INDUSTRIAL ORGANIZATION

Empirical Project: Estimating the Demand for Cereal

Canberk Atak (6496177)
Maryam Moradi (6492077)
Nigar Salmanzade (6441957)
Stephanie Siguencia Ibadango (6491937)

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1 Overview of the market

The ready-to-eat (RTE) breakfast cereal industry is highly competitive, with a range of established and new companies competing for market share. To stand out, companies strive for innovation and excellence by improving product quality, pricing strategies, and customer satisfaction. The dynamics of the market are influenced by various factors, including technological advancements, changes in regulations, and shifts in consumer tastes. This dynamic rivalry not only contributes to market growth but also presents challenges and opportunities for companies. As a result, strategic partnerships, mergers, and acquisitions are encouraged as companies seek to secure their competitive position in this rapidly changing landscape. The market is characterized by adaptability and creativity, with companies needing to constantly evolve to succeed.

Product differentiation arises when a collection of goods, closely enough related in the eyes of consumers to constitute a product category, offers a range of similar but not identical products (Lancaster, 1975). Differentiated products are those that possess certain features or characteristics that appeal to specific consumer preferences. Product differentiation depends on consumer preferences, which may be influenced by heterogeneity among consumers. Consumer preferences are typically defined based on the underlying characteristics of a product or service.This approach is commonly referred to as the 'characteristics approach'. Furthermore, consumers are typically assumed to make a discrete choice between products, including a possible off-brand option, meaning that they decide which brand or product to buy and do not mix products (Belleflamme and Peitz 2018, pp. 111-138).

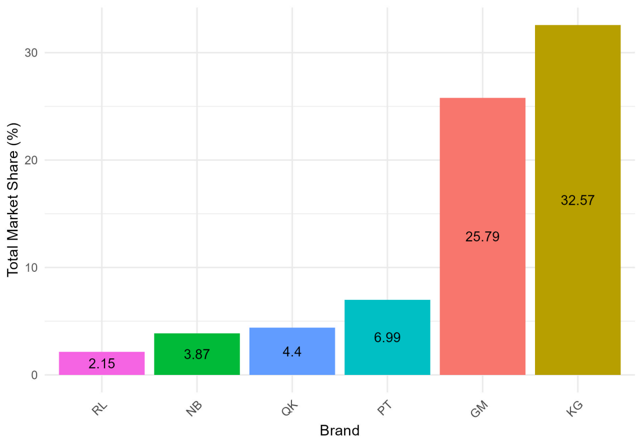

Figure 1:
Market Shares/ Brands

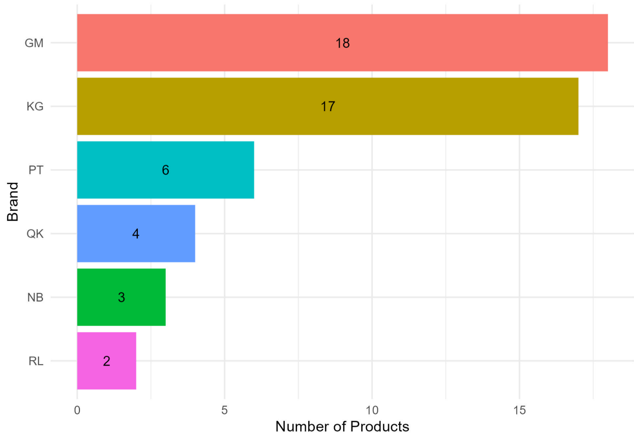

Figure 2:
Number of Products by Brand

As depicted in Figure 1, the leading three brands—KG, GM, and PT—hold around 65% of the total market share. As shown in Figure 2, the two leading brands, KG and GM, have a total of 35 different products, which represents approximately 70% of the market. Referencing a scenario described in ChurchWare, a comparable situation unfolded in the United States from the 1950s to the 1980s. During this period, the four largest companies, often referred to as the pioneers of the RTE breakfast cereal market, were accused of preventing new competitors from entering the RTE cereal industry. They achieved this by saturating the market with their products and strategically launching new brands to occupy potential market segments that could have facilitated new entrants. At the heart of these grievances was the claim that such actions led to a highly concentrated and noncompetitive market landscape, where monopoly power was both preserved and protected through extensive brand expansion and preemptive measures by these established firms (Church and Ware 2000, pp. 367–368).

The RTE breakfast cereal sector is characterized by intense competition, encompassing a wide array of both established giants and innovative newcomers vying for dominance and market share. Companies are propelled to excel and innovate, focusing on enhancing product quality, refining pricing strategies, and elevating customer experience to differentiate themselves. Market dynamics are significantly influenced by factors such as technological breakthroughs, regulatory shifts, and changing consumer preferences. This vigorous competition not only stimulates market growth but also brings forth both obstacles and prospects for businesses. Consequently, there is an increased emphasis on forming strategic alliances, undergoing mergers, and pursuing acquisitions as firms aim to fortify their competitive standing in this swiftly transforming arena. Overall, the RTE breakfast cereal market is distinguished by its emphasis on adaptability and ingenuity, where continuous innovation is key to prevailing success (Connor,1999).

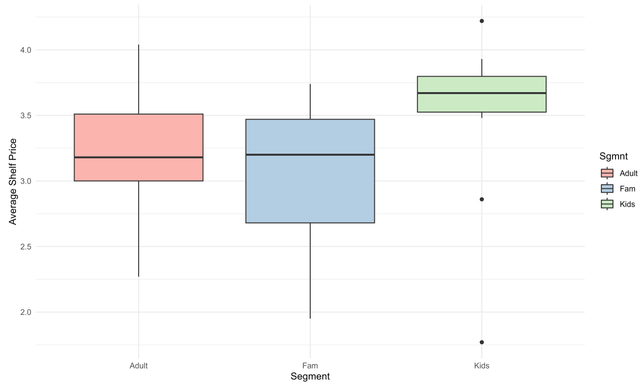

Figure 3:
Different pricing strategies between the Segments

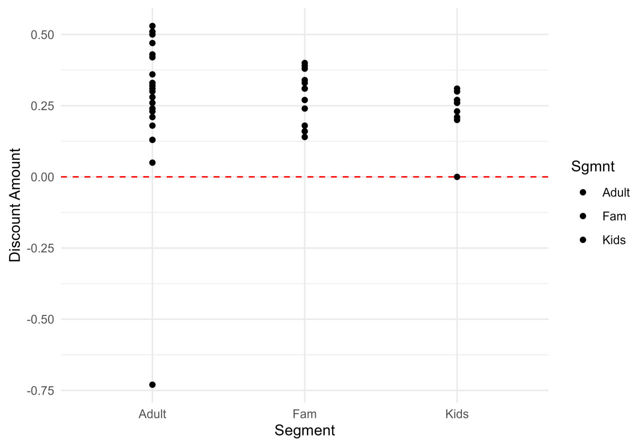

Figure 4:
Different discounts for different segments

Figure 3 shows the market segments to which the product belongs: adult, family, and kids. The figure presents an objective analysis of the pricing strategies used in the cereal market. Clearly, adult cereal products have a slightly higher median shelf price than those aimed at families or children. This indicates that adult cereals could be positioned as premium products, possibly due to factors such as healthier ingredients, organic labels, or brand prestige. The interquartile range in the family segment suggests a highly competitive market where brands compete for market share through consistent and aggressive pricing strategies. In contrast, the kids' segment has a wider price range with notable outliers, indicating a market with diverse offerings, ranging from value-oriented to premium products that likely include character endorsements or tie-ins with popular media, justifying the higher price points.

Figure 4 shifts focus to the discounts offered across the cereal segments. All segments display a positive median discount, indicating that discounts are commonly used across the board. The Adult and Family segments show a similar level of median discount, but the Family segment demonstrates a wider interquartile range, suggesting more varied discounting practices. This variance may cater to budget-conscious family shoppers who are motivated by discounts. The Kids segment, while similar in median discount, shows instances of products receiving no discount, which could suggest that certain kids' cereals can command full shelf prices, perhaps due to branding or popularity with children.

Combining the insights from both Figure 3 and Figure 4 provides a detailed understanding of market behavior in the cereal industry. The consistency in median prices and discounts across the Adult and Family segments suggests that while adults may be willing to pay a premium, they, along with families, are accustomed to receiving discounts. In contrast, the greater variability in prices and discounts for the Kids segment indicates a more dynamic market. Some products may be sold at a premium without discounts, possibly because the decision-makers (parents buying for children) are less sensitive to specific cereal attributes such as branding, taste, or nutritional claims. These findings demonstrate how cereal brands strategically manage pricing and discounts to appeal to their respective consumer segments.

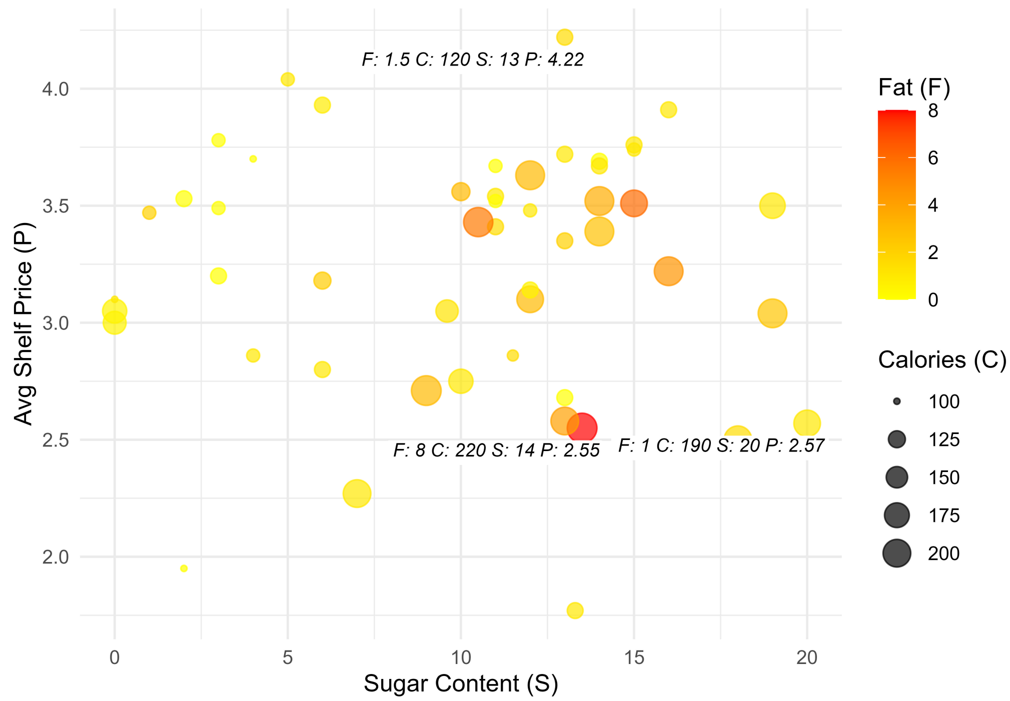

Figure 5:
Difference Nutritional Content for Different Prices

The two graphs provide a visual analysis of cereal products from both a nutritional and economic perspective. Figure 5 shows a scatter plot of individual cereal products, comparing their average shelf price to their nutritional values. The x-axis represents the sugar content, while the y-axis represents the average shelf price. The size of the points indicates the calorie content, and the color represents the fat content. The graph does not reveal any clear trend linking sugar, calorie, or fat content with shelf price. However, it is worth noting that some cereals with the lowest calorie and fat content can be classified as premium, and therefore have higher prices. This suggests that there may be unobservable characteristics of consumers at play.

Figure 6 compares the average content of calories, fat, and sugar across three market segments: Adult, Family (Fam), and Kids, using stacked bars. It is evident that cereals aimed at adults and kids have a significantly higher average calorie count than those targeted at families. However, the fat content is relatively low across

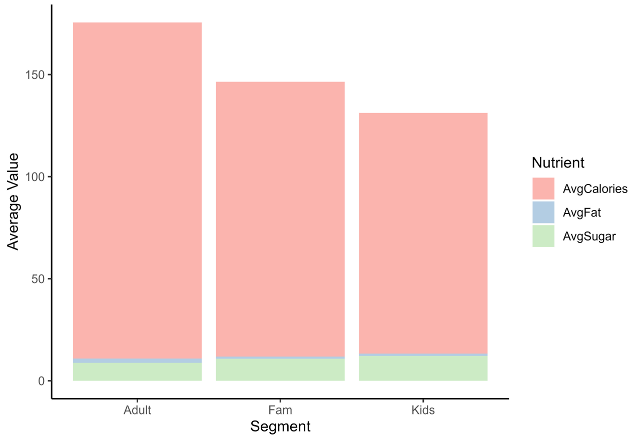

Figure 6:
Different pricing strategies between the Segments

all segments, with the sugar content slightly higher in cereals marketed to children. This suggests that while cereals marketed to adults and children may be more calorie-dense, they do not necessarily contain more fat or sugar. The emphasis on calorie content over fat and sugar may reflect a market trend where calorie count is a more significant factor in product differentiation.

Upon synthesizing insights from both figures, it is evident that the relationship between a cereal's nutritional content and its price is multifaceted. Although certain nutritional factors, such as calorie count, appear to differentiate products within market segments, these factors do not translate in a straightforward manner to pricing strategies. The interplay between various factors suggests that cereal pricing is influenced by more than just nutritional content. Brand equity, consumer preferences, marketing efforts, and health claims may also play a role.

2 OLS Estimation

To identify the demand for cereal, we use the indirect utility of consumers.

$$u_{ij} = \delta_j + \epsilon_{ij}$$

where u_{ij} represents the conditional indirect utility for consumer i of cereal j, δ_j is the mean utility of cereal j, and ϵ_{ij} is the error term.

The logit model specification is given by:

$$\ln(s_j) - \ln(s_0) = x_j\delta - \alpha p_j + \epsilon_j, \quad j = 1, \ldots, J$$

where s_j represents the choice probability of product j, while s_0 is the choice probability of the outside good , x_j is a vector of observed characteristics of product j , β is a vector of coefficients, p_j is the price of product j, and ϵ_j is the structural error term.

For our estimation, the specific model used is given by:

$$\ln(s_j) - \ln(s_0) = \text{Caloric Content} \times \beta_1 + \text{Fat Content} \times \beta_2 + \text{Sugar Content} \times \beta_3 + \alpha \times \text{Average Shelf Price} + \epsilon_j,$$

where $j = 1, \ldots, 50$.

Therefore, the left-hand side of the model represents the mean utility, and the right-hand side consists of observed variables such as caloric content, fat content, sugar content, the average shelf price and the unobserved characteristics in the error term ϵ.

To estimate the demand of the cereal market we use Ordinary Least Squares (OLS), both with and without brand fixed effects, employing various error estimation approaches. The options considered for standard error estimation include IID (Independent and Identically Distributed), robust, and clustering.

Table 1 presents six alternative specifications for estimating the demand of the cereal. One of the findings is that the average shelf price has a negative coefficient in all six models, with varying degrees of statistical significance.

In Model 1, which does not include brand fixed effects and utilizes standard errors assuming IID errors, the coefficient is estimated to be -0.268 with a standard error of 0.138. The negative sign indicates an inverse relationship between the average shelf price and the demand for cereal. This means that as the average shelf price increases, the demand for cereal decreases. This result is statistically significant at the 10% level.

In Model 2 (without fixed effects and employing heteroskedasticity-robust standard errors) and Model 3 (without brand fixed effects and using standard errors clustered at the brand level) the coefficient estimates for the average shelf price remain the same but there are not statistically significant.

In Model 4, which includes brand fixed effects and assumes standard errors to be IID, the coefficient is estimated to be -0.443 with a standard error of 0.155. The negative coefficient indicates an inverse relationship between the average shelf price and cereal demand, with statistical significance at the 1% level.

In Model 5 (with brand fixed effects and utilizing heteroskedasticity-robust standard errors) and Model 6 (with brand fixed effects and employing standard errors clustered at the brand level) the coefficients estimate for the average shelf price remain unchanged but are statistically significant at the 5% and 10% levels, respectively.

Examining the other factors that can affect cereal consumption, sugar content is an important consideration for cereal companies. In Models 1, 2, and 3, where brand fixed effects are not included, the estimated coefficient for sugar lies at -0.028. However, its statistical significance is only evident at the 10% level in Model 1.

On the other hand, when brand fixed effects are incorporated in Models 4, 5, and 6, the coefficient for sugar becomes more pronounced, at -0.037. In Models 4 and 5, this negative association achieves statistical significance at the 5% level, while in Model 6, it gets significance at the 1% level. All six models contain negative coefficient estimates for sugar content, which implies that customers are probably going to be more sensitive to rising sugar levels in cereals and might even choose lower-sugar options.

Overall, the coefficients have the expected sign, the average shelf price and sugar coefficients are robust across almost all specifications (excluding model 2 and 3). Hence, our preferred specification is Model 4 because average shelf price and sugar are statistically significant and the model accounts for brand fixed effects to control heterogeneity (specific characteristics associated with each brand).

While analyzing the cereal market, the choice of standard errors important for obtaining reliable estimates. The estimations of table 1 includes the three different standard error options:

IID (Independent and identically distributed errors) which assume variances and errors within observations are unrelated. Moreover, the heteroskedasticity-robust standard errors occur when the variance of the errors varies among observations. And in clustering standard errors the correlations between observations are within the same market.

Model 1 through Model 3 represents the demand of cereal market without considering brand fix effects. For instance, we observe consistent estimates for the coefficients such as sugar content and average shelf price coefficient in the three models. Nonetheless, there are variations in standard errors. Despite, maintaining identical R-Squared values (proportion of the variance in the mean utility that is explained by the independent variables such as caloric content, fat content, sugar content, and average shelf price), discrepancies in significance levels of the coefficients occur due to the utilization of different standard error. For these cases, model 1which uses independent and identically distributed (IID) errors, is the preferred because it exhibits statistical significance in coefficient variables compared to the other models without brand fix effects.

Model 4 through Model 6 show the demand of cereal market considering brand fix effects. Notably, the estimated coefficients remain the same across all error types. Regardless, variation in standard errors amongst the models are observed. The R-Squared values are the same for the three models. However, with the change in the standard errors from one type to another, the significance level differs among models.

Overall, the coefficients of the independent variables remain constant across the models, irrespective of the standard error used. The variation arises from the inclusion of exclusion of brand fix effects, which capture the unobserved heterogeneity related to different brands in the market of cereal. The marginal differences in standard errors among models imply that the choice of a specific error type in the model may not have a significant impact on the main results of the analysis. However, our preference goes towards models where coefficients are more statistically significant, hence Model 1 in cases of no brand fixed effects and Model 4 with brand fixed effects, both utilizing independent and identically distributed (IID) errors.

Table 1: Analysis of cereal market using OLS with and without brand fixed-effects

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
(Intercept)	-1.762^{***}	-1.762^{*}	-1.762			
	(0.610)	(0.906)	(1.046)			
Caloric content	0.000	0.000	0.000	0.001	0.001	0.001
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.001)
Fat content	-0.001	-0.001	-0.001	0.016	0.016	0.016
	(0.057)	(0.048)	(0.062)	(0.060)	(0.055)	(0.072)
Sugar content	-0.028^{**}	-0.028	-0.028	-0.037^{**}	-0.037^{**}	-0.037^{**}
	(0.014)	(0.017)	(0.015)	(0.014)	(0.016)	(0.011)
Average Shelf Price	-0.268^{*}	-0.268	-0.268	-0.443^{***}	-0.443^{**}	-0.443^{*}
	(0.138)	(0.207)	(0.287)	(0.155)	(0.173)	(0.197)
Observations	50	50	50	50	50	50
R2 adj.	0.102	0.102	0.102	0.242	0.242	0.242
Brand FE	No	No	No	Yes	Yes	Yes
Errors used	IID	HC1	clustered	IID	HC1	clustered

$^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$

3 Instruments and IV estimation

In investigating the question of price endogeneity within the context of consumer goods—specifically cereal products—our investigation identifies two key instrumental variables (IVs): "Average Transaction Price" and "Average Advertising Expenditure". Endogeneity concerns arise when an explanatory variable is correlated with the error term in the regression, potentially due to omitted variable bias, measurement error, or simultaneity. Endogeneity leads to biased and inconsistent estimates, thereby obfuscating the true relationship between the variables of interest.

Selection of Instrumental Variables:

"Average Transaction Price" is a standout candidate for an IV, as it is presumed to influence the "Average Shelf Price" but is not directly influenced by the unobserved factors that affect the demand for cereal thus meeting the exclusion restriction criterion. Its role as an instrument is premised on the economic logic that transaction prices, reflective of the costs incurred in bringing a product to the shelf, naturally affect the final shelf price. Yet, these costs are plausibly independent of the individual consumer preferences that drive demand and, by extension, the error term of our mean utility regression equation.

"Average Advertising Expenditure," the second instrument, captures the marketing efforts exerted to enhance brand visibility and consumer appeal. It is posited to affect "Average Shelf Price" through increased demand or perceived value, yet, importantly, it is assumed not to be correlated with the error term. This assumption rests on the notion that advertising influences consumers uniformly, independent of the idiosyncratic factors that might affect an individual's utility from consuming cereal.

Analyzing Correlation Matrix and IV Strength:

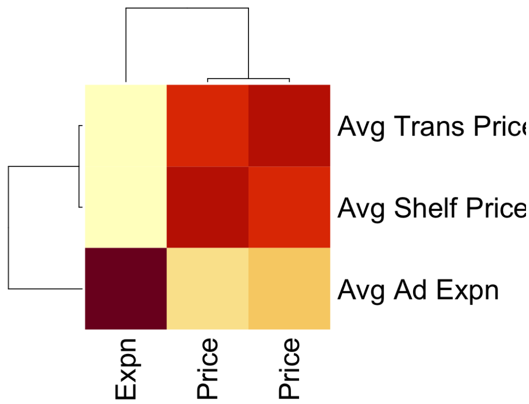

Figure 7:
Heatplot correlation Matrix with IV

A pivotal step in IV analysis is the assessment of the correlation between the potential IVs and the endogenous variable. Our correlation matrix indicates a weak, negative relationship between "Average Advertising Expenditure" and "Average Shelf Price." Although counterintuitive, this could arise in a scenario where higher advertising spending is associated with price promotions that temporarily reduce the shelf price to boost demand. Conversely, the robust positive correlation between "Average Transaction Price" and "Average Shelf Price" corroborates the hypothesized direct cost-pass-through mechanism

However, the choice and validity of IVs are not solely dictated by their correlation with the endogenous variable. The strength of an instrument its ability to explain variation in the endogenous regressor is equally critical. Weak instruments can undermine the reliability of IV estimates, leading to imprecise and biased

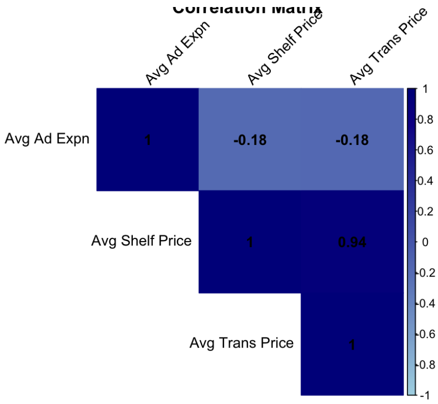

Figure 8:
Correlation Matrix with IV

results. Therefore, the suitability of "Average Transaction Price" as a strong IV for "Average Shelf Price" is supported by both its substantial correlation and the economic rationale behind this relationship.

Regression Models Interpretation with Instrumental Variables

Baseline OLS without brand fix effects the average shelf price estimate is -0.268. The IV1 (average advertising expenditure) estimate has a steeper demand curve, which suggests that the instrument is solving the endogeneity problem. This is also the case when the instrumental variables are combined, even though the price estimate flattens slightly. This suggests that an instrument (IV2: average transaction price) doesn't add much value.

Effectiveness in terms of instrument validity in OLS without Brand Fix Effect

Iv1a_2 (Average Advertising Expenditure by Brand):

- Wald (1st stage) statistic: 2.99417, p = 0.015585
- F-test (1st stage) statistic: 2.99417, p = 0.015585
- Kleibergen-Paap statistic: 0.492372, p = 0.99793
- Sargan statistic: 31.8, p = 6.571e-6

Iv1a_3 (Average Transaction Price by Brand):

- Wald (1st stage) statistic: 62.4, p < 2.2e-16
- F-test (1st stage) statistic: 62.4, p < 2.2e-16
- Kleibergen-Paap statistic: 10.3, p = 0.113926
- Sargan statistic: 8.64954, p = 0.123886

Iv1a_4 (Combination of Average Advertising Expenditure and Average Transaction Price by Brand):

- Wald (1st stage) statistic: 26.2, p = 1.084e-13
- F-test (1st stage) statistic: 26.2, p = 1.084e-13
- Kleibergen-Paap statistic: 5.44514, p = 0.941437
- Sargan statistic: 39.6, p = 4.197e-5

Iv1a_3 (Average Transaction Price by Brand) shows the highest Wald and F-test statistics (stat = 62.4, p < 2.2e-16). This shows that the average transaction price is quite successful at mitigating price endogeneity. Iv1a_2 (Average Advertising Expenditure by Brand) has statistical significance, although not as much as iv1a_3. Combined Average Advertising Expenditure and Average Transaction Price by Brand has significant Wald and F-test statistics, although not as strong as iv1a_3.

Therefore, even though iv1a_3 (Average Transaction Price by Brand) is the most effective instrument according to the tests, it coeficient of price average shelf price is not significant, so we will work with the iv1a_2. The Average Advertising Expenditure by Brand exhibits a stronger instrumental relevance and is statistically significant, indicating its potential effectiveness in isolating the exogenous variation in pricing without brand-specific effects.

In the baseline OLS with brand fixed effects, the average shelf price estimate is -0.443. All the IV estimates (average advertising expenditure, average transaction price) exhibit a steeper demand curve, suggesting that the instruments effectively address the endogeneity problem inherent in the baseline model. This is also the case when the instrumental variables are combined.

Effectiveness for validity of instruments in OLS with Brand Fix Effect:

Iv2a_5 (Average Advertising Expenditure by Brand):

- Wald (1st stage) statistic: 4.41389, p = 0.001768
- F-test (1st stage) statistic: 4.41389, p = 0.001768
- Kleibergen-Paap statistic: 0.821339, p = 0.991489
- Sargan statistic: 28.8, p = 2.544e-5

Iv2a_6 (Average Transaction Price by Brand):

- Wald (1st stage) statistic: 40.0, p = 6.015e-15
- F-test (1st stage) statistic: 40.0, p = 6.015e-15
- Kleibergen-Paap statistic: 7.44453, p = 0.281685
- Sargan statistic: 7.90243, p = 0.161696

Iv2a_7 (Combination of Average Advertising Expenditure and Average Transaction Price by Brand):

- Wald (1st stage) statistic: 16.6, p = 7.478e-10
- F-test (1st stage) statistic: 16.6, p = 7.478e-10
- Kleibergen-Paap statistic: 3.90542, p = 0.972602
- Sargan statistic: 39.5, p = 4.323e-5

The most significant statistical result is iv2a_6 (Average Transaction Price by Brand), which also manages price endogeneity quite successfully. An extensive correlation between the average transaction price and the endogenous variable is shown by this instrument's very significant Wald and F-test statistics. Furthermore, the instrument's validity is reinforced by the Sargan statistics.

Iv2a_5 (Average Advertising Expenditure by Brand) exhibits statistical significance. So, it also helps to solve price related endogeneity issues. Further control over price endogeneity is given by iv2a_7 (Combination of Average Advertising Expenditure and Average Transaction Price by Brand), which incorporates both advertising expenditure and transaction price. It does not outperform iv2a_6 in terms of addressing price endogeneity, although showing statistical significance.

As a result, of the models examined iv2a_6 (Average Transaction Price by Brand) appears to be the most effective at accounting for price endogeneity in OLS with brand fix effect.

The limited sample size of our study (N = 50) introduces a degree of uncertainty concerning the robustness of the instrumental variable tests. Given this constraint, the results of these tests should be approached with caution. Nevertheless, the adjusted R-squared values from our models suggest that the chosen instrumental variables are appropriate, albeit with the acknowledgment that these values are not sufficiently high to confirm an exhaustive fit to the data. The observed increase in the adjusted R-squared, while not definitive, does indicate a positive trend in the model's explanatory power and lends some support to the validity of the instruments.

Table 2: Analysis of cereal market using IV in the OLS with and without brand fixed-effects

	Model without Brand FE				Model with Brand FE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(Intercept)	-1.762***	-0.478	-1.924***	-1.808***		-1.529**	-0.841	2.259
	(0.610)	(1.173)	(0.641)	(0.635)		(0.645)	(1.479)	(2.872)
Cals	0.000	-0.002	0.000	0.000	0.001	-0.002	0.001	0.001
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Fat	-0.001	0.018	-0.003	-0.001	0.016	0.064	0.012	0.016
	(0.057)	(0.062)	(0.057)	(0.057)	(0.060)	(0.070)	(0.060)	(0.060)
Sugar	-0.028**	-0.023	-0.029**	-0.028**	-0.037**	-0.030*	-0.038**	-0.037**
	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.016)	(0.015)	(0.014)
Avg Shelf Price	-0.268*				-0.443***			
	(0.138)				(0.155)			
fit_Avg Shelf Price		-0.598**	-0.226	-0.256*		-0.898***	-0.409**	-0.446**
		(0.292)	(0.147)	(0.146)		(0.285)	(0.169)	(0.167)
Num.Obs.	50	50	50	50	50	50	50	50
R2	0.176	0.071	0.174	0.175	0.381	0.247	0.380	0.381
R2 Adj.	0.102	-0.011	0.100	0.102	0.242	0.078	0.241	0.242
R2 Within					0.314	0.166	0.313	0.314
R2 Within Adj.					0.245	0.083	0.245	0.245
AIC	72.4	78.3	72.5	72.4	68.1	77.9	68.1	68.1
BIC	82.0	87.9	82.1	82.0	87.2	97.0	87.3	87.2
RMSE	0.45	0.48	0.45	0.45	0.39	0.43	0.39	0.39
Std.Errors	IID	IID	IID	IID	IID	IID	IID	IID
FE: fbrand				X		X	X	X

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

4 More instruments and IV estimation

In the market dynamics, prices and quantities are related because they're determined simultaneously by various market forces. However, capturing the true relationship between price and demand is difficult due to unobserved characteristics that are embedded within the error term. Therefore, the use of Instrumental variables (IVs) helps to solve this problem.

We create three instruments such as "iva" that enable us to observe the pricing dynamics within the cereal market, particularly the variations in prices among products within the same cereal brand. Additionally, "Ivb" captures discounts or coupons received among products of cereal brands. Moreover, the "ivc" instrument adjusts each cereal's price relative to the average price within its respective segment (Adult, Fam, Kids).

Table 3: Correlation matrix of new IV

	Avg Shelf Price	iva	ivb	ivc
Avg Shelf Price	1.00000000	0.3420604	0.3569142	0.03176738
iva	0.34206040	1.0000000	0.1664130	-0.31285101
ivb	0.35691423	0.1664130	1.0000000	-0.15762185
ivc	0.03176738	-0.3128510	-0.1576219	1.00000000

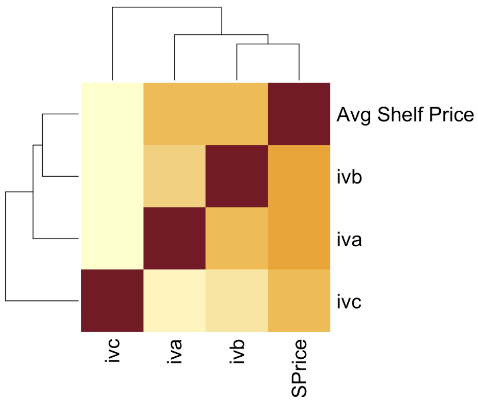

Figure 9: Correlation matrix with new instrumental variables.

Table 4 illustrates the correlation coefficients between the average shelf price and the instruments (iva, ivb, ivc) utilized to address price endogeneity in the cereal market. A positive correlation is observed between the average shelf price and iva, indicating a direct relationship. A negative correlation exists between the average shelf price and ivb, suggesting an inverse relation. Furthermore, a weak positive correlation between the average shelf price and ivc implies a minimal positive relationship between them.

In the baseline OLS without fixed effects using iid error, the estimate for Avg Shelf Price is -0.268, but none of the instrumental variables (IVs) demonstrate significance, implying ineffectiveness in addressing endogeneity concerns within the regression model. However, when brand fixed effects are incorporated alongside instrumental variables in the OLS model, the estimate for Avg Shelf Price shifts to -0.443 to −0.397 in instrumental variable "iva". Making the demand curve steeper, indicating that the combined inclusion of brand fixed effects and instrumental variable (iva) is more adept at addressing endogeneity problem (Table 4).

Table 4: Analysis of cereal market with new IV using OLS with and without brand fixed-effects

	Model without Brand FE				Model with Brand FE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(Intercept)	-1.762***	-4.876***	-1.151	37.237		-1.529**	-0.841	2.259
	(0.610)	(1.741)	(1.251)	(178.859)		(0.645)	(1.479)	(2.872)
Caloric content	0.000				0.001			
	(0.002)				(0.003)			
Fat content	-0.001				0.016			
	(0.057)				(0.060)			
Sugar content	-0.028**				-0.037**			
	(0.014)				(0.014)			
Avg Shelf Price	-0.268*				-0.443***			
	(0.138)				(0.155)			
fit_Avg Shelf Price		0.607	-0.543	-12.384		-0.397**	-0.593	-1.476*
		(0.536)	(0.385)	(55.172)		(0.181)	(0.420)	(0.817)
fbrandKG						0.076	0.014	-0.264
						(0.166)	(0.205)	(0.340)
fbrandNB						-0.278	-0.372	-0.794
						(0.300)	(0.352)	(0.567)
fbrandPT						-0.339	-0.419	-0.783*
						(0.229)	(0.278)	(0.458)
fbrandQK						-0.661**	-0.865*	-1.782*
						(0.317)	(0.506)	(0.924)
fbrandRL						-0.218	-0.228	-0.274
						(0.343)	(0.346)	(0.493)
Brand FE	No	No	No	No	Yes	Yes	Yes	Yes
Instruments	None	IVA	IVB	IVC	None	IVA	IVB	IVC
Observations	50	50	50	50	50	50	50	50
R2 adj.	0.102	-0.807	-0.015	-164.094	0.242	0.160	0.152	-0.720

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

```
fitstat(iv3c_1, ~ ivwald1 + ivf1 + kpr + sargan)
## Wald (1st stage), ‘Avg Shelf Price‘: stat = 6.36046, p = 0.015041, on 1
 and 48 DoF, VCOV: IID.
## F-test (1st stage), ‘Avg Shelf Price‘: stat = 6.36046, p = 0.015041, on 1
 and 48 DoF.
## Kleibergen-Paap: stat = 0.936985, p = 0.333055, on 1 DoF.
## Sargan: NA

fitstat(iv3c_2, ~ ivwald1 + ivf1 + kpr + sargan)
## Wald (1st stage), ‘Avg Shelf Price‘: stat = 7.00725, p = 0.010948, on 1
 and 48 DoF, VCOV: IID.
## F-test (1st stage), ‘Avg Shelf Price‘: stat = 7.00725, p = 0.010948, on 1
 and 48 DoF.
## Kleibergen-Paap: stat = 1.03227, p = 0.309627, on 1 DoF.
## Sargan: NA

fitstat(iv3c_3, ~ ivwald1 + ivf1 + kpr + sargan)
## Wald (1st stage), ‘Avg Shelf Price‘: stat = 0.048489, p = 0.826648, on 1
 and 48 DoF, VCOV: IID.
## F-test (1st stage), ‘Avg Shelf Price‘: stat = 0.048489, p = 0.826648, on 1
 and 48 DoF.
## Kleibergen-Paap: stat = 0.007143, p = 0.932646, on 1 DoF.
## Sargan: NA

fitstat(iv3c_4, ~ ivwald1 + ivf1 + kpr + sargan)
## Wald (1st stage), ‘Avg Shelf Price‘: stat = 91.4, p = 3.31e-12, on 1
 and 43 DoF, VCOV: IID.
## F-test (1st stage), ‘Avg Shelf Price‘: stat = 91.4, p = 3.31e-12, on 1
 and 43 DoF.
## Kleibergen-Paap: stat = 15.0, p = 1.057e-4, on 1 DoF.
## Sargan: NA

fitstat(iv3c_5, ~ ivwald1 + ivf1 + kpr + sargan)
## Wald (1st stage), ‘Avg Shelf Price‘: stat = 6.29237, p = 0.015977, on 1
and 43 DoF, VCOV: IID.
## F-test (1st stage), ‘Avg Shelf Price‘: stat = 6.29237, p = 0.015977, on 1
 and 43 DoF.
## Kleibergen-Paap: stat = 1.03474, p = 0.309048, on 1 DoF.
## Sargan: NA

fitstat(iv3c_6, ~ ivwald1 + ivf1 + kpr + sargan)
## Wald (1st stage), ‘Avg Shelf Price‘: stat = 3.16194, p = 0.082445, on 1
 and 43 DoF, VCOV: IID.
## F-test (1st stage), ‘Avg Shelf Price‘: stat = 3.16194, p = 0.082445, on 1
 and 43 DoF.
## Kleibergen-Paap: stat = 0.51996, p = 0.470859, on 1 DoF.
## Sargan: NA
```

To determine the best instrumental variable (IV) for estimating the demand for cereal while addressing price endogeneity, we assess the statistical test ivf1, ivwald1, Kleibergen-Paap and Sargan tests. As result, instrument "iva" (with brand fix effects) has the highest Wald statistic (91.4) with a very low p-value (3.31e-12) indicating strong statistical significance. This IV captures variations in prices among products within the same brand of cereal.
Ivb (without brand fix effects) representing discounts or coupons by each product in the cereal market has the second highest results with a Wald statistic (7.00) and a low p-value (0.01), however for estimating average shelf price lacked statistical significance.

And Ivc (without brand fix effects) representing the price of the segment in the cereal market has the lowest significance level, with high p-values for both Wald and Kleibergen-Paap tests.

In the table 4, the instrument Iva with brand-fixed effects is recommended for addressing price endogeneity and evaluating cereal demand due to its statistical significance and validity supported by the tests.

Combined Instrumental Variables

The baseline OLS estimate for the average shelf price of cereal (with brand fix effects) is -0.443. The combined instrument IV (iva+ivb+ivc) estimate suggests a steeper demand curve for cereal which suggests that the instrument is doing its job. The instruments combined are effectively capturing the demand dynamics, highlighting consumers' increased responsiveness to changes in cereal prices (Table 5).

Table 5: Analysis of cereal market with combined new IV using OLS with and without brand fixed-effects

	(1)	(2)	(3)	(4)
Coefficients				
Intercept	-1.762***	-2.009**		-1.228*
	(0.610)	(0.871)		(0.627)
Cals	0.000		0.001	
	(0.002)		(0.003)	
Fat	-0.001		0.016	
	(0.057)		(0.060)	
Sugar	-0.028**		-0.037**	
	(0.014)		(0.014)	
Avg Shelf Price	-0.268*		-0.443***	
	(0.138)		(0.155)	
fit_Avg Shelf Price		-0.278		-0.483***
		(0.268)		(0.176)
fbrandKG			0.049	
			(0.165)	
fbrandNB			-0.319	
			(0.298)	
fbrandPT			-0.374	
			(0.228)	
fbrandQK			-0.750**	
			(0.313)	
fbrandRL			-0.222	
			(0.342)	
Brand FE	No	No	Yes	Yes
Instruments	None	IVA+IVB+IVC	None	IVA+IVB+IVC
Observations	50	50	50	50
R^2 adj.	0.102	0.064	0.242	0.165

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

```
fitstat(iv4c_1, ~ ivwald1 + ivf1 + kpr + sargan)
## Wald (1st stage), ‘Avg Shelf Price‘: stat = 4.90945, p = 0.004831, on 3
and 46 DoF, VCOV: IID.
## F-test (1st stage), ‘Avg Shelf Price‘: stat = 4.90945, p = 0.004831, on 3
and 46 DoF.
## Kleibergen-Paap: stat = 0.754674, p = 0.860275, on 3 DoF.
## Sargan: stat = 13.0, p = 0.001471, on 2 DoF.

fitstat(iv4c_2, ~ ivwald1 + ivf1 + kpr + sargan)
## Wald (1st stage), ‘Avg Shelf Price‘: stat = 34.8, p = 2.419e-11, on 3 and
 41 DoF, VCOV: IID.
## F-test (1st stage), ‘Avg Shelf Price‘: stat = 34.8, p = 2.419e-11, on 3 and
41 DoF.
## Kleibergen-Paap: stat = 5.99605, p = 0.111803, on 3 DoF.
## Sargan: stat = 5.12687, p = 0.07704, on 2 DoF.
```

5 Thinking out of the matrix

The average shelf price and sugar content are two key factors that influence cereal market demand, as demonstrated by the results of our previous models. We decided to use sugar as a dummy variable in our analysis to improve the specification of our models.

Our findings consistently showed that the variable representing sugar content in cereal products had a negative and statistically significant effect on mean utility across all models. This means that higher levels of sugar in cereals were associated with a decrease in mean utility, indicating that consumers prefer cereals with lower sugar content. By creating a dummy variable for sugar, we aimed to capture this relationship more accurately and effectively in our models. This allowed us to better understand how sugar content influences consumer preferences and, ultimately, cereal sales.

Table 6 demonstrates the factors influencing mean utility in the cereal market are clarified by comparing the various models. Two important variables that affect mean utility are average shelf price and sugar content, both of which show consistent negative correlations in various models. Models 1 and 6 demonstrate how important sugar content is, with Model 6 underlining its significance by representing it as a dummy variable. The fact that mean utility and average shelf price have a negative relationship further highlights how sensitive consumers are to pricing tactics. Adding brand fixed effects to Models 7 and 8 provides more detailed insights into sales dynamics and improves our understanding of consumer behavior.

While sugar content is still an important determinant in both Model 2 and Model 8, including brand fixed effects in Model 8 provides a more thorough knowledge of sales dynamics, resulting in a better-fitting model with a higher adjusted R-squared value. As a result, considering brand-specific dynamics is critical for effectively estimating sales and understanding consumer preferences in the cereal industry.

The analysis has already demonstrated the importance of certain variables, such as sugar content and fit_average shelf price, in impacting mean utility. Nested logit models, on the other hand, might offer more information about how these factors interact with customer preferences across various brand selections. A more thorough analysis of how sugar content affects brand choice within the cereal market would be possible, for instance, if the sugar_dummy variable were nested within larger categories of cereal brands.

Additionally, connections between decisions made within the same brand category might be taken into consideration via nested logit models, which would give a more accurate picture of how consumers make decisions. Nestled logit models have the potential to enhance the analysis's predictive accuracy and offer significant insights for market segmentation and targeting tactics by encapsulating these interdependencies.

Table 6: Analysis of cereal market including Sugar Dummy using OLS with and without brand fixed-effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(Intercept)	-1.762***	-2.170***			-0.478	-0.815		
	(0.610)	(0.683)			(1.173)	(1.220)		
Cals	0.000	0.001	0.001	0.001	-0.002	-0.001	0.001	0.001
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Fat	-0.001	-0.012	0.016	0.015	0.018	0.007	0.012	0.012
	(0.057)	(0.057)	(0.060)	(0.060)	(0.062)	(0.062)	(0.060)	(0.061)
Sugar	-0.028**	-0.039**	-0.037**	-0.042***	-0.023	-0.033*	-0.038**	-0.043***
	(0.014)	(0.016)	(0.014)	(0.016)	(0.015)	(0.018)	(0.015)	(0.016)
Avg Shelf Price	-0.268*	-0.267*	-0.443***	-0.442***				
	(0.138)	(0.137)	(0.155)	(0.155)				
sugar_dummy		0.432		0.325		0.428		0.325
		(0.333)		(0.373)		(0.356)		(0.373)
fit_Avg Shelf Price					-0.598**	-0.615**	-0.409**	-0.409**
					(0.292)	(0.291)	(0.169)	(0.170)
Brand FE	No	No	Yes	Yes	No	No	Yes	Yes
Instruments	None	None	None	None	Avg Expen*brand	Avg Expen*brand	Avg Trans Price*brand	Avg Trans Price*brand
Observations	50	50	50	50	50	50	50	50
R2 adj.	0.102	0.116	0.242	0.237	-0.011	-0.013	0.241	0.236
New variable	No	Yes	No	Yes	No	Yes	No	Yes

$^{*} p < 0.1$, $^{**} p < 0.05$, $^{***} p < 0.01$

6 Wrapping-up

6.1 Which specification do you suggest, and why?

We are exploring the demand dynamics of the cereal market by looking at a wide range of 50 cereal products that are spread over six different brands and fall into three different categories: adult, kid, and family-oriented. First, we examine important variables including fat, sugar, calories, and average shelf price to determine how these affect cereal choices. Furthermore, we extend our research by integrating brand fix effects to more fully account for variances across various brands and identify their distinct influence on customer decisions.

Our research clarified two important factors influencing the demand for cereals in the market. First, we find a strong relationship between consumer behavior and the average shelf price. There is a noticeable decline in cereal sales when prices rise, indicating price sensitivity on the part of consumers. Second, the results of our analysis highlight the importance of sugar content, since higher sugar content is associated with lower cereal consumption. This suggests that consumers may be wary of cereals that have a high sugar level. In our estimation of cereal market demand, we encounter the endogeneity problem. This issue arises because certain aspects of consumer preferences for a particular cereal brand, such as its reputation or perceived quality, are not directly observable or measurable. These unobservable factors are closely associated with the cereal's price (as well as other characteristics of the product), leading to complications when analyzing the relationship between price and consumer demand. Essentially, this hidden influence of brand-related attributes on both price and demand poses a challenge in accurately assessing how changes in price affect cereal consumption. To address this issue, we employ instrumental variables (IVs).

Average Advertising Expenditure by Brand functions as a good instrumental variable. This variable not only exhibits a strong correlation with price but also provides valuable insights into consumer perceptions and attitudes towards different cereal brands. Brands that allocate greater resources to advertising may be perceived as more reputable, trustworthy, or appealing by consumers, irrespective of their actual product attributes.

Finally, the average transaction price of cereals across different brands (IV), factoring in discounts, coupons, and promotional offers, provides valuable insight. Brands commanding higher transaction prices, even after considering discounts and coupons, may be perceived as offering premium-quality products or enjoying stronger brand loyalty among consumers.

Our comprehensive analysis across various models reveals that the key determinants of consumer preferences in the cereal market—namely, average shelf price and sugar content—consistently influence mean utility, showing a negative correlation. This trend persists regardless of the standard error approach used, indicating robustness in our findings. Particularly, models incorporating brand fixed effects unveil the nuanced impact of brand-related factors, enriching our understanding of consumer behavior by capturing unobserved heterogeneity among cereal brands. Notably, the comparison between models with and without brand fixed effects emphasizes the significance of brand dynamics. For instance, Model 1, which lacks brand fixed effects, and Model 4, which includes them, both highlight the reliability of our variables' coefficients, suggesting that our model choices—favoring statistical significance—offer a solid foundation for analyzing consumer preferences. The analysis further identifies the instrumental role of advertising expenditure and transaction prices in addressing the endogeneity problem, with certain instruments proving more effective than others. For example, the average advertising expenditure by brand (iv1a_2) emerges as a crucial factor in isolating exogenous variations in pricing, especially when brand specifics are not considered. In contrast, when brand fixed effects are included, the average transaction price by brand (iv2a_6) significantly contributes to managing price endogeneity, as evidenced by robust statistical tests.

Moreover, our exploration extends to nested logit models, proposing a deeper dive into how sugar content and pricing strategies interact with brand selection preferences. These models suggest potential for a more granular understanding of consumer decisions within brand categories, offering valuable insights for market segmentation and targeted marketing strategies.

In summary, our findings highlight the paramount importance of considering both universal product attributes and brand-specific dynamics to accurately consumer preferences in the cereal market. The model 6 in the table 2 that includes average transaction price as Instrumental Variable and using Brand Fix Effect.This approach not only enhances the predictive accuracy of our models but also offers strategic insights for addressing consumer needs more effectively.

6.2 Plots and Elasticity Matrix

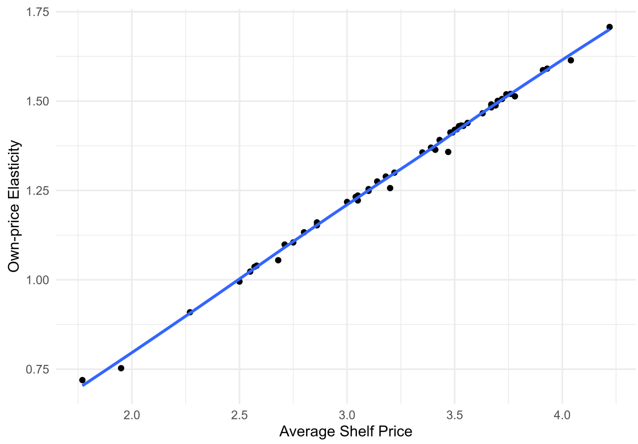

Figure 10:
Own price elasticities against price

The figure 10 illustrates a linear relationship between the average shelf price of products and their own-price elasticity. As the average shelf price increases, the own-price elasticity also increases, indicating a direct correlation between price and demand sensitivity. This pattern suggests that consumers are more responsive to price changes in higher-priced products, possibly because these goods are considered less essential or have more available substitutes. Products with a high own-price elasticity, typically greater than one, may be considered luxury items or non-necessities. Consumers are likely to reduce their consumption if prices rise or switch to alternative products if they find cheaper options.

In contrast, products with lower prices on the shelf exhibit lower price elasticity, indicating that consumers are less sensitive to price changes for these goods. These products may be viewed as necessities with fewer substitutes available, leading to a more inelastic demand. This behaviour may reflect a market segment where consumers continue to purchase similar quantities despite price fluctuations, possibly due to brand loyalty, habitual purchasing, or a lack of suitable alternatives. The consistent linear trend across the price spectrum suggests that this behaviour is not isolated to certain price points but rather a widespread characteristic of the dataset's market structure.

The figure 11 illustrates a nonlinear relationship between shelf prices and markups. It shows a steep ascent as prices increase from the lowest end, followed by a gradual flattening out, indicating a deceleration in the rate of markup increase with price. It is worth noting that there is a wide dispersion of markups at mid-range prices, where the variation in markups appears to be most significant.

The markup is a crucial element of pricing strategy, representing the difference between the cost of producing or purchasing the product and its selling price. The pattern observed here could indicate that lower-priced products have a wide range of markups, possibly due to varying costs or competitive pricing strategies. As prices increase, the markups become more consistent, hovering around a plateau. This could indicate a market equilibrium where premium or specialty items achieve a consistent profit margin due to lower price

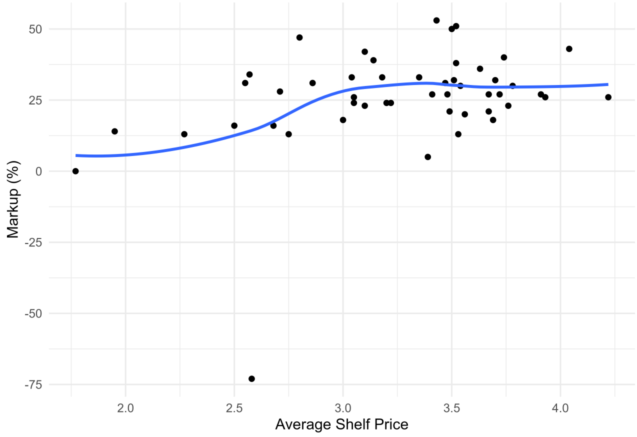

Figure 11: Markups against prices

sensitivity among consumers. The negative mark-ups observed may indicate that products are being sold at less than cost, which could be the result of promotional strategies or efforts to reduce inventories.

6.3 Elasticity Matrix

	[,1]	[,2]	[,3]	[,4]	[,5]	[,6]	[,7]	[,8]	[,9]	[,10]
[1,]	0.75269262	-0.03494958	-0.03223660	-0.03048114	-0.02178364	-0.01883128	-0.01803334	-0.01723541	-0.01691623	-0.01659706
[2,]	-0.08050924	1.35772379	-0.05736461	-0.05424080	-0.03876371	-0.03351002	-0.03209010	-0.03067019	-0.03010222	-0.02953426
[3,]	-0.07424484	-0.05735315	1.25653165	-0.05002033	-0.03574751	-0.03090261	-0.02959318	-0.02828375	-0.02775997	-0.02723620
[4,]	-0.06218005	-0.04803327	-0.04430466	1.05475789	-0.02993854	-0.02588094	-0.02478429	-0.02368764	-0.02324898	-0.02281032
[5,]	-0.05800378	-0.04480715	-0.04132897	-0.03907838	0.99506658	-0.02414267	-0.02311967	-0.02209668	-0.02168748	-0.02127828
[6,]	-0.09373411	-0.07240836	-0.06678762	-0.06315067	-0.04513124	1.61414428	-0.03736139	-0.03570823	-0.03504697	-0.03438570
[7,]	-0.07911715	-0.06111695	-0.05637272	-0.05330291	-0.03809344	-0.03293060	1.36382902	-0.03013987	-0.02958172	-0.02902358
[8,]	-0.08770171	-0.06774841	-0.06248940	-0.05908652	-0.04222675	-0.03650371	-0.03495694	1.51335724	-0.03279147	-0.03217276
[9,]	-0.05266743	-0.04068489	-0.03752671	-0.03548317	-0.02535839	-0.02192154	-0.02099266	-0.02006378	0.90918661	-0.01932068
[10,]	-0.07076461	-0.05466472	-0.05042134	-0.04767563	-0.03407185	-0.02945405	-0.02820600	-0.02695795	-0.02645873	1.22209357
[11,]	-0.05916385	-0.04570329	-0.04215555	-0.03985995	-0.02848630	-0.02462552	-0.02358207	-0.02253861	-0.02212123	-0.02170385
[12,]	-0.06380416	-0.04928787	-0.04546187	-0.04298622	-0.03072052	-0.02655693	-0.02543164	-0.02430635	-0.02385623	-0.02340611
[13,]	-0.07192468	-0.05556087	-0.05124792	-0.04845720	-0.03463040	-0.02993691	-0.02866839	-0.02739988	-0.02689247	-0.02638507
[14,]	-0.05985990	-0.04624098	-0.04265150	-0.04032889	-0.02882143	-0.02491523	-0.02385950	-0.02280377	-0.02238148	-0.02195919
[15,]	-0.06635632	-0.05125938	-0.04728034	-0.04470567	-0.03194934	-0.02761921	-0.02644890	-0.02527860	-0.02481048	-0.02434235
[16,]	-0.05962788	-0.04606175	-0.04248618	-0.04017258	-0.02870972	-0.02481866	-0.02376702	-0.02271538	-0.02229473	-0.02187407
[17,]	-0.07865312	-0.06075850	-0.05604208	-0.05299029	-0.03787002	-0.03273746	-0.03135027	-0.02996309	-0.02940822	-0.02885335
[18,]	-0.08561358	-0.06613536	-0.06100156	-0.05767969	-0.04122135	-0.03563458	-0.03412464	-0.03261470	-0.03201072	-0.03140674
[19,]	-0.07470887	-0.05771161	-0.05323171	-0.05033296	-0.03597094	-0.03109575	-0.02977814	-0.02846052	-0.02793347	-0.02740643
[20,]	-0.08422149	-0.06505998	-0.06000967	-0.05674181	-0.04055109	-0.03505515	-0.03356976	-0.03208438	-0.03149022	-0.03089607

	[,11]	[,12]	[,13]	[,14]	[,15]	[,16]	[,17]	[,18]	[,19]	[,20]
[1,]	-0.01563954	-0.01468201	-0.01236800	-0.01220841	-0.01212862	-0.01164986	-0.010053988	-0.01164986	-0.01077213	-0.010452956
[2,]	-0.02783036	-0.02612646	-0.02200870	-0.02172472	-0.02158273	-0.02073078	-0.017890943	-0.02073078	-0.01916887	-0.018600901
[3,]	-0.02566488	-0.02409356	-0.02029621	-0.02003432	-0.01990338	-0.01911772	-0.016498852	-0.01911772	-0.01767734	-0.017153569
[4,]	-0.02149434	-0.02017836	-0.01699807	-0.01677874	-0.01666908	-0.01601109	-0.013817789	-0.01601109	-0.01480477	-0.014366114
[5,]	-0.02005069	-0.01882310	-0.01585641	-0.01565181	-0.01554951	-0.01493572	-0.012889728	-0.01493572	-0.01381042	-0.013401226
[6,]	-0.03240191	-0.03041812	-0.02562396	-0.02529333	-0.02512801	-0.02413612	-0.020829801	-0.02413612	-0.02231764	-0.021656381
[7,]	-0.02734914	-0.02567470	-0.02162815	-0.02134907	-0.02120954	-0.02037232	-0.017581590	-0.02037232	-0.01883742	-0.018279272
[8,]	-0.03031664	-0.02846052	-0.02397489	-0.02366554	-0.02351086	-0.02258280	-0.019489269	-0.02258280	-0.02088136	-0.020262653
[9,]	-0.01820603	-0.01709137	-0.01439762	-0.01421185	-0.01411896	-0.01356163	-0.011703873	-0.01356163	-0.01253986	-0.012168313
[10,]	-0.02446184	-0.02296418	-0.01934482	-0.01909521	-0.01897041	-0.01822157	-0.015725469	-0.01822157	-0.01684872	-0.016349495
[11,]	1.02300251	-0.01919956	-0.01617354	-0.01596485	-0.01586050	-0.01523443	-0.013147523	-0.01523443	-0.01408663	-0.013669250
[12,]	-0.02205576	1.10458835	-0.01744205	-0.01721699	-0.01710447	-0.01642929	-0.014178701	-0.01642929	-0.01519147	-0.014741348
[13,]	-0.02486285	-0.02334064	1.24885101	-0.01940825	-0.01928140	-0.01852029	-0.015983263	-0.01852029	-0.01712492	-0.016617520
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