Echoes of Price Dispersion: Unravelling Retail Market Dynamics in the Headphone Market

Abstract

This research analyses pricing strategies in the headphones category across selected retail stores, leveraging data from the PriceSpy website. Focused on the top three stores with the highest number of products, we conducted statistical analyses to uncover patterns in pricing behaviour for four specific headphone products. The findings reveal insights into how prices are adjusted by different stores for these products, shedding light on pricing strategies and market dynamics. Through this research, we aim to provide actionable insights for price optimization and strategic decision-making in the retail sector.

Keywords: *Pricing Strategies, Price variation, Market dynamics, Correlation, Price Dispersion.*

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1. INTRODUCTION

The proliferation of online commerce has sparked debates regarding the accuracy and competitiveness of prices offered by digital retailers.

Here we have used a large dataset on retail pricing. We have documented that there is a significant variation in the price at which the same product is sold in the same period and in the same market. This is because retailers that are, on average, equally expensive set persistently different prices for that particular product. As part of a research project in microdata analysis, pricing and related variables were systematically retrieved from PriceSpy spanning the years 2012 to early 2017. The dataset comprises prices at the retailer-product level, encompassing both CPI adjusted prices and the logarithm of CPI adjusted prices. This Price data is critical to understanding online pricing and competition.

The aim of this report is to conduct a detailed analysis of price changing frequency. This was done by choosing a category across selected retail stores from the dataset, utilizing pricing data collected from the PriceSpy website. The primary objectives include identifying patterns and trends in pricing behaviour for four specific products. Then the report moves on to understanding the variations in prices set by different stores, and shedding light on competitive pricing strategies and market dynamics. This research utilizes statistical analyses like clustering, descriptive assessments, and price variability techniques to offer insights for strategic decision-making in the online retail sector. By leveraging these methods, it aims to inform targeted strategies that enhance competitiveness and market positioning.

In this report, we have given a summary of the research, including objectives, methodologies, and key findings. In the introduction, we mentioned an overview of the study's focus on pricing data from PriceSpy for headphones. Literature review section is to examine existing literature on online pricing, competition, and price dispersion. Moving on to the methodology section, we explained the data, materials used for our analysis and the methods we have applied to come up with our analysis. The findings were discussed in the result section and then we move on to our conclusion.

2. REVIEW OF LITERATURE

Price dispersion, the variance in prices across different sellers for identical or similar products, is a common phenomenon in various markets, deviating from the ideal of the "law of one price." Despite its prevalence, empirical studies examining the magnitude, determinants, and persistence of price dispersion have been limited. Notably, since the

seminar work (Pratt et al., 1979) empirical investigations into price dispersion have been scarce. This happens primarily due to a lack of comprehensive and suitable datasets. In this study, he aims to address this gap by utilizing unique store-level price data for four homogenous products in the Israeli market. The persistence of price dispersion over time raises questions regarding consumers' ability to discern consistently low-priced stores and the feasibility of sustaining such price differentials. By empirically examining the evolution of price distributions over time with micro level data, this study endeavours to shed light on these dynamics. (Lindgren et al., 2020).

This research contributes to the broader literature on price dispersion by understanding the factors driving price differentials across stores and the persistence of these disparities over time. Additionally, it lays a foundation for further explorations into the complexities of pricing behaviour in online markets. This contributes to enhancing competition and expanding consumer choice by providing insights into the underlying mechanisms driving pricing dynamics.

3. METHODS AND MATERIALS

3.1 DATA

The methodology involves utilizing the existing dataset sourced from PriceSpy Sweden spanning the years 2012 to 2017. This dataset comprises 1,20,27,209 observations of price, capturing pricing information for 1,767 distinct products across 469 unique stores.

3.2 MATERIALS

Data extraction, analysis, and visualization were conducted in R using packages like data.table, dplyr, tidyr, factoextra, dendextend, cluster, tidyverse, lubridate and forcats. The dataset was initially processed using data.table for efficient handling, while additional libraries facilitated various analyses such as data tidying, hierarchical clustering, and dendrogram manipulation. Raw CSV data was converted to RDS format for optimized storage and retrieval. Visualization was carried out using ggplot2 for creating informative plots. Statistical analyses, including filtering and summarization, were performed using dplyr functions. The tidyverse package streamlined data manipulation, contributing to a comprehensive dataset understanding.

3.3 METHOD

After conducting k-means analysis *(Fig 3.1)* to cluster stores based on the number of products sold in each store, three clusters were identified. The investigation was further narrowed down by identifying the top three stores in the cluster with the highest product range. Selection refined to store IDs 428, 1260, and 3303 based on its price variation over the period.

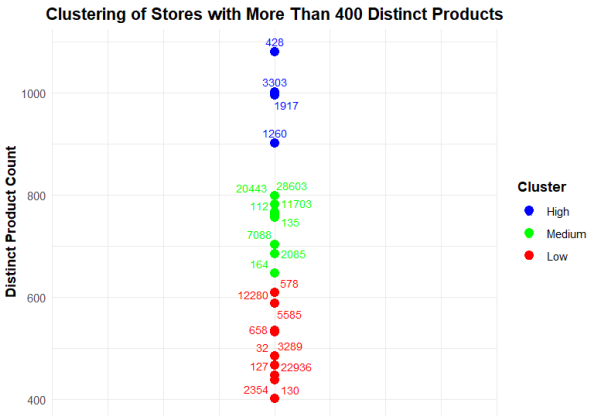

Fig 3.1 Clustering of Stores with More than 400 Distinct products

Subsequently, attention was focused on selecting four headphone products due to its variability in prices. This selection ultimately resulted in the identification of product IDs 1406701, 132943, 1038763, and 2764455.

Next, we have done summary statistics to provide a comprehensive overview of the pricing distribution for each product within and between stores. By calculating the mean, median, and standard deviation of prices, we gain insights into the central tendency and variability of prices for each product. We also do plot analysis between prices of selected products across different stores. Pricing variations and strategies were analysed by extracting subsets of data for specific products and stores. Their price trajectory was plotted to visualize how prices fluctuate over time and to identify patterns in pricing behaviour. Additionally, hierarchical clustering analysis was utilized to identify patterns and relationships contributing to price dispersion across different price ranges over time.

4. RESULTS AND DISCUSSIONS

The hierarchical clustering analysis compared pricing strategies across 10 store IDs to ascertain similarities in approaches across different price clusters. The analysed store IDs were: 428, 3303, 1917, 1260, 20443, 28603, 11703, 112, 135, and 7088, with consideration given to the average price over the analysed period. Specifically, stores 428, 1260, and 3303 were selected for further examination. Different pricing strategies were observed for the two mentioned products, 132943 and 1038763. For product 132943, *(Fig 4.1)* stores 3303, 1917, and 1260 displayed distinct average price clusters, while store 428 was grouped separately. Conversely, the average prices of stores 428, 3303, and 1260 were found to fall within the same price cluster for product 1038763. *(Fig 4.2)*

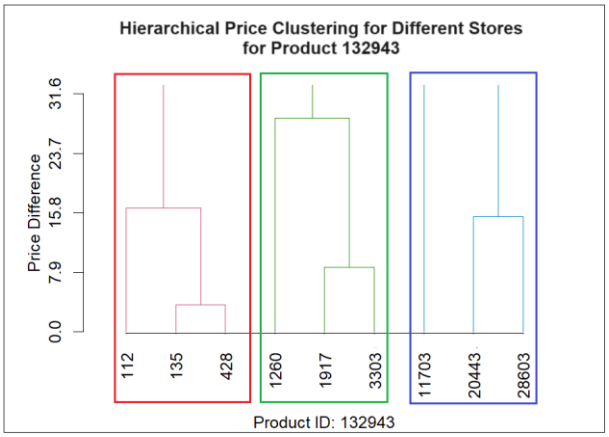

Fig 4.1 Hierarchical Price Clustering analysis for Product ID 132943.

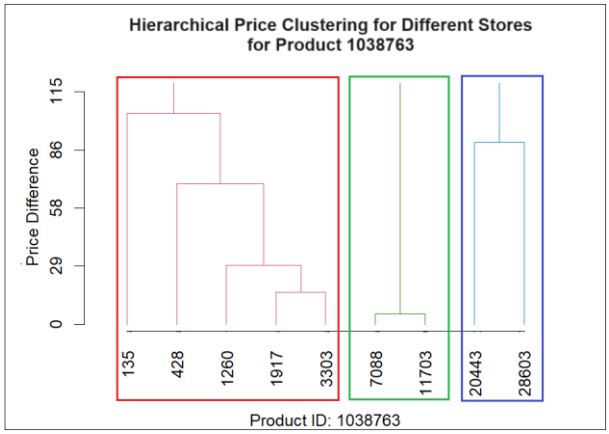

Fig 4.2 Hierarchical Price Clustering analysis for Product ID 1038763

For product 1406701, *(Table 4.1)* store 3303 displays higher mean, median, and standard deviation, indicating greater price variability compared to store 428, which exhibits lower variability in prices. Similarly, for the second product 132943, *(Table 4.2)* store 3303 shows greater variability in price due to its higher standard deviation and mean values. Whereas store 1260 has the least variability because of its lowest standard deviation, despite having the highest mean and median values. For product 1038763, *(Table 4.3)* store 428 maintains consistent pricing, while store 3303 demonstrates higher variability in prices. The product 2764455 price also disperses across all three stores, with store 428 showing maximum variation and store 1260 displaying minimum variations. *(Table 4.4)*

Table 4.1 Mean, Median and Standard deviation for product 1406701

product_id	store_id	mean_price	median_price	sd_price
1406701	428	254.0000	249	45.59548
1406701	1260	252.6300	226	51.04121
1406701	3303	309.3608	330	65.56091

Table 4.2 Mean, Median and Standard deviation for product 132943

product_id	store_id	mean_price	median_price	sd_price
132943	428	287.8649	290	28.24323
132943	1260	372.0602	374	12.71292
132943	3303	336.2706	333	21.62251

Table 4.3 Mean, Median and Standard deviation for product 1038763

product_id	store_id	mean_price	median_price	sd_price
1038763	428	1999.000	1999.0	0.00000
1038763	1260	1628.976	1627.5	30.05563
1038763	3303	1849.356	1865.0	198.23385

Table 4.4 Mean, Median and Standard deviation for product 2764455

product_id	store_id	mean_price	median_price	sd_price
2764455	428	684.8333	698.0	38.503247
2764455	1260	633.9107	631.5	9.402663
2764455	3303	612.9818	599.0	45.473432

It can be concluded that Store 3303 tends to exhibit higher price variability compared to store 428. This indicates potential differences in pricing strategies and market positioning between the two stores. Similarly, store 1260 demonstrates more stable pricing patterns with lower variability.

Hence, from all these descriptive analyses, we can say that the variations in price are different for various products across various stores. Different stores may deploy distinct pricing strategies for the same product. This can be clarified by the fact that some stores try to maintain consistent pricing whereas others are more inclined to a fluctuating price. (Liu, 2010)

The correlation analysis was conducted to understand the relationship between prices of selected products across different stores. The correlation matrix reveals strong positive correlations between prices of selected

products across different stores, indicating synchronized price movements.

We analysed price variations across stores by plotting price changes for each product over time. For product 132943, *(Fig 4.3)* stores 1260 and 3303 maintained competitive prices, while store 428 engaged in predatory pricing by entering the market later and initially setting lower prices.

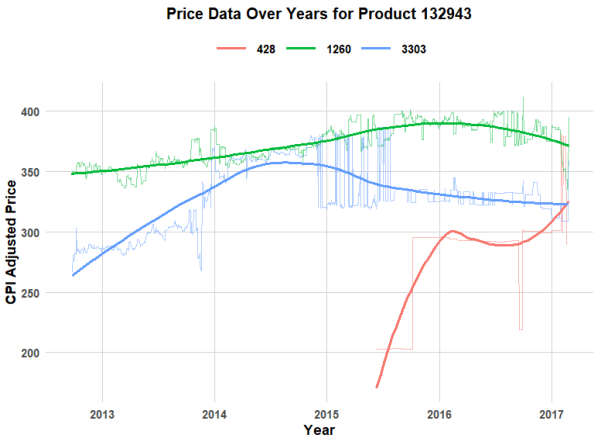

Fig 4.3 Price data over years for product 132943

Over time, store 428 adjusted prices to match competitors. This strategy aims to gain market share by undercutting rivals before returning to normal pricing levels (Markovits, 2023).

Figure 4.4 illustrates the pricing dynamics for product 1406701 across different stores. Initially, store 1260 attempted to undercut prices but was unable to maintain this strategy and eventually matched its prices with store 3303. Subsequently, store 428 entered the market, initially matching the prices of stores 1260 and 3303, and then gradually lowering its prices over time. As time progressed, all stores gradually reduced their prices, closely aligning with each other. This pricing strategy demonstrates a trend of price matching, where stores strive to remain competitive by adjusting their prices to match those of their competitors.

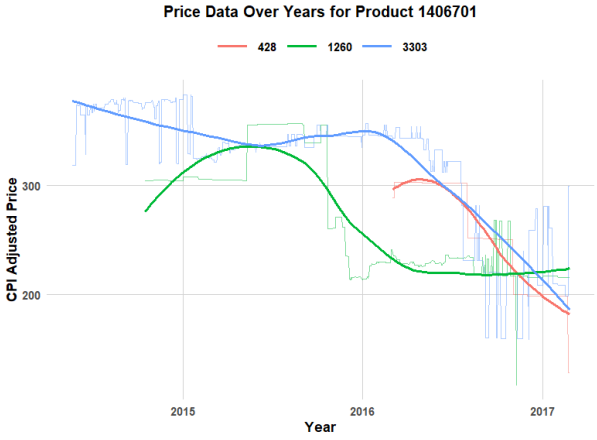

Fig 4.4 Price data over years for product 1406701.

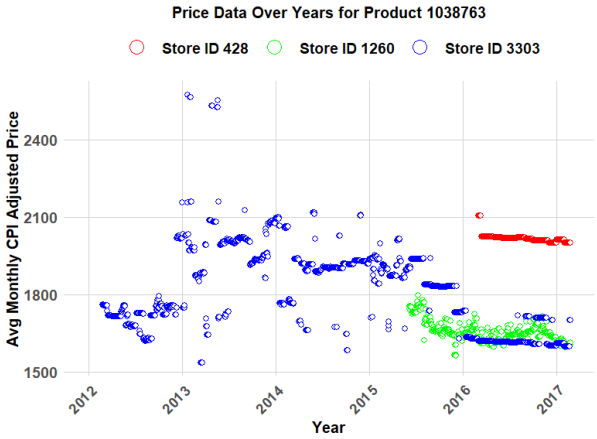

Fig 4.5 Average Monthly CPI adjusted Price data over years for product 1038763.

In *Fig. 4.5*, we observe the average monthly CPI-adjusted value for product 1038763 across different stores over time. Initially, store 3303 monopolized the market, setting prices without competition, known as monopoly pricing. However, as store 1260 entered with lower prices, store 3303 gradually adjusted its prices, indicative of competitive pricing.

5. CONCLUSION

Descriptive statistics revealed notable variations in pricing trends among different stores for the same products. For instance, store 3303 exhibited higher variability in prices compared to others, indicating potentially diverse pricing strategies across stores. Furthermore, the correlation matrix highlighted strong positive correlations between prices of selected products across all pairs of stores. This suggests synchronized price movements within the market, emphasizing the interconnectedness of pricing strategies among retailers.

Our analysis also shed light on intriguing pricing trends, such as instances of predatory pricing observed in the price variation analysis. For example, store 428 initially introduced a product at a significantly lower price, potentially aiming to gain a competitive edge, before eventually adjusting its pricing strategy in line with other stores.

Overall, our findings underscore the complexity of pricing dynamics within the online retail landscape. These dynamics are influenced by factors such as competition, consumer demand, and market conditions. By understanding these dynamics, retailers can optimize their pricing strategies to remain competitive and responsive to market fluctuations. As a further improvement we could use hierarchical analysis over the period to see whether there is a relationship in the price clusters.

6. REFERENCES

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