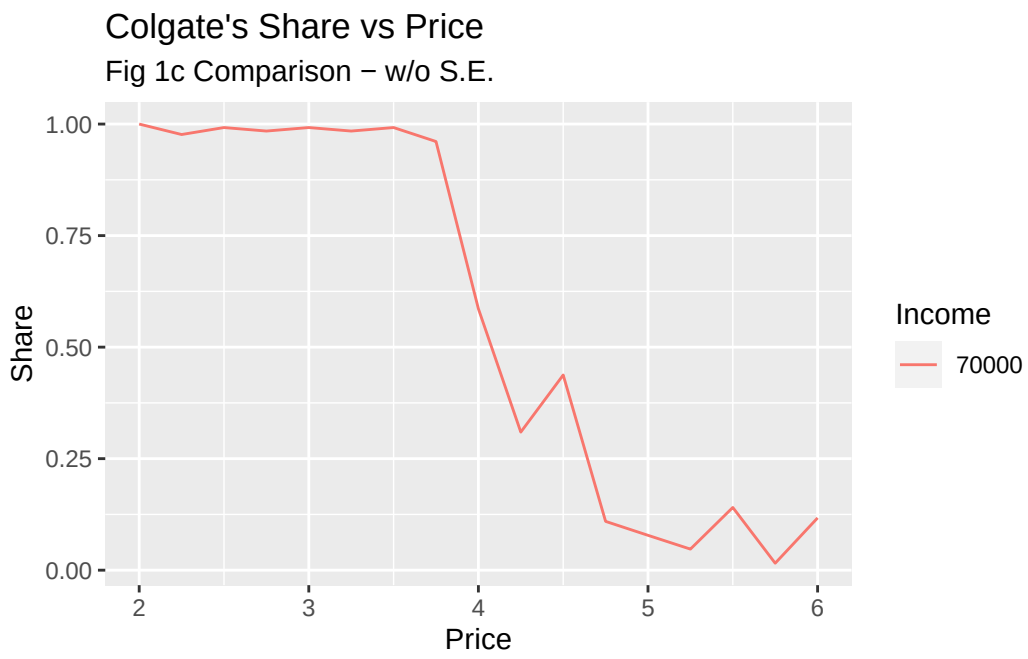
```r
#Create dynamic variable based on model and prompt
if(chat == TRUE){
  var_name <- paste('tp_', 'chat_p', prompt_num, '_inc', length(inc), sep = '')
}

if(chat == FALSE){
  var_name <- paste('tp_', 'comp_p', prompt_num, '_inc', length(inc), sep = '')
}

#Assign dataframe appropriate name
assign(var_name, data.frame(choice = choice_v, income = income_v, price = price_v, text =


# Perform cleaning on the dynamically named dataframe
df <- get(var_name)
df_nn <- drop_na(df)
df_clean <- subset(df_nn, choice != 'Inconclusive')
df_binary <- df_clean |>
  mutate(choice = recode(choice, "colgate" = 1, "crest" = 0))
df_mean <- df_binary |>
  group_by(price, income) |>
  summarise(avg_choice = mean(choice, na.rm = TRUE))
```

```
`summarise()` has grouped output by 'price'. You can override using the
`.groups` argument.
```

```r
# If you want to save the cleaned dataframes back to dynamically named variables, you can

assign(paste0(var_name, "_mean"), df_mean)
```

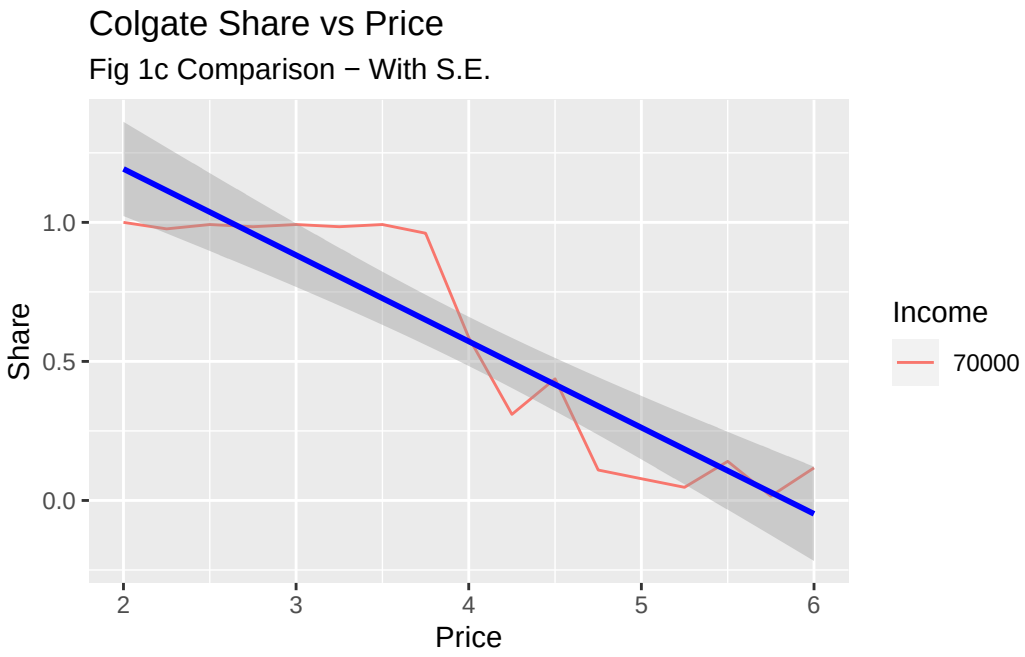
Fig 1c Plots

```
ggplot(data = tp_comp_p1_inc1_mean, aes(x = price, y = avg_choice, color = as.factor(incom
  geom_line() +
  labs(title = "Colgate's Share vs Price",
       subtitle = "Fig 1c Comparison - w/o S.E.",
       y = "Share",
       x = "Price",
       color = 'Income')
```




```
ggplot(data = tp_comp_p1_inc1_mean, aes(x = price, y = avg_choice, color = as.factor(incom
  geom_line() +
  geom_smooth(method = "lm", se = TRUE, color = 'blue') +
  labs(title = "Colgate Share vs Price",
       subtitle = 'Fig 1c Comparison - With S.E.',
       y = "Share",
       x = "Price",
       color = "Income")
```

```
`geom_smooth()` using formula = 'y ~ x'
```



Yogurt

Prompt

DF