Analyzing market competition in the Hungarian fuel market

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***Abstract*—This article investigates the factors influencing price evolution and competitive dynamics in Hungary's fuel market following the lifting of a fuel price cap imposed during the Russian war against Ukraine. By applying mathematical and statistical tools, the study models pricing strategies and behavior within the market using data from fuel prices and census data. Three significant dates in the spring of 2023 are selected for analysis. The paper examines pricing strategies at three levels: global, wholesale, and local. Regression models, market responses to wholesale price changes, and price endings are analyzed in each respective section.**

I. Introduction

The primary focus of the article revolves around exploring the factors that influence price evolution and competitive dynamics within the fuel market of Hungary. The significance of this topic arises from the fuel price cap imposed in Hungary due to Russian war against Ukraine, which lasted for over a year until its suspension on 6th December 2022. Examining the manner in which market competition reemerged in the Hungarian fuel industry as a consequence of these events presents an intriguing inquiry.

Our main focus was to employ mathematical and statistical tools in order to model the pricing strategies and behavior within the fuel market. To conduct our analysis, we utilized data obtained from two reputable sources: the largest fuel price comparison website holtankoljak.hu and the Hungarian Statistical Office. For the purpose of data collection, we specifically selected three significant dates in the spring of 2023: March 28, April 6, and April 23.

In this paper, our primary emphasis will be investigating the factors influencing fuel prices in Section II-A, then in Section II-B we will analyze the wholesale price transmission to retail prices. Finally in Section II-C we will analyze the pricing strategies of the stations.

A. Literature Overview:

Given our focus on the Hungarian market, we drew inspiration from the study discussed in [1]. This study aimed to offer valuable insights into the determinants of fuel pricing decisions and the strategies employed by fuel stations to adjust their prices in response to factors like competition, location, and market conditions. By considering this study, we sought to gain a deeper understanding of the dynamics and influences within the Hungarian fuel market.

In a retail gasoline market, [2] examined the impact of price transparency on fuel prices in the Italian highway system and found that increased price transparency through fuel price signs on the Italian highway system led to lower retail prices. The following study [3] found evidence of the effects of price competition on firms' operations and market price in a retail gasoline market. Psychological pricing strategies employed by retail gasoline stations were analyzed by [4] and found that the use of psychological pricing strategies, specifically prices ending in 0, 5, and 9, is prevalent in retail gasoline stations. The study [5] found that price dispersion is influenced by price responsiveness, information availability, and the asymmetry of price adjustments. The effects of antitrust prosecution on retail fuel prices were studied by [6], and found that antitrust prosecution has a significant impact on retail fuel prices. [7] examined the price effects of spatial competition in retail fuel markets and found that the introduction of a new competitor in close proximity leads to price reductions in retail fuel markets. The asymmetric dynamic pricing was analyzed by [8] and found evidence of asymmetric dynamic pricing in a local gasoline retail market, while [9] provided evidence on the pricing behavior of Italian fuel stations using data from the Cuneo retail fuel market.

Collectively, these studies contribute to our understanding of pricing dynamics, competition, price transparency, psychological pricing strategies, and the effects of antitrust prosecution in retail fuel markets.

B. Available Data:

Our primary data source was holtankoljak.hu which is the largest and most popular price comparison website for petrol stations located in Hungary. The website serves as a valuable resource for individuals seeking up-to-date information on fuel prices, promotions, and discounts offered by various petrol stations in the country. Users can access real-time data on fuel prices, compare prices between different stations, and find the nearest petrol stations based on their location.

As part of our data collection process, we utilized Python's web-scraping tools, including Selenium and BeautifulSoup, to select three significant dates in the spring of 2023: March 28, April 6, and April 23. Unfortunately, due to inconsistencies in the website's link generation, certain links had to be manually replaced.

After collecting regional data from Hungarian Central Statistical Office our dataset attributes can be found in Table I.

C. The Hungarian Fuel Market:

To accurately depict the Hungarian fuel market conditions, it is essential to identify the key players who hold signifi-

	Count	Mean	Std	Min	25%	50%	75%	Max
Highway	1264.00	0.06	0.25	0.00	0.00	0.00	0.00	1.00
Services	1258.00	13.25	4.15	1.00	11.00	13.00	16.00	30.00
WC	1258.00	0.61	0.49	0.00	0.00	1.00	1.00	1.00
Number of competition 1km	1264.00	1.98	1.23	0.00	1.00	2.00	3.00	6.00
Number of competition 1-5km	1264.00	12.24	16.33	0.00	2.00	5.00	15.25	72.00
Number of competition 5-10km	1264.00	18.11	30.26	0.00	1.00	4.00	15.00	106.00
Number of competition 10-20km	1264.00	51.25	61.73	1.00	13.00	20.00	38.00	188.00
Number of competition 20-30km	1264.00	54.10	53.96	0.00	17.00	28.00	112.00	194.00
Number of competition 30-40km	1264.00	88.55	71.96	1.00	38.00	52.00	174.00	239.00
Housing	1246.00	469.85	68.38	267.00	421.00	480.00	526.00	890.00
Retail stores	1246.00	143.93	50.06	26.00	111.00	146.00	172.00	555.00
Unemployed 15-64	1246.00	7.78	1.90	1.40	6.70	7.50	8.60	17.70
Allowance	1246.00	25.67	3.73	8.00	23.50	25.10	28.30	40.10
Income tax per person	1246.00	1943.53	438.99	419.00	1601.25	1944.00	2335.00	3196.00
Commuters Abroad	1163.00	3.32	8.64	0.00	0.40	1.20	1.80	69.60
N drinking water	1246.00	95.93	7.34	37.70	94.50	98.60	100.10	104.70
Employed 15-64	1246.00	58.31	5.09	30.80	55.10	59.30	62.90	67.90
Tax per 1000	1246.00	504.25	33.03	127.00	491.00	508.00	523.00	689.00
N of cars per 1000	1246.00	425.43	50.63	146.90	407.10	423.60	451.82	1293.50
N of agriculture	1246.00	623.08	735.74	4.00	112.25	316.00	702.75	2157.00
Commuter Difference	1075.00	0.69	1.62	0.00	0.00	0.00	1.00	18.00
Income Tax per Person	1246.00	3836.13	764.93	1785.00	3251.25	3824.50	4486.00	6054.00
Locally Employed	1075.00	29.88	11.54	5.00	21.50	29.20	37.30	76.30
AVIA	1264.00	0.03	0.17	0.00	0.00	0.00	0.00	1.00
Orlen	1264.00	0.06	0.24	0.00	0.00	0.00	0.00	1.00
MOL	1264.00	0.38	0.49	0.00	0.00	0.00	1.00	1.00
Independent	1264.00	0.18	0.38	0.00	0.00	0.00	0.00	1.00
Mobil Petrol	1264.00	0.04	0.19	0.00	0.00	0.00	0.00	1.00
OIL!	1264.00	0.03	0.18	0.00	0.00	0.00	0.00	1.00
OMV	1264.00	0.14	0.34	0.00	0.00	0.00	0.00	1.00
Shell	1264.00	0.14	0.35	0.00	0.00	0.00	0.00	1.00
95 Gasoline E10	1120.00	605.96	9.02	569.00	605.90	606.00	606.90	647.00
Diesel	1128.00	606.05	8.59	579.90	605.90	606.00	606.00	689.90
100 Gasoline E5	932.00	651.30	19.25	598.90	643.00	643.00	651.17	728.00
Premium Diesel	894.00	661.37	12.18	605.00	661.00	661.00	661.90	697.90

Table I: Dataset Attributes

cant shares. By referring to Figure 1, we can examine the distribution of fuel stations among various companies which reveals that MOL, OMV, and Shell dominate the market in Hungary. This structure aligns with the fuel sectors of many Western European countries, where a small number of large oil companies control the entire production process, ranging from oil extraction to fuel sales at the pump. These established brands engage in competition with each other as well as with independent unbranded retailers commonly referred to as "white pumps" (referred to as "Independent" in our analysis). Due to the significantly higher number of fuel stations in Budapest, the capital city of Hungary, compared to the rest of the country, we conducted a separate analysis for each district within Budapest.

In our data analysis, our initial focus was on examining the number of fuel stations in specific cities, namely Győr, Budapest XI, Miskolc, Kecskemét, and Szeged stood out by having the most stations. By applying the Chi-Squared statistic to analyze the relationship between the City and Franchise attributes, we determined that there exists a significant association between these variables, mainly because smaller franchises are situated close to urban regions.

Additionally, we investigated the presence of a highway near fuel stations and observed a noteworthy price difference because fuel stations located near highways typically have

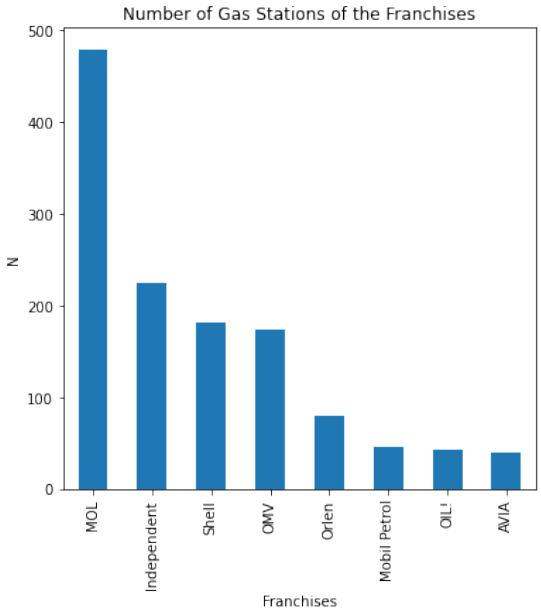


Figure 1: Number of Stations in Hungary

higher prices, averaging an increase of 22 Ft. By employing the same Chi-Squared statistic to explore the association between Franchise and Highway, we discovered a significant relationship. This finding indicates that major franchises, such as Mol, OMV, and Shell, dominate the higher-priced highway market since they own a significant number of fuel stations located alongside highways (Figure 2).

From our analysis of competition and franchises, we can draw the following conclusions: while branded fuel stations (OMV, Shell, Orlen, Mobil Petrol and MOL) are generally located closer to each other, smaller brands and independent stations tend to position themselves in more isolated areas.

The analysis of average fuel prices across different counties confirms a widely recognized observation: counties located closer to countries with higher GDP tend to have higher average fuel prices compared to those farther away.

Upon examining the prices and competition within a given radius, we observed significant variations. These findings indicate that we cannot definitively conclude that higher competition within the radius results in lower prices. Therefore, further analysis is required to determine the factors that influence pricing.

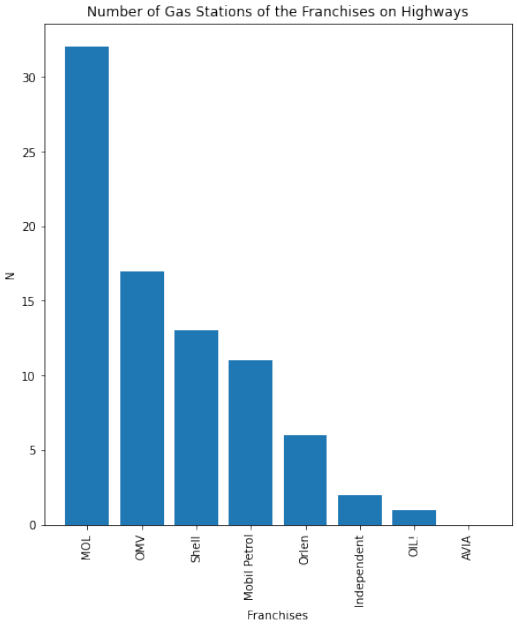


Figure 2: Number of Stations next to Highways

II. Pricing Strategy

In the following section, we will be investigating the factors influencing fuel prices in Section II-A, then in Section II-B we will analyze the wholesale price transmission to retail prices. Finally in Section II-C we will analyze the pricing strategies of the stations.

	coef	std err	t	$P > \|t\|$	95% CI	95% CI
const	621.433	10.13	61.343	0	601.569	641.298
Highway	22.7231	0.404	56.253	0	21.931	23.515
Services	0.0583	0.034	1.698	0.09	-0.009	0.126
WC	-0.0806	0.272	-0.296	0.767	-0.615	0.454
Number of competition 1km	-0.0628	0.117	-0.538	0.591	-0.292	0.166
Number of competition 1-5km	-0.1011	0.029	-3.514	0	-0.157	-0.045
Number of competition 5-10km	0.027	0.016	1.674	0.094	-0.005	0.059
Number of competition 10-20km	-0.014	0.007	-1.946	0.052	-0.028	0
Number of competition 20-30km	-0.0084	0.006	-1.402	0.161	-0.02	0.003
Number of competition 30-40km	-0.0021	0.005	-0.422	0.673	-0.012	0.008
Housing	-0.0009	0.003	-0.317	0.751	-0.006	0.005
Retail stores	0.0007	0.003	0.254	0.8	-0.005	0.006
Unemployed 15-64	-0.0999	0.091	-1.098	0.272	-0.278	0.079
Allowance	-0.1508	0.048	-3.159	0.002	-0.244	-0.057
Income tax per person	0.0082	0.006	1.397	0.162	-0.003	0.02
Commuters Abroad	-0.0284	0.015	-1.845	0.065	-0.059	0.002
N drinking water	0.049	0.017	2.921	0.004	0.016	0.082
Employed 15-64	-0.0485	0.048	-1.015	0.31	-0.142	0.045
Tax per 1000	-0.0289	0.02	-1.43	0.153	-0.069	0.011
N of cars per 1000	0.0063	0.003	1.868	0.062	-0	0.013
N of agriculture	-3.344e-05	0	-0.1	0.921	-0.001	0.001
Commuter Difference	-0.1104	0.128	-0.864	0.388	-0.361	0.14
Income Tax per Person	-0.0042	0.003	-1.402	0.161	-0.01	0.002
Locally Employed	-0.0115	0.012	-0.978	0.328	-0.034	0.012
AVIA	-1.9795	0.854	-2.317	0.021	-3.655	-0.304
Orlen	-0.5315	0.433	-1.227	0.22	-1.381	0.318
Magán	-6.9795	0.341	-20.468	0	-7.648	-6.311
Mobil Petrol	-11.1369	0.553	-20.153	0	-12.221	-10.053
OIL!	-2.2655	0.622	-3.641	0	-3.486	-1.045
OMV	5.1657	0.362	14.252	0	4.455	5.876
Shell	2.5592	0.328	7.808	0	1.916	3.202
2023.04.06	4.4824	0.246	18.248	0	4.001	4.964
2023.04.23	-12.1528	0.245	-49.582	0	-12.633	-11.672

Table II: Regression Results on 95 Gasoline target variable

A. Investigating the factors influencing fuel prices

In this project, as outlined in Section I-B, we gathered data from three specific dates: March 28, April 6, and April 23. To obtain more reliable results for the four price attributes mentioned in Table I (95 Gasoline E10, Diesel, 100 Gasoline E5, Premium Diesel), we opted not to create separate regression models for each date. Instead, we incorporated all the data into our dataset, utilizing a Time attribute.

We conducted ordinary least squares (OLS) linear regression on the complete dataset, with the constant term being the price of MOL (which is not on a highway) on the date of 03.28. The outcome of this regression analysis is presented in Table II.

As we can see in Table II the constant coefficient (621.433) represents the average price of MOL at the reference date (03.28). This can be considered the baseline price.

Each variable's coefficient (e.g., Highway, Services, WC, etc.) represents the estimated effect of that variable on the price of MOL. The "std err" column provides the standard error of the coefficient estimates, while the "t" column presents the t-statistic, which assesses the significance of the coefficient. The $P > |t|$ column shows the corresponding p-value for each coefficient. The signs (positive or negative) of the coefficients indicate the direction of the relationship between the independent variable and the price of MOL. A positive coefficient suggests a positive relationship, meaning an increase in the independent variable is associated with an increase in the MOL price, while a negative coefficient indicates an inverse relationship. The magnitude of the coefficient indicates the strength of the relationship.

At a significance level of 0.05, we can determine that the significant variables in the analysis were the time attributes, franchise, constant, and highway. Additionally, the number of competitions within a 5km radius, Allowance, and N drinking water attributes were also found to be statistically significant. These variables are particularly noteworthy as they inherently incorporate the number of households in the corresponding regions.

The coefficient of Highway (binary variable) is 22 which suggests that if a fuel station is next to a highway the price is associated with an estimated increase of 22 units in the dependent variable (the price of MOL) when holding other variables constant.

Based on the coefficients related to different brands, we can deduce the following: When it comes to larger franchises like OMV and Shell, they are ceteris paribus slightly but significantly more expensive than MOL. However, for smaller franchises, the opposite holds true. These stations normally provide lower prices than the market leader, MOL.

Table IV: RMSE and R-squared values of Full Regression

Fuel Type	RMSE	R-squared
95 Gasoline E10	5.08	0.80
Diesel	5.18	0.88
100 Gasoline E5	5.96	0.90
Premium Diesel	4.65	0.92

During the application of Regression with backward elimination, we can draw the same conclusions as before since the same variables remained significant (Table III). The consistent presence of these patterns indicates that our findings appear to be robust in this scenario as well.

Table V: RMSE and R-squared values of Backward Elimination

Fuel Type	RMSE	R-squared
95 Gasoline E10	5.10	0.80
Diesel	5.19	0.88
100 Gasoline E5	5.98	0.90
Premium Diesel	4.66	0.92

B. Analyzing wholesale price transmission to retail prices

Significant differences can be observed in the frequency distributions of market price changes in two distinct time

	coef	std err	t	$P > \|t\|$	95% CI	95% CI
const	605.544	1.628	372.037	0	602.352	608.736
Highway	22.9086	0.397	57.739	0	22.131	23.687
Number of competition 1km	-0.0736	0.114	-0.644	0.52	-0.298	0.151
Number of competition 1-5km	-0.0939	0.022	-4.255	0	-0.137	-0.051
Number of competition 5-10km	0.02	0.015	1.337	0.181	-0.009	0.049
Number of competition 10-20km	-0.0123	0.007	-1.742	0.082	-0.026	0.002
Number of competition 20-30km	-0.0086	0.006	-1.505	0.132	-0.02	0.003
Number of competition 30-40km	0.0004	0.005	0.079	0.937	-0.009	0.01
Allowance	-0.1162	0.033	-3.558	0	-0.18	-0.052
N drinking water	0.0383	0.015	2.582	0.01	0.009	0.067
AVIA	-1.8314	0.839	-2.182	0.029	-3.477	-0.186
Orlen	-0.6971	0.413	-1.686	0.092	-1.508	0.114
Independent	-7.0864	0.321	-22.105	0	-7.715	-6.458
Mobil Petrol	-11.1299	0.521	-21.35	0	-12.152	-10.108
OIL!	-2.4125	0.597	-4.04	0	-3.584	-1.241
OMV	5.2965	0.331	15.996	0	4.647	5.946
Shell	2.4597	0.297	8.274	0	1.877	3.043
2023.04.06	4.4827	0.246	18.243	0	4.001	4.964
2023.04.23	-12.1483	0.245	-49.552	0	-12.629	-11.668

Table III: Regression Results on 95 Gasoline with backward elimination

periods and across different types of fuels, as depicted in Figure 3. The price changes between Gasoline and Diesel exhibit noticeable differences.

Both Diesel and Premium Diesel responded similarly to price fluctuations. The high responsiveness of this market to market changes is evident from these findings, which is why our regression models exhibited better performance as demonstrated in Table IV and Table V.

The situation is different when it comes to Gasoline prices. While an increase in the wholesale price does not necessarily lead to a corresponding increase in prices at all fuel stations (as shown in the blue part of Figure 3), it is important to note that the increases observed are not insignificant either. We can conclude that the rate of price increase is not necessarily proportional to the rate of wholesale price increase. When the price decreases, fuel stations tend to make only minimal reductions in their prices, often in a trivial manner.

C. Analyzing the pricing strategies of the stations

At the local level, it is important to examine the price endings. The results of a study [4] are consistent with our findings, as nearly all fuel stations employ the psychological pricing tactics described in the study by setting their prices to end with either 0 or 9 (for example 604.9).

However, the last character, in this case, the 'pengő', is no longer a valid currency, so it is important to analyze the second-to-last characters as well. Similar to the last digits, it can be observed that the gas stations strive to end in digits close to zero, five, or nine (at all analyzed dates).

A noticeable pattern in the penultimate characters of prices can be observed, as many fuel stations tend to end their prices with either 0, 9, or 5 (or a value close to 5) throughout all 3 dates. This phenomenon aligns with well-documented psychological effects that have been extensively studied in the field of economics [10], [11].

III. Conclusion and Summary

In summary, we conducted an analysis of the Hungarian fuel market, which is dominated by major franchises. The scripts and datasets are publicly available at the link below[1].

During our exploratory analysis, we discovered several well-known patterns and insights. However, we also found that the

[1]https://github.com/csabamedgyes/Hungarian-Gas-Market-Analysis

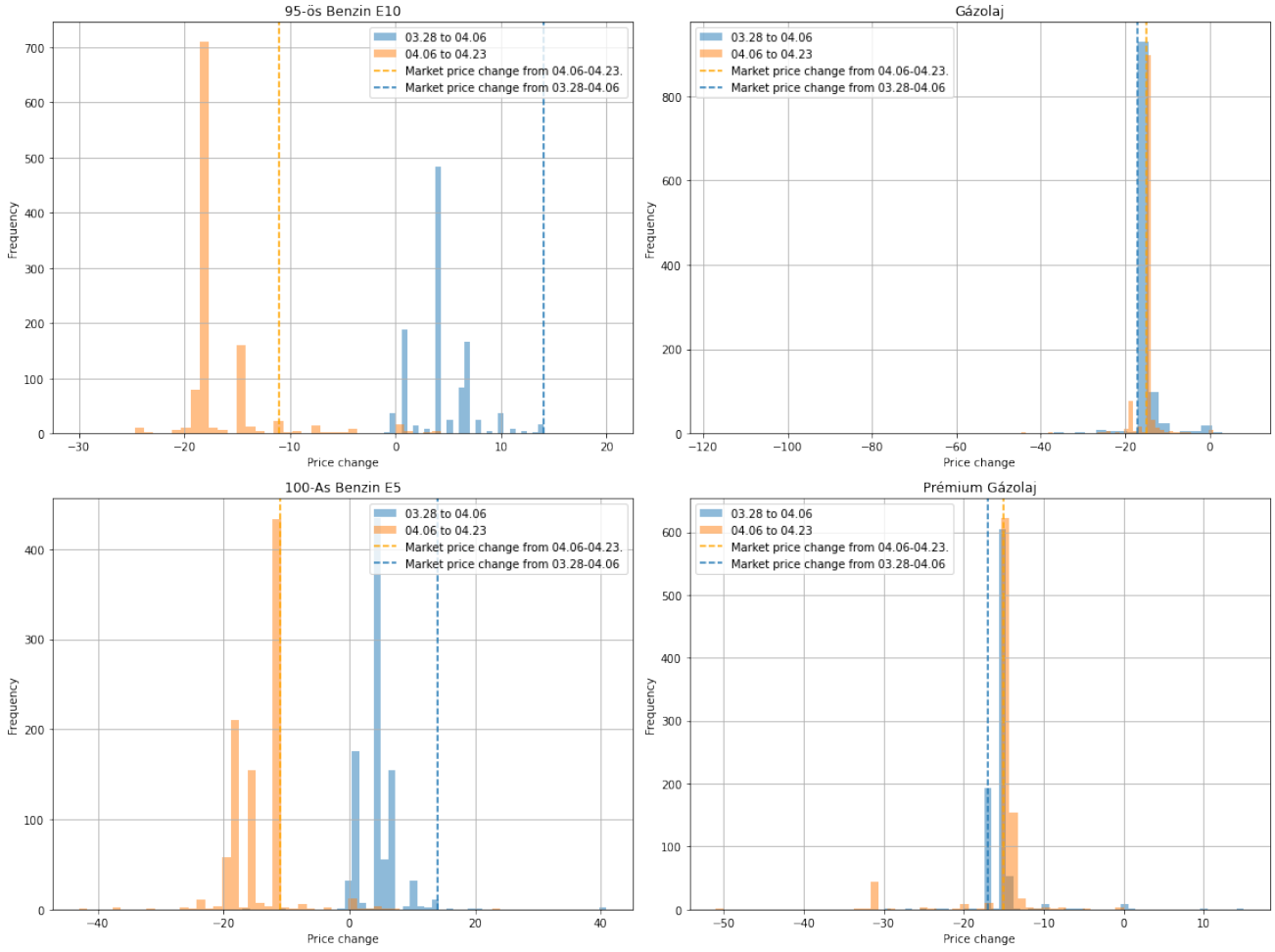
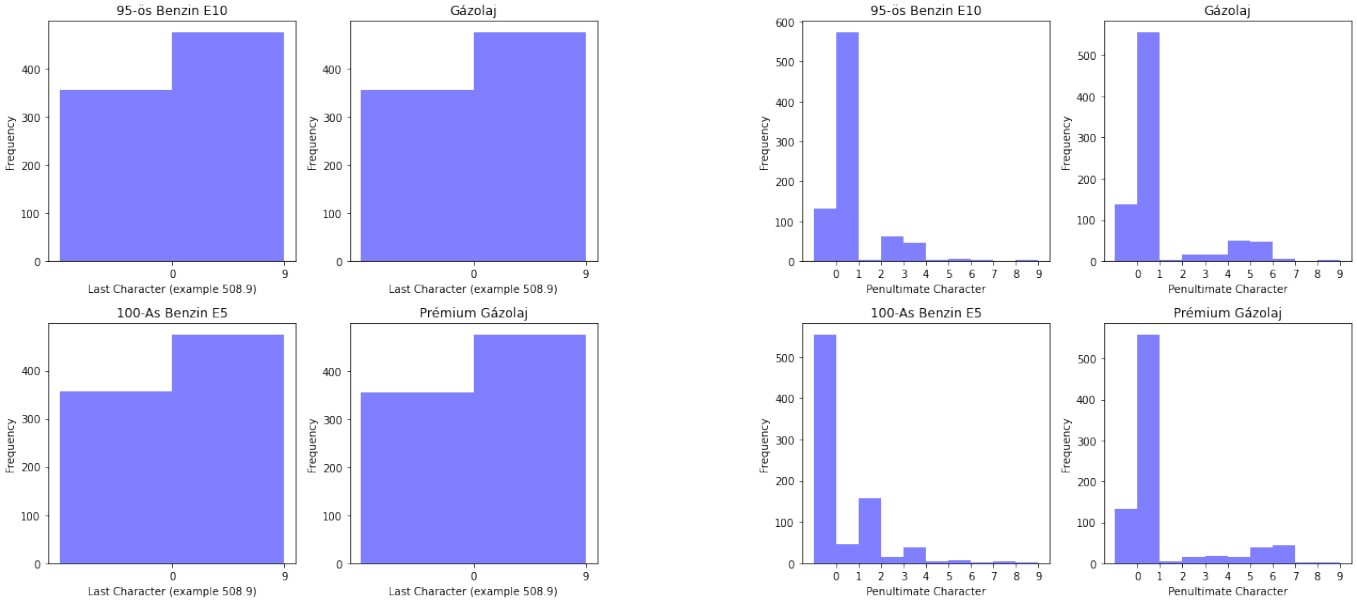


Figure 3: Price change frequencies due to wholesale price change



(a) Last Characters

(b) Penultimate Characters

Figure 4: 03.28 Price Ending Distributions

relationship between competition and pricing is not simply linear but exhibits a more complex structure in the market. Our regression yielded a root mean squared error of around 5 and an r-squared value of at least 80%. Notably, we found that the response of fuel stations to a unit price increase by MOL (a major player) depends on the size of their franchises, as larger franchises exhibited a positive response while smaller ones did not. Then we examined the reasons behind the better performance of our regression model for Diesel and Premium Diesel prices. We discovered that fuel stations generally align their prices with wholesale price changes in these cases. However, we could not draw the same conclusion for Gasoline types. After that, we conducted an analysis of price endings and confirmed the well-established psychological effects of price endings in economics.

Overall, our analysis provides valuable insights into the Hungarian fuel market, shedding light on pricing dynamics, competition, and the influence of wholesale prices and psychological factors on fuel station pricing.

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