Homework 9

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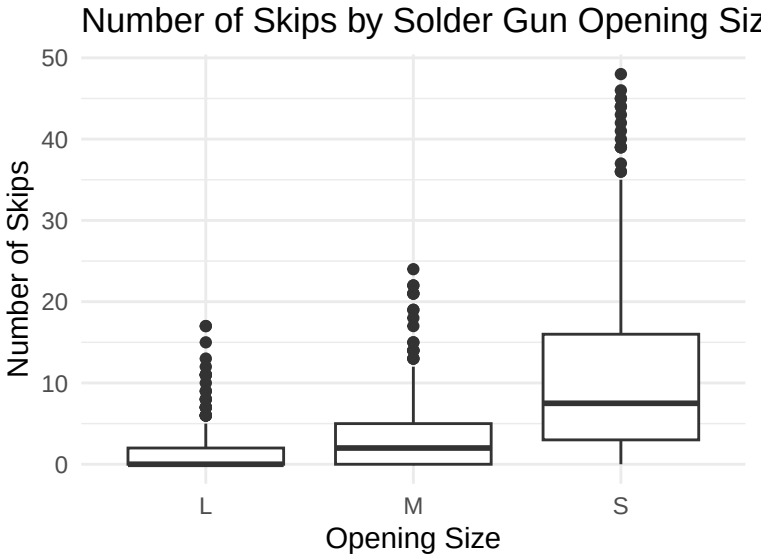
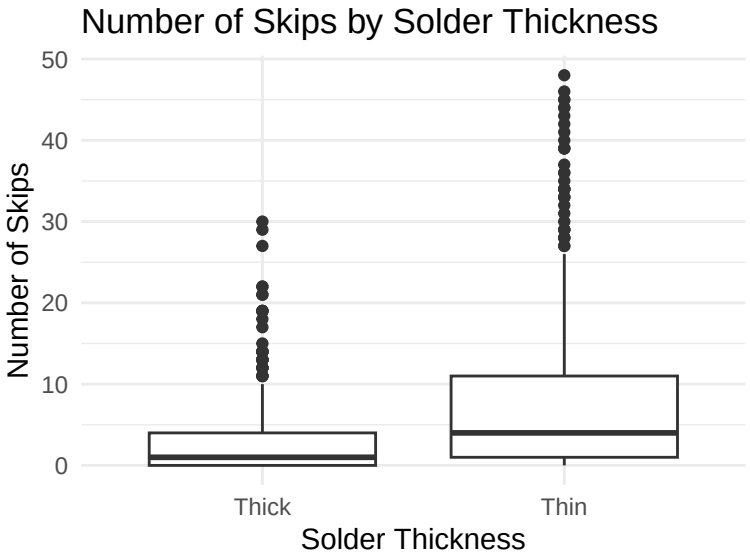
Github Link: https://github.com/Ahantya/SDS315/blob/main/HW9/HW9Markdown.Rmd

Problem 1 - Manufacturing flaws in circuit boards

Part A.



This boxplot shows that as the opening size is smaller, the number of skips is higher on average.



This boxplot shows that a thinner solder has a larger number of skips on average than the thicker solder.

Part B.

```
## # A tibble: 6 x 7
##   term                  estimate std_error statistic p_value lower_ci upper_ci
##   <chr>                    <dbl>     <dbl>     <dbl>   <dbl>    <dbl>    <dbl>
## 1 intercept                0.393     0.520     0.756  0.450    -0.628     1.41
## 2 Opening: M               2.41      0.736     3.27   0.0011    0.962     3.85
## 3 Opening: S               5.13      0.736     6.97   0         3.68      6.57
## 4 Solder: Thin             2.28      0.736     3.10   0.002     0.836     3.72
## 5 Opening: M:SolderThin   -0.74      1.04     -0.711  0.477    -2.78      1.30
## 6 Opening: S:SolderThin    9.65      1.04      9.28   0         7.61     11.7
```

Part C.

Intercept (0.3933): This is the estimated number of skips when the opening is large and the solder is thick (the baseline group). On average, boards with this combination have about 0.3933 skips.

Opening: M (2.4067): Compared to large openings, using a medium opening increases the number of skips by about 2.4067, on average, when the solder is thick.

Opening: S (5.1267): Compared to large openings, using a small opening increases the number of skips by about 5.1267, on average, when the solder is thick.

Solder: Thin (2.2800): When using a thin solder instead of a thick one, the number of skips increases by about 2.28, on average, when the opening is large.

Opening: M × Solder: Thin (–0.7400): The interaction term indicates that the combined effect of using a medium opening with thin solder leads to 0.74 fewer skips than we would expect from the skips in a medium opening and thin solder alone.

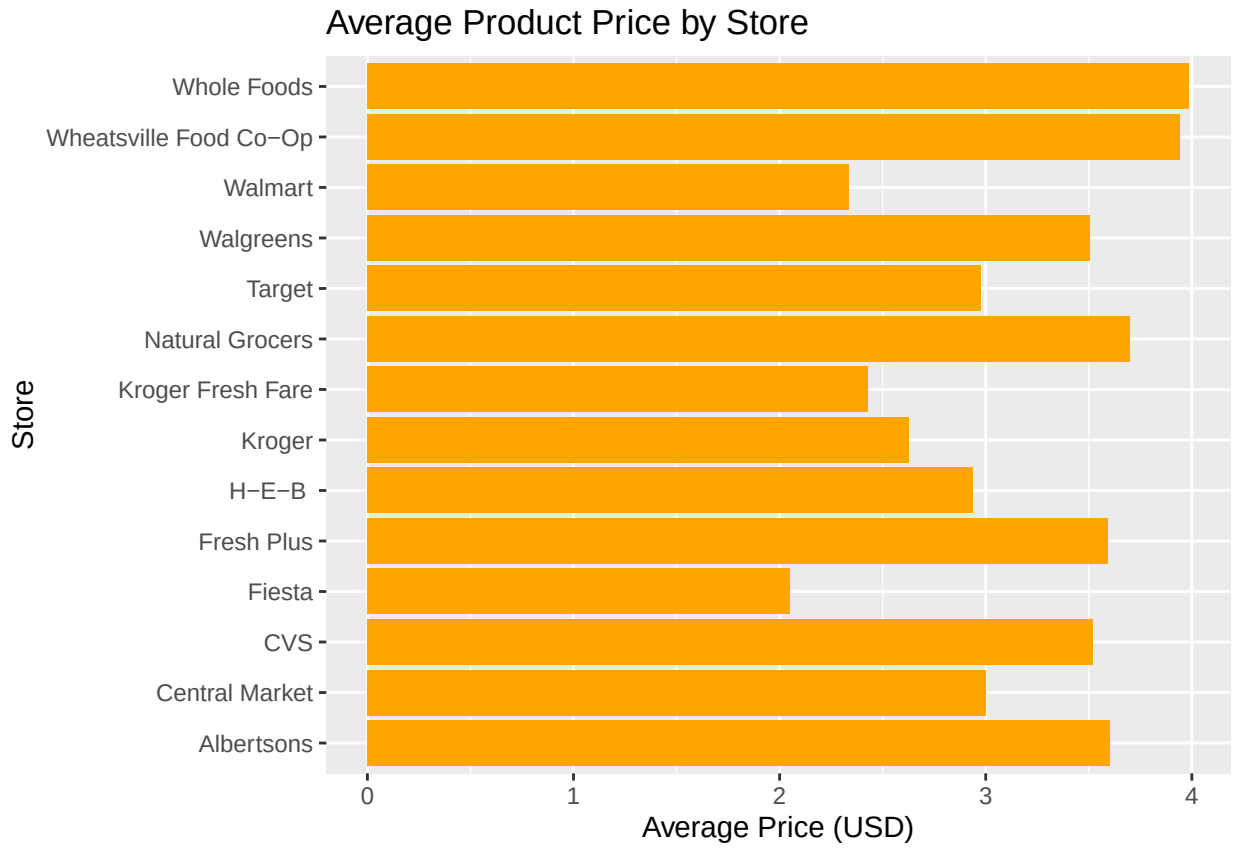
Opening: S × Solder: Thin (9.6533): The interaction term shows that using a small opening with thin solder results in 9.65 more skips than we would expect from the effects of small opening and thin solder.

Part D.

According to the regression model, I would recommend a combination of a thick solder with a large opening to AT&T because it's reported to have the least amount of skips.

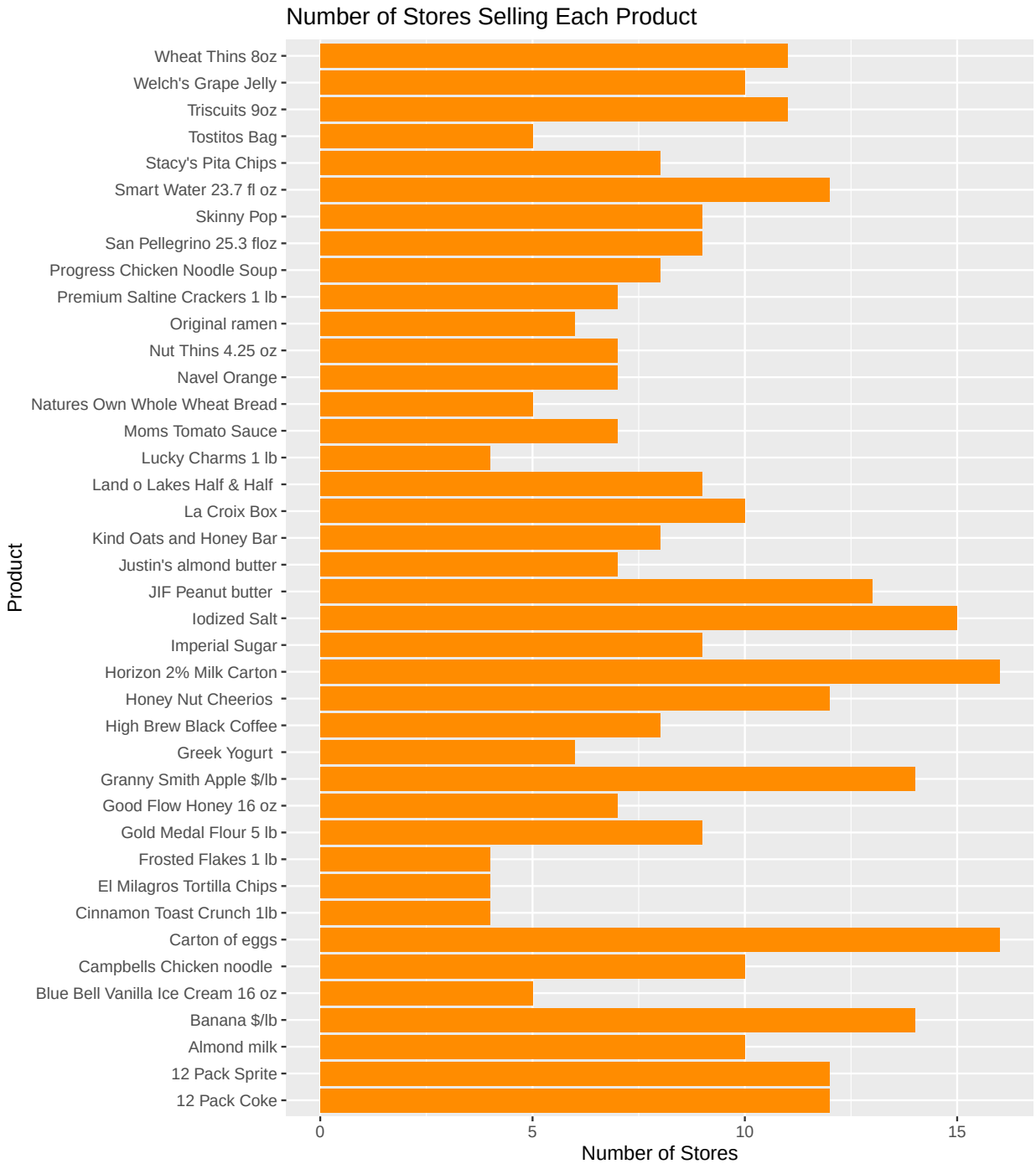
Problem 2 - Grocery store prices

Part A.



This bar graph shows the average price of an item in each store, specifically pointing that Whole Foods being the most expensive in terms of average price and Fiesta being the cheapest in terms of average price.

Part B.



This bar graph shows the item availability by the number of stores, so the most common available items include Carton of eggs, Horizon 2% Milk Cartons, and Iodized Salt while the least common available items include Frosted Flakes 1lb, El Milagros Tortilla Chips, Cinnamon Toast Crunch 1lb, and Lucky Charms 1lb.

Part C.

```
##                                             2.5 %       97.5 %
## (Intercept)                              5.4461802  6.4011154524
## Product12 Pack Sprite                   -0.6340950  0.5974283379
## ProductAlmond milk                      -2.8525515 -1.5573896506
## ProductBanana $/lb                      -5.4799319 -4.2894146000
## ProductBlue Bell Vanilla Ice Cream 16 oz -3.7520923 -2.1421358570
## ProductCampbells Chicken noodle         -4.1115515 -2.8163896506
## ProductCarton of eggs                   -3.5774725 -2.4241176770
## ProductCinnamon Toast Crunch 1lb        -1.8696613 -0.1241717453
## ProductEl Milagros Tortilla Chips       -2.9129671 -1.1651607441
## ProductFrosted Flakes 1 lb              -2.1246613 -0.3791717453
## ProductGold Medal Flour 5 lb            -2.8372300 -1.5046125814
## ProductGood Flow Honey 16 oz             0.2808176  1.7240341201
## ProductGranny Smith Apple $/lb          -4.3199319 -3.1294146000
## ProductGreek Yogurt                     -4.6079636 -3.0970491791
## ProductHigh Brew Black Coffee           -3.6121524 -2.2295143472
## ProductHoney Nut Cheerios               -2.3416352 -1.1094592274
## ProductHorizon 2% Milk Carton           -1.6774725 -0.5241176770
## ProductImperial Sugar                   -3.1483411 -1.8157236926
## ProductIodized Salt                     -4.4512391 -3.2812048876
## ProductJIF Peanut butter                -3.3245622 -2.1168826179
## ProductJustin's almond butter            6.0836747  7.5268912630
## ProductKind Oats and Honey Bar          -2.5550655 -1.1701652933
## ProductLa Croix Box                     -1.7195515 -0.4243896506
## ProductLand o Lakes Half & Half         -3.9644300 -2.6289732430
## ProductLucky Charms 1 lb                -2.3746613 -0.6291717453
## ProductMoms Tomato Sauce                 0.7236747  2.1668912630
## ProductNatures Own Whole Wheat Bread    -3.2238381 -1.6152736311
## ProductNavel Orange                     -4.6806110 -3.2373944513
## ProductNut Thins 4.25 oz                -3.1963253 -1.7531087370
## ProductOriginal ramen                   -5.8118874 -4.3004408731
## ProductPremium Saltine Crackers 1 lb    -3.0518795 -1.6146755310
## ProductProgress Chicken Noodle Soup     -3.7593438 -2.3812397045
## ProductSan Pellegrino 25.3 floz         -4.3177633 -2.9823065764
## ProductSkinny Pop                       -2.7046528 -1.3717357209
## ProductSmart Water 23.7 fl oz           -4.3084790 -3.0761838276
## ProductStacy's Pita Chips               -2.4986751 -1.1174141159
## ProductTostitos Bag                     -2.4860923 -0.8761358570
## ProductTriscuits 9oz                    -2.8861621 -1.6263080570
## ProductWelch's Grape Jelly              -3.5819230 -2.2890645533
## ProductWheat Thins 8oz                  -2.8952530 -1.6353989661
## TypeGrocery                             -0.9154098 -0.4131031458
## TypeHigh-end Grocery                    -0.5944834 -0.0008968566
## TypeNatural                             -0.4037250  0.2192581912
## TypeSmall Format                        -0.7454724 -0.1428388392
```

Compared with ordinary grocery stores (like Albertsons, HEB, or Krogers), convenience stores charge somewhere between 0.41 to 0.92 dollars more for the same product.

Part D.

```
##                               (Intercept)
##                                5.75467102
##                     Product12 Pack Sprite
##                                -0.01833333
##                        ProductAlmond milk
##                                -2.29296977
##                        ProductBanana $/lb
##                                -4.85693618
## ProductBlue Bell Vanilla Ice Cream 16 oz
##                                -3.07796542
##         ProductCampbells Chicken noodle
##                                -3.55196977
##                     ProductCarton of eggs
##                                -2.98094026
##         ProductCinnamon Toast Crunch 1lb
##                                -1.17329768
##        ProductEl Milagros Tortilla Chips
##                                -1.91049850
##               ProductFrosted Flakes 1 lb
##                                -1.42829768
##             ProductGold Medal Flour 5 lb
##                                -2.24497040
##             ProductGood Flow Honey 16 oz
##                                 0.90422020
##           ProductGranny Smith Apple $/lb
##                                -3.69693618
##                       ProductGreek Yogurt
##                                -3.93157321
##            ProductHigh Brew Black Coffee
##                                -3.01257661
##                ProductHoney Nut Cheerios
##                                -1.67833193
##            ProductHorizon 2% Milk Carton
##                                -1.08094026
##                     ProductImperial Sugar
##                                -2.59735628
##                       ProductIodized Salt
##                                -3.85508884
##                  ProductJIF Peanut butter
##                                -2.63260723
##            ProductJustin's almond butter
##                                 6.70707734
##           ProductKind Oats and Honey Bar
##                                -1.89546566
##                        ProductLa Croix Box
##                                -1.15996977
##         ProductLand o Lakes Half & Half
##                                -3.38093292
##                   ProductLucky Charms 1 lb
##                                -1.67829768
##                  ProductMoms Tomato Sauce
##                                 1.34707734
```

```
##     ProductNatures Own Whole Wheat Bread
##                              -2.42875040
##                       ProductNavel Orange
##                              -4.05720837
##                  ProductNut Thins 4.25 oz
##                              -2.57292266
##                     ProductOriginal ramen
##                              -5.20079852
##     ProductPremium Saltine Crackers 1 lb
##                              -2.39372509
##      ProductProgress Chicken Noodle Soup
##                              -3.13842212
##          ProductSan Pellegrino 25.3 floz
##                              -3.73426626
##                         ProductSkinny Pop
##                              -2.18537924
##            ProductSmart Water 23.7 fl oz
##                              -3.65720625
##                 ProductStacy's Pita Chips
##                              -1.91171777
##                       ProductTostitos Bag
##                              -1.81196542
##                     ProductTriscuits 9oz
##                              -2.12160260
##                ProductWelch's Grape Jelly
##                              -2.81797075
##                    ProductWheat Thins 8oz
##                              -2.13069351
##                      StoreCentral Market
##                              -0.57338651
##                                 StoreCVS
##                               0.19311241
##                              StoreFiesta
##                              -0.70323198
##                           StoreFresh Plus
##                              -0.03616437
##                              StoreH-E-B
##                              -0.64595932
##                              StoreKroger
##                              -0.70331815
##                    StoreKroger Fresh Fare
##                              -0.90177969
##                     StoreNatural Grocers
##                              -0.08117985
##                              StoreTarget
##                              -0.37336967
##                            StoreWalgreens
##                               0.21548328
##                             StoreWalmart
##                              -0.99254892
##                StoreWheatsville Food Co-Op
##                               0.29029303
##                           StoreWhole Foods
##                               0.36415850
```

The two stores that seem to charge the lowest prices when comparing the same product are Kroger Fresh Fare (at about $0.90 less than the baseline) and Walmart (at about $0.99 less than the baseline). The two stores that seem to charge the highest prices when comparing the same product are Wheatsville Food Co-Op (at about $0.29 more than the baseline) and Whole Foods (at about $0.36 more than the baseline). So, the store that charges the lowest prices when comparing the same product is Walmart, and the store that charges the highest prices when comparing the same product is Whole Foods.

Part E.

```
##                                             2.5 %       97.5 %
## (Intercept)                              5.29481829  6.214523748
## Product12 Pack Sprite                   -0.58263797  0.545971300
## ProductAlmond milk                      -2.88979207 -1.696147469
## ProductBanana $/lb                      -5.40393837 -4.309933984
## ProductBlue Bell Vanilla Ice Cream 16 oz -3.81973745 -2.336193387
## ProductCampbells Chicken noodle         -4.14879207 -2.955147469
## ProductCarton of eggs                   -3.51080489 -2.451075642
## ProductCinnamon Toast Crunch 1lb        -1.97850431 -0.368091042
## ProductEl Milagros Tortilla Chips       -2.72058833 -1.100408677
## ProductFrosted Flakes 1 lb              -2.23350431 -0.623091042
## ProductGold Medal Flour 5 lb            -2.86004284 -1.629897962
## ProductGood Flow Honey 16 oz             0.23900798  1.569432416
## ProductGranny Smith Apple $/lb          -4.24393837 -3.149933984
## ProductGreek Yogurt                     -4.62930236 -3.233844060
## ProductHigh Brew Black Coffee           -3.65021535 -2.374937874
## ProductHoney Nut Cheerios               -2.24361184 -1.113052020
## ProductHorizon 2% Milk Carton           -1.61080489 -0.551075642
## ProductImperial Sugar                   -3.21104464 -1.983667913
## ProductIodized Salt                     -4.39282443 -3.317353240
## ProductJIF Peanut butter                -3.18794602 -2.077268441
## ProductJustin's almond butter            6.04186513  7.372289559
## ProductKind Oats and Honey Bar          -2.53297768 -1.257953650
## ProductLa Croix Box                     -1.75679207 -0.563147469
## ProductLand o Lakes Half & Half         -3.99630165 -2.765564195
## ProductLucky Charms 1 lb                -2.48350431 -0.873091042
## ProductMoms Tomato Sauce                 0.68186513  2.012289559
## ProductNatures Own Whole Wheat Bread    -3.17207699 -1.685423804
## ProductNavel Orange                     -4.72242059 -3.391996155
## ProductNut Thins 4.25 oz                -3.23813487 -1.907710441
## ProductOriginal ramen                   -5.89711766 -4.504479380
## ProductPremium Saltine Crackers 1 lb    -3.05683364 -1.730616540
## ProductProgress Chicken Noodle Soup     -3.77416621 -2.502678040
## ProductSan Pellegrino 25.3 floz         -4.34963499 -3.118897529
## ProductSkinny Pop                       -2.79946086 -1.571297623
## ProductSmart Water 23.7 fl oz           -4.22335959 -3.091052907
## ProductStacy's Pita Chips               -2.54783030 -1.275605236
## ProductTostitos Bag                     -2.55373745 -1.070193387
## ProductTriscuits 9oz                    -2.70212738 -1.541077829
## ProductWelch's Grape Jelly              -3.41187152 -2.224069988
## ProductWheat Thins 8oz                  -2.71121828 -1.550168738
## StoreCentral Market                     -0.92164719 -0.225125837
## StoreCVS                                -0.16684400  0.553068808
## StoreFiesta                             -1.23351226 -0.172951704
```

```
## StoreFresh Plus                          -0.35487988  0.282551136
## StoreH-E-B                               -0.94513262 -0.346786025
## StoreKroger                              -1.16242453 -0.244211765
## StoreKroger Fresh Fare                   -1.36088607 -0.442673303
## StoreNatural Grocers                     -0.46989988  0.307540177
## StoreTarget                              -0.74706831  0.000328972
## StoreWalgreens                           -0.14031581  0.571282360
## StoreWalmart                             -1.45165530 -0.533442534
## StoreWheatsville Food Co-Op              -0.06146201  0.642048073
## StoreWhole Foods                          0.01672253  0.711594471
```

Knowing that H-E-B's coefficient is approximately -0.646 and Central Market's coefficient is approximately -0.573, we can see that Central Market charges slightly more than H-E-B on average—about 7 cents more per item but the average price difference (between Central Market and H-E-B) is very small (about 7 cents). We can also note that there is a huge overlap in both confidence intervals. So, in terms of context, when you compare their coefficients to something like Whole Foods' coefficient, which is almost a dollar more expensive than an item on average t H-E-B and Central Market, you can comparatively conclude that Central Market charges a similar amount to H-E-B for the same product.

Part F.

```
##                                (Intercept)
##                                 5.61626393
##                      Product12 Pack Sprite
##                                -0.01833322
##                         ProductAlmond milk
##                                -2.11397813
##                         ProductBanana $/lb
##                                -4.90809699
## ProductBlue Bell Vanilla Ice Cream 16 oz
##                                -2.90774621
##          ProductCampbells Chicken noodle
##                                -3.37297700
##                      ProductCarton of eggs
##                                -2.97368523
##          ProductCinnamon Toast Crunch 1lb
##                                -1.19525160
##         ProductEl Milagros Tortilla Chips
##                                -1.99991217
##                ProductFrosted Flakes 1 lb
##                                -1.45025231
##              ProductGold Medal Flour 5 lb
##                                -2.09917625
##              ProductGood Flow Honey 16 oz
##                                 1.05624929
##            ProductGranny Smith Apple $/lb
##                                -3.74809689
##                       ProductGreek Yogurt
##                                -3.91708654
##             ProductHigh Brew Black Coffee
##                                -2.82308850
##                ProductHoney Nut Cheerios
##                                -1.69470259
```

```
##            ProductHorizon 2% Milk Carton
##                              -1.07368514
##                     ProductImperial Sugar
##                              -2.41570236
##                       ProductIodized Salt
##                              -3.83801272
##                  ProductJIF Peanut butter
##                              -2.74837249
##             ProductJustin's almond butter
##                               6.85910402
##            ProductKind Oats and Honey Bar
##                              -1.68695395
##                       ProductLa Croix Box
##                              -0.98097742
##          ProductLand o Lakes Half & Half
##                              -3.17021004
##                  ProductLucky Charms 1 lb
##                              -1.70025196
##                  ProductMoms Tomato Sauce
##                               1.49910623
##      ProductNatures Own Whole Wheat Bread
##                              -2.47081269
##                       ProductNavel Orange
##                              -3.90518351
##                  ProductNut Thins 4.25 oz
##                              -2.42089276
##                     ProductOriginal ramen
##                              -4.97932196
##      ProductPremium Saltine Crackers 1 lb
##                              -2.24717549
##       ProductProgress Chicken Noodle Soup
##                              -3.02351669
##           ProductSan Pellegrino 25.3 floz
##                              -3.52354212
##                          ProductSkinny Pop
##                              -1.95282880
##             ProductSmart Water 23.7 fl oz
##                              -3.73465424
##                 ProductStacy's Pita Chips
##                              -1.67865112
##                       ProductTostitos Bag
##                              -1.64175580
##                     ProductTriscuits 9oz
##                              -2.29216210
##                ProductWelch's Grape Jelly
##                              -3.00914839
##                    ProductWheat Thins 8oz
##                              -2.30125288
##                                Income10K
##                              -0.01408973
```

The sign of the Income10K coefficient, which is negative, so this means that when the average income increases, the price of items decreases. By the linear model trend, this means that poorer ZIP codes will usually be paying more for the same product, on average.

```
## # Standardization method: refit
##
## Parameter | Std. Coef. |        95% CI
## --------------------------------------
## Income10K |      -0.03 | [-0.07, 0.01]
```

A one-standard deviation increase in the income of a ZIP code seems to be associated with a -0.03 standard-deviation change in the price that consumers in that ZIP code expect to pay for the same product.

Problem 3 - redlining

A. ZIP codes with a higher percentage of minority residents tend to have more FAIR policies per 100 housing units

TRUE: With Figure A1, we can see the model_A has a R-Squared value of 0.5164, which shows a positive, linear trend of FAIR Policies per 100 Housing Units increasing when the percentage of minority residents increase. We also see that the 95% confidence interval for the percentage of minorities is (0.009, 0.018), which doesn't contain 0 and is only positive, so the statement is also statistically signficant while being true.

B. The evidence suggests an interaction effect between minority percentage and the age of the housing stock in the way that these two variables are related to the number of FAIR policies in a ZIP code.

UNDECIDABLE: With Figure B1, model_B has a R-Square value of 0.0609, showing that the percentage of minority students almost has no correlation to the housing age. However, correlation doesn't imply interaction and either can be true without the other. So this question is undecidable.

C. The relationship between minority percentage and number of FAIR policies per 100 housing units is stronger in high-fire-risk ZIP codes than in low-fire-risk ZIP codes

FALSE: The regression model model_C shows that the interaction between minority percentage and number of FAIR policies per 100 housing units is -0.001 weaker in low-fire-risk ZIP codes, however, the confidence interval is (-0.012, 0.01), which contains zero. This means that the difference in the relationship between minority percentage and number of FAIR policies per 100 housing units across fire-risk levels is not statistically significant. So, we cannot conclude that the relationship is stronger in high-fire-risk ZIP codes, and the statement is false. Also, in Figure C1 (that compares the FAIR policies per 100 housing units against the Minority Percentage by Fire Risk Group), you can see that the slopes in the High Fire Risk and the Low Fire Risk Zip Codes seem parallel, which means that the relationship between minority percentage and number of FAIR policies per 100 housing units most likely doesn't depend on whether the fire risk is high or low, so this statement is false.

D. Even without controlling for any other variables, income "explains away" all the association between minority percentage and FAIR policy uptake.

FALSE: We can see that the coefficient for minority percentage in model_D1 where the relationship over FAIR policies per 100 housing units vs. minority percentage was 0.014. Now when they also controlled for income in model_D2, the minority percentage coefficient still remained at 0.01, which is very similar to model_D1. Since the coefficients are so similar when income is and isn't controlled for, this means that income isn't a factor that simply "explains away" all the association between minority percentage and FAIR policy uptake. Note: both the 95% CI for each model's (D1 and D2) minority coefficient didn't contain zero, so we can explain this statement by comparing their coefficients directly.

E. Minority percentage and number of FAIR policies are still associated at the ZIP code level, even after controlling for income, fire risk, and housing age.

TRUE: Even after controlling for income, fire risk, and housing age, we can still see that the coefficient for minority percentage is 0.008 with the 95% confidence interval being (0.003, 0.014), which means that it still has an association (no matter it being small) with the number of FAIR policies at the ZIP code level.