**Shyam Parmar | Assignment 8**

**Predictor Table**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Feature** | **Rationale** | **Spend** | **Units** | **Household** | **Product** |
| BASE\_PRICE | Item's base pay can determine the sale | + | - | + | + |
| DISPLAY | If item can be seen, then it will be sold | + | - | + | + |
| FEATURE | If item was featured then it will be sold | + | - | + | + |
| HHS | The higher the household purchasers, the better | + | - | NA | + |
| PRICE | If the price is reasonable there will be higher sales | + | - | + | + |
| SPEND | The higher the sales, the better | NA | - | + | + |
| TPR\_ONLY | This can boost sales | + | - | + | + |
| UNITS | The more units sold, the better | + | NA | + | + |
| VISITS | The higher visits, the better | + | - | + | + |
| WEEK\_END\_DATE | NA | NA | NA | NA | NA |
| UPC | NA | NA | NA | NA | NA |
| STORE\_NUM | NA | NA | NA | NA | NA |
| CATEGORY | Helps track which categories perform better over others | ? | ? | ? | ? |
| DESCRIPTION | Able to know which item it is | ? | ? | ? | NA |
| MANUFACTURER | Able to know if manufacturers play a role in sales | ? | ? | ? | ? |
| PRODUCT\_SIZE | Product size usually does not matter but can be correlated to display | + | + | + | + |
| SUB\_CATEGORY | Helps track which categories perform better over others | ? | ? | ? | ? |
| CITY | Different cities may carry different products and have different sales | + | - | + | + |
| STATE | Different states may have more or less stores compared to other states | ? | ? | ? | ? |
| AVG\_WEEKLY\_BASKETS | NA | NA | NA | NA | NA |
| MSA | NA | NA | NA | NA | NA |
| PARKING | Parking usually wont change much in terms of sales | NA | NA | NA | NA |
| SEGMENT | Store segments can determine sales | ? | ? | ? | ? |
| SIZE | Small stores make less than big stores | ? | ? | ? | ? |
| STORE\_APPEAL | Poor appealing stores can drive less customers and vice versa | + | - | + | + |
| price\_elastic | Not sure | ? | ? | ? | ? |

**Visuals**

*Spend*

Chart

Description automatically generatedChart, histogram

Description automatically generated

*Units*

Chart

Description automatically generatedChart, histogram

Description automatically generated

*HHS*

Chart

Description automatically generatedChart, histogram

Description automatically generated

**Models**

We use multilevel models (LMER) since the data is on multiple levels (item, store, city, state)

***Question 1:***

**What are the effects of product display, being featured on in-store circular, and temporary price reduction on product sales (spend), unit sales, and number of household purchasers?**

Spend

spend\_m2 <- lmer(LOGSPEND ~ DISPLAY + FEATURE + TPR\_ONLY + HHS + PRODUCT\_SIZE + UNITS + VISITS + (1 | STORE\_NAME) + (1 | CITY), data=df, REML=FALSE)

Units

units\_m1 <- lmer(UNITS ~ DISPLAY + FEATURE + TPR\_ONLY + HHS + PRODUCT\_SIZE + SPEND + VISITS + (1 | STORE\_NAME) + (1 | CITY), data = df, REML = FALSE)

HHS

hhs\_m1 <- lmer(HHS ~ DISPLAY + FEATURE + TPR\_ONLY + UNITS + PRODUCT\_SIZE + SPEND + VISITS + (1 | ST ORE\_NAME) + (1 | CITY), data = df, REML = FALSE)

Stargazer

|  |  |  |  |
| --- | --- | --- | --- |
|  | *Dependent variable:* | | |
|  |  | | |
|  | LOGSPEND | UNITS | HHS |
|  | (1) | (2) | (3) |
|  | | | |
| DISPLAY1 | 0.212\*\*\* (0.004) | -0.420\*\*\* (0.030) | 0.098\*\*\* (0.007) |
| FEATURE1 | 0.193\*\*\* (0.004) | 1.065\*\*\* (0.034) | 0.231\*\*\* (0.008) |
| TPR\_ONLY1 | -0.078\*\*\* (0.003) | 1.274\*\*\* (0.026) | 0.156\*\*\* (0.006) |
| HHS | -0.033\*\*\* (0.001) | -0.212\*\*\* (0.006) |  |
| PRODUCT\_SIZE11 OZ | 0.693\*\*\* (0.008) | -2.551\*\*\* (0.063) | 0.162\*\*\* (0.016) |
| PRODUCT\_SIZE12 OZ | 0.827\*\*\* (0.007) | -1.890\*\*\* (0.055) | 0.036\*\*\* (0.014) |
| PRODUCT\_SIZE12.2 OZ | 0.750\*\*\* (0.007) | -4.159\*\*\* (0.060) | 0.277\*\*\* (0.015) |
| PRODUCT\_SIZE12.25 OZ | 0.702\*\*\* (0.006) | -2.268\*\*\* (0.050) | 0.446\*\*\* (0.013) |
| PRODUCT\_SIZE13 OZ | 0.492\*\*\* (0.006) | -1.650\*\*\* (0.051) | -0.072\*\*\* (0.013) |
| PRODUCT\_SIZE13.2 OZ | 0.531\*\*\* (0.010) | -0.561\*\*\* (0.080) | 0.057\*\*\* (0.020) |
| PRODUCT\_SIZE13.3 OZ | 0.484\*\*\* (0.011) | -0.460\*\*\* (0.092) | 0.045\* (0.023) |
| PRODUCT\_SIZE14 OZ | 0.434\*\*\* (0.007) | -2.098\*\*\* (0.062) | 0.155\*\*\* (0.015) |
| PRODUCT\_SIZE14.7 OZ | 0.327\*\*\* (0.012) | -0.574\*\*\* (0.103) | -0.014 (0.026) |
| PRODUCT\_SIZE15 OZ | 0.377\*\*\* (0.005) | -1.617\*\*\* (0.045) | 0.202\*\*\* (0.011) |
| PRODUCT\_SIZE16 OZ | 0.137\*\*\* (0.005) | -0.151\*\*\* (0.041) | 0.097\*\*\* (0.010) |
| PRODUCT\_SIZE18 OZ | 1.076\*\*\* (0.005) | -2.600\*\*\* (0.044) | -0.843\*\*\* (0.011) |
| PRODUCT\_SIZE20 OZ | 0.711\*\*\* (0.007) | 0.899\*\*\* (0.060) | 0.211\*\*\* (0.015) |
| PRODUCT\_SIZE22.7 OZ | 0.538\*\*\* (0.007) | -1.093\*\*\* (0.062) | 0.108\*\*\* (0.015) |
| PRODUCT\_SIZE26.11 OZ | 0.356\*\*\* (0.008) | -0.721\*\*\* (0.066) | 0.033\*\* (0.016) |
| PRODUCT\_SIZE27.35 OZ | 0.428\*\*\* (0.008) | -0.899\*\*\* (0.063) | 0.078\*\*\* (0.016) |
| PRODUCT\_SIZE28.3 OZ | 1.430\*\*\* (0.007) | -3.620\*\*\* (0.063) | 0.421\*\*\* (0.016) |
| PRODUCT\_SIZE29.6 OZ | 0.844\*\*\* (0.007) | 0.440\*\*\* (0.060) | 0.196\*\*\* (0.015) |
| PRODUCT\_SIZE29.8 OZ | 0.961\*\*\* (0.007) | -2.187\*\*\* (0.061) | 0.207\*\*\* (0.015) |
| PRODUCT\_SIZE30.5 OZ | 0.652\*\*\* (0.007) | 0.251\*\*\* (0.060) | 0.157\*\*\* (0.015) |
| PRODUCT\_SIZE32.7 OZ | 0.923\*\*\* (0.006) | -1.641\*\*\* (0.050) | 0.235\*\*\* (0.012) |
| UNITS | -0.012\*\*\* (0.0002) |  | -0.013\*\*\* (0.0004) |
| SPEND |  | 0.038\*\*\* (0.0003) | -0.005\*\*\* (0.0001) |
| VISITS | 0.068\*\*\* (0.001) | 1.327\*\*\* (0.006) | 1.003\*\*\* (0.0005) |
| Constant | 2.584\*\*\* (0.036) | -0.602\*\*\* (0.111) | 0.011 (0.048) |
|  | | | |
| Observations | 418,727 | 418,727 | 418,727 |
| Log Likelihood | -394,190.800 | -1,283,308.000 | -700,773.800 |
| Akaike Inf. Crit. | 788,443.500 | 2,566,678.000 | 1,401,610.000 |
| Bayesian Inf. Crit. | 788,782.800 | 2,567,018.000 | 1,401,949.000 |
|  | | | |
| *Note:* | \*p<0.1; \*\*p<0.05; \*\*\*p<0.01 | | |

***Question 2:***

**How do the effects of display, feature, and TPR on SPEND vary by product categories (cold cereals, frozen pizza, bag snacks) and store segments (mainstream, upscale, value)?**

The question asked what variable effects on SPEND are vary by Categories and Segments. For that reason, we use those two columns as our random effects.

question2\_m <- lmer(LOGSPEND ~ DISPLAY + FEATURE + TPR\_ONLY + PRODUCT\_SIZE + UNITS + VISITS + (1 | CATEGORY) + (1 | SEGMENT), data = df, REML = FALSE)

***Question 3:***

**What are the five most price elastic and five least price elastic products? Price elasticity is the change in sales for unit change in product price?**

question3\_m <- lmer(log(PRICE\_ELASTIC) ~ DESCRIPTION + DISPLAY + FEATURE + TPR\_ONLY + PRODUCT\_SIZE + UNITS + VISITS + (1 | CATEGORY) + (1 | SEGMENT), data = df, REML = FALSE)

***Question 4:***

**As the retailer, which products would you lower the price to maximize (a) product sales and (b) unit sales, and why?**

question4\_m <- lmer(log(PRICE) ~ UNITS + DESCRIPTION + DISPLAY + FEATURE + PRODUCT\_SIZE + VISITS + (1 | STORE\_NAME) + (1 | CITY), data = df, REML = FALSE)

*Stargazer for questions 2, 3, and 4*

|  |  |  |  |
| --- | --- | --- | --- |
|  | | | |
|  | *Dependent variable:* | | |
|  |  | | |
|  | LOGSPEND | log(PRICE\_ELASTIC) | log(PRICE) |
|  | (1) | (2) | (3) |
|  | | | |
| DESCRIPTIONDIGRN PEPP PIZZA |  | 0.453\*\*\* (0.008) | 0.010\*\*\* (0.001) |
| DESCRIPTIONDIGRN SUPREME PIZZA |  | 0.239\*\*\* (0.008) | 0.005\*\*\* (0.001) |
| DESCRIPTIONFRSC 4 CHEESE PIZZA |  | -0.630\*\*\* (0.009) | 0.024\*\*\* (0.002) |
| DESCRIPTIONFRSC BRCK OVN ITL PEP PZ |  | -0.471\*\*\* (0.008) | 0.028\*\*\* (0.001) |
| DESCRIPTIONFRSC PEPPERONI PIZZA |  | -0.571\*\*\* (0.008) | 0.026\*\*\* (0.002) |
| DESCRIPTIONGM CHEERIOS |  | 1.144\*\*\* (0.008) | -0.363\*\*\* (0.001) |
| DESCRIPTIONGM HONEY NUT CHEERIOS |  | 1.623\*\*\* (0.008) | -0.759\*\*\* (0.002) |
| DESCRIPTIONKELL BITE SIZE MINI WHEAT |  | 1.498\*\*\* (0.008) | -0.655\*\*\* (0.001) |
| DESCRIPTIONKELL FROOT LOOPS |  | 1.245\*\*\* (0.008) | -0.713\*\*\* (0.001) |
| DESCRIPTIONKELL FROSTED FLAKES |  | 1.486\*\*\* (0.008) | -0.730\*\*\* (0.001) |
| DESCRIPTIONMKSL DUTCH PRETZELS |  | 0.705\*\*\* (0.011) | -1.065\*\*\* (0.002) |
| DESCRIPTIONMKSL MINI TWIST PRETZELS |  | 0.759\*\*\* (0.011) | -1.066\*\*\* (0.002) |
| DESCRIPTIONMKSL PRETZEL STICKS |  | 0.501\*\*\* (0.011) | -1.072\*\*\* (0.002) |
| DESCRIPTIONNWMN OWN 4 CHEESE PIZZA |  | -0.321\*\*\* (0.012) | -0.062\*\*\* (0.002) |
| DESCRIPTIONNWMN OWN PEPPERONI PIZZA |  | -0.300\*\*\* (0.010) | -0.053\*\*\* (0.002) |
| DESCRIPTIONNWMN OWN SUPREME PIZZA |  | -0.539\*\*\* (0.013) | -0.033\*\*\* (0.002) |
| DESCRIPTIONPL BT SZ FRSTD SHRD WHT |  | 1.888\*\*\* (0.008) | -1.051\*\*\* (0.001) |
| DESCRIPTIONPL HONEY NUT TOASTD OATS |  | 1.885\*\*\* (0.008) | -1.260\*\*\* (0.001) |
| DESCRIPTIONPL MINI TWIST PRETZELS |  | 2.400\*\*\* (0.008) | -1.534\*\*\* (0.002) |
| DESCRIPTIONPL PRETZEL STICKS |  | 2.405\*\*\* (0.008) | -1.542\*\*\* (0.001) |
| DESCRIPTIONPL RAISIN BRAN |  | 2.224\*\*\* (0.008) | -1.254\*\*\* (0.001) |
| DESCRIPTIONPL SR CRUST 3 MEAT PIZZA |  | 0.782\*\*\* (0.008) | -0.554\*\*\* (0.001) |
| DESCRIPTIONPL SR CRUST PEPPRN PIZZA |  | 0.955\*\*\* (0.008) | -0.546\*\*\* (0.001) |
| DESCRIPTIONPL SR CRUST SUPRM PIZZA |  | 0.765\*\*\* (0.008) | -0.554\*\*\* (0.001) |
| DESCRIPTIONPL TWIST PRETZELS |  | 2.089\*\*\* (0.008) | -1.560\*\*\* (0.001) |
| DESCRIPTIONPOST FM SZ HNYBNCH OT ALM |  | 1.484\*\*\* (0.008) | -0.651\*\*\* (0.002) |
| DESCRIPTIONPOST FRUITY PEBBLES |  | 1.491\*\*\* (0.008) | -0.871\*\*\* (0.002) |
| DESCRIPTIONPOST HNY BN OTS HNY RSTD |  | 1.565\*\*\* (0.008) | -0.657\*\*\* (0.002) |
| DESCRIPTIONQKER CAP N CRUNCH |  | 1.272\*\*\* (0.008) | -0.896\*\*\* (0.002) |
| DESCRIPTIONQKER CAP N CRUNCH BERRIES |  | 1.590\*\*\* (0.008) | -0.886\*\*\* (0.002) |
| DESCRIPTIONQKER LIFE ORIGINAL |  | 0.888\*\*\* (0.008) | -0.811\*\*\* (0.002) |
| DESCRIPTIONRLDGLD BRAIDED HONEY WHT |  | 0.656\*\*\* (0.009) | -0.784\*\*\* (0.002) |
| DESCRIPTIONRLDGLD PRETZEL STICKS |  | 0.806\*\*\* (0.008) | -0.773\*\*\* (0.001) |
| DESCRIPTIONRLDGLD TINY TWISTS PRTZL |  | 1.013\*\*\* (0.008) | -0.770\*\*\* (0.001) |
| DESCRIPTIONSHURGD MINI PRETZELS |  | 1.968\*\*\* (0.011) | -1.318\*\*\* (0.002) |
| DESCRIPTIONSHURGD PRETZEL RODS |  | 1.325\*\*\* (0.014) | -0.861\*\*\* (0.002) |
| DESCRIPTIONSHURGD PRETZEL STICKS |  | 1.989\*\*\* (0.011) | -1.312\*\*\* (0.002) |
| DESCRIPTIONSNYDR FF MINI PRETZELS |  | 0.785\*\*\* (0.008) | -0.784\*\*\* (0.001) |
| DESCRIPTIONSNYDR PRETZEL RODS |  | 0.973\*\*\* (0.008) | -0.995\*\*\* (0.001) |
| DESCRIPTIONSNYDR SOURDOUGH NIBBLERS |  | 0.755\*\*\* (0.008) | -0.786\*\*\* (0.002) |
| DISPLAY1 | 0.227\*\*\* (0.004) | 0.386\*\*\* (0.004) | -0.053\*\*\* (0.001) |
| FEATURE1 | 0.084\*\*\* (0.004) | 0.497\*\*\* (0.004) | -0.181\*\*\* (0.001) |
| TPR\_ONLY1 | -0.069\*\*\* (0.003) | 0.279\*\*\* (0.003) |  |
| PRODUCT\_SIZE11 OZ | -0.085\*\*\* (0.009) |  |  |
| PRODUCT\_SIZE12 OZ | 0.258\*\*\* (0.008) | 0.420\*\*\* (0.008) | -0.421\*\*\* (0.001) |
| PRODUCT\_SIZE12.2 OZ | -0.042\*\*\* (0.009) |  |  |
| PRODUCT\_SIZE12.25 OZ | -0.115\*\*\* (0.008) |  |  |
| PRODUCT\_SIZE13 OZ | -0.270\*\*\* (0.008) |  |  |
| PRODUCT\_SIZE13.2 OZ | 0.182 (0.384) |  |  |
| PRODUCT\_SIZE13.3 OZ | 0.159 (0.384) |  |  |
| PRODUCT\_SIZE14 OZ | -0.339\*\*\* (0.009) |  |  |
| PRODUCT\_SIZE14.7 OZ | -0.051 (0.384) |  |  |
| PRODUCT\_SIZE15 OZ | 0.109\*\*\* (0.006) |  |  |
| PRODUCT\_SIZE16 OZ | 0.148\*\*\* (0.005) |  |  |
| PRODUCT\_SIZE18 OZ | 0.326\*\*\* (0.008) |  |  |
| PRODUCT\_SIZE20 OZ | -0.083\*\*\* (0.009) |  |  |
| PRODUCT\_SIZE22.7 OZ | 0.185 (0.384) |  |  |
| PRODUCT\_SIZE26.11 OZ | 0.025 (0.384) |  |  |
| PRODUCT\_SIZE27.35 OZ | 0.082 (0.384) |  |  |
| PRODUCT\_SIZE28.3 OZ | 1.045\*\*\* (0.384) |  |  |
| PRODUCT\_SIZE29.6 OZ | 0.450 (0.384) |  |  |
| PRODUCT\_SIZE29.8 OZ | 0.594 (0.384) |  |  |
| PRODUCT\_SIZE30.5 OZ | 0.266 (0.384) |  |  |
| PRODUCT\_SIZE32.7 OZ | 0.542 (0.384) |  |  |
| UNITS | -0.010\*\*\* (0.0002) | -0.006\*\*\* (0.0002) | -0.001\*\*\* (0.00003) |
| VISITS | 0.035\*\*\* (0.0002) | 0.029\*\*\* (0.0002) | 0.0002\*\*\* (0.00004) |
| Constant | 2.955\*\*\* (0.248) | -0.173\* (0.101) | 1.845\*\*\* (0.005) |
|  | | | |
| Observations | 418,727 | 418,727 | 418,727 |
| Log Likelihood | -401,213.600 | -398,613.900 | 319,445.100 |
| Akaike Inf. Crit. | 802,487.300 | 797,327.800 | -638,792.100 |
| Bayesian Inf. Crit. | 802,815.600 | 797,875.000 | -638,255.800 |
|  | | | |
| *Note:* | \*p<0.1; \*\*p<0.05; \*\*\*p<0.01 | | |

**Answers**

***Question 1:***

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Spend** | **Units** | **Household Purchasers** |
| **Display** | For every product displayed, there is a 21% increase in sales (Spend) | For every product displayed, there is 42% increase sales of units. (More units leave the store) | For every product displayed, there is a 10% increase of household purchasers |
| **Feature** | For every product featured, there is a 19% increase in sales (Spend) | For every product displayed, there is 107% decrease sales of units.  (Less units leave the store) | For every product displayed, there is a 23% increase of household purchasers |
| **Temporary** | For every product featured, there is a 8% decrease in sales (Spend) | For every product displayed, there is 127% decrease sales of units. (Less units leave the store) | For every product displayed, there is a 17% increase of household purchasers |

***Question 2:***

|  |  |
| --- | --- |
|  | **Spend** |
| **Display** | There is a 23% increase in sales (spend) when products are on Display |
| **Feature** | There is an 8% increase in sales (spend) when products are Featured |
| **TPR** | There is a 7% decrease in sales (spend) when products are on Temporary |

|  |
| --- |
| **Random Effect Variation** |
| $CATEGORY  (Intercept)  BAG SNACKS -3.657649e-01  COLD CEREAL 3.657644e-01  FROZEN PIZZA -2.202603e-07  $SEGMENT  (Intercept)  MAINSTREAM 0.0422283  UPSCALE 0.1812761  VALUE -0.2235042 |

***Question 3:***

The five most price elastic and five least price elastic products are:

|  |  |  |  |
| --- | --- | --- | --- |
| **Most Elastic Price** | | **Least Elastic Price** | |
| **Product** | **Price** | **Product** | **Price** |
| DESCRIPTIONPL PRETZEL STICKS | 241% | DESCRIPTIONFRSC 4 CHEESE PIZZA | -63% |
| DESCRIPTIONPL MINI TWIST PRETZELS | 240% | DESCRIPTIONNWMN OWN SUPREME PIZZA | -54% |
| DESCRIPTIONPL RAISIN BRAN | 222% | DESCRIPTIONNWMN OWN 4 CHEESE PIZZA | -32% |
| DESCRIPTIONPL TWIST PRETZELS | 209% | DESCRIPTIONFRSC PEPPERONI PIZZA | -57% |
| DESCRIPTIONSHURGD PRETZEL STICKS | 199% | DESCRIPTIONFRSC BRCK OVN ITL PEP PZ | -47% |

***Question 4:***

The top 5 products that I as a retailer would lower the price are in the table below. This is because the price elasticity of these products is high. Meaning If I lower the price, I can expect to increase the sales and units sales.

This can be determined with the price elasticity values being positive and high, where as the price values being in the negative ranges.

|  |  |  |
| --- | --- | --- |
| **Top 5 Product Recommendations** | | |
| **Product** | **Price Elasticity** | **Price** |
| DESCRIPTIONPL PRETZEL STICKS | 240.5% | -154.2% |
| DESCRIPTIONPL MINI TWIST PRETZELS | 240% | -153.4% |
| DESCRIPTIONPL RAISIN BRAN | 222.4% | -125.4% |
| DESCRIPTIONPL TWIST PRETZELS | 208.9% | -156.0% |
| DESCRIPTIONSHURGD PRETZEL STICKS | 198.9% | -131.2% |