Pricing of Hungarian petrol stations before and after the introduction of the price cap

Marcell P. Granát and Nándor Szakmáry

Advisor: Zoltán Madari

Corvinus University of Budapest, Hungary

Abstract

The paper focuses on the pricing of petrol stations in Hungary that has been greatly influenced by the introduction of the price cap. It aims to answer the questions of how the government intervention has changed the pricing strategy of wells. Based on previous empirical studies and the available panel database of 1334 stations, it investigates the factors that influence the pricing of individual petrol stations, with a particular focus on the number and behaviour of competitors in four different time periods. The database includes a couple of distance-based variables such as the number of stations within a particular distance, which are used in the econometric modelling. According to our results MOL was the market leader before the introduction of the price cap and his position strengthened directly after the price control, as it has adapted to the new conditions the most easily of all brands. However, as other stations get used to this new economic environment the gap between the leader MOL and its followers started to reduce.

Keywords: Petrol stations; price cap; competition

1. Introduction

The number of cars in Hungary has been growing constantly in recent years based on the data of the Hungarian Central Statistical Office (2021). Although electric vehicles are becoming more popular, the number of newly registered cars with internal combustion engines is still not falling. Consequently, the demand for fuel in Hungary has been increasing. There is however a considerable divergence in the price of petrol in different parts of the country, with a number of factors contributing to this variation such as the brand, the distance from a highway or the number and quality of services provided by individual wells (Farkas 2017). On the one hand, the situation of the domestic fuel market is exceptional, as the largest wholesaler owns most of the petrol stations of all the networks. On the other hand, the gasoline market is considered homogeneous in terms of products making it an appropriate area for analysing the territorial pricing of oligopoly markets (Békés, Koren, and Zsohár 2011). The sector is characterised by high entry and shutdown costs. Furthermore, it constitutes a significant share of public revenues due to excise taxes, which makes it an important market from a competition economic point of view (Békés, Koren, and Zsohár 2011).

Fuel prices determine the operation and pricing of a large number of industries according to Leung et al. (2019), who summarized more than 40 years of literature in search of general

To support reproducibility and understanding, the R codes used in this study are available in the following Github repository: https://github.com/MarcellGranat/fuel-prices

characteristics of the gasoline market. From agricultural prices to the service industry, gasoline prices have an enormous impact on world-wide economy, as transportation costs are incorporated into consumer prices and thus affect practically all products (Leung et al. 2019). Therefore, the demand for fuel market goods is price-inelastic due to globalised supply chains (Leung et al. 2019). Political influence on consumer prices is also high due to taxes, while demand and substitutability also play a major role in this sector. Increases in fuel prices lead to concerns about economic impacts, since they have spillover effects (Leung et al. 2019).

Noel (2007) identified three distinct pricing patterns in the Canadian gasoline market: cost-based pricing, sticky pricing and asymmetric price cycles in the retail market. His results are consistent with the theory of Edgeworth cycles, i.e. the pattern of prices is cyclical, characterised by an initial jump followed by a slower decline towards the initial level (Noel 2007). This is a theoretical environment in which two firms bid successively and the winner captures the entire market. This can occur in the presence of high levels of capacity underutilization (Noel 2007). Noel (2007) found recurrent price cycles in 43 percent of the periods in the sample, sticky prices in almost one third, and cost-based pricing in more than one quarter. Prices rise rapidly from one week to the next and then gradually decline over the following two to three weeks. Stations that charge very low or very high prices are more likely to keep their pricing position than stations that offer prices close to the average (Hosken, McMillan, and Taylor 2008).

The situation of the Hungarian fuel market is unique, as the sector is characterised by significant vertical integration. The largest wholesaler owns the largest retail distribution chain, giving MOL a huge market share in the Hungarian fuel market. MOL, together with Shell and OMV, form the three major networks in the Hungarian retail petrol market. The three networks own approximately two thirds of all domestic wells (Farkas, Csorba, and Koltay 2009). The number of petrol stations - which provide data for *holtankoljak.hu* - are listed in Table 1 by brand. Their pricing strategy differs from the other wells, not only because MOL stations are over-represented along the motorways, OMV wells in the west and white pumps in the east (Békés, Koren, and Zsohár 2011).

Table 1. Number of petrol stations by brand

brand	n	p
MOL	485	36.36%
Shell	189	14.17%
OMV	181	13.57%
Lukoil	79	5.92%
Mobilpetrol	49	3.67%
OIL!	47	3.52%
Avia	39	2.92%
ENVI	21	1.57%
Auchan	18	1.35%
HunPetrol	11	0.82%
EDO	8	0.60%
Grovi	7	0.52%
NKM	4	0.30%
Egyéb	196	14.69%

Source: holtankoljak.hu

MOL changes its domestic prices based on the Mediterranean market price of gasoline and diesel.

The price of gasoline did not increase more than the consumer basket calculated by the KSH, and even became relatively cheaper in 2005–2009 compared to the turn of the millennium (Sugár 2011), but this corrected in 2010. In 1999–2000 and 2010, the CPI was at least 1 percent higher than it would have been if the change in petrol prices had not been taken into account. There is a very strong correlation between the price level and the tax content of petrol (Sugár 2011). The price formation takes into account the oil market changes of the last 2 weeks. The current weekly (tax-adjusted gasoline/diesel) price is determined by the previous week's gasoline price and the previous week's Mediterranean market price, but MOL reacts less to price decreases than to price increases (Sugár 2011). Conversely, in the retail petrol market, prices on average respond symmetrically to wholesale price changes according to Csorba et al. (2011). However, this result is often argued as Farkas and Biliana (2019) claim that not only wholesale prices adjust more slowly to a fall in the world oil price than to a rise, but there is also a certain asymmetry in the pricing of retail units. The effect of wholesale price increases is incorporated into retail prices faster than when the wholesale price moves downwards (Farkas and Yontcheva 2019). An increase in the oil price is incorporated into retail prices within a few weeks, while a decrease can take twice as long to adjust (Borenstein, Cameron, and Gilbert 1997). This process is called asymmetric cost transmission.

While this asymmetry is not present in Slovakia (Szomolányi, Lukáčik, and Lukáčiková 2019), it can also be observed in the Greek petrol market according to Bragoudakis and Sideris (2012). Market participants adopt a strategy of asymmetric adjustment, which means that they delay the reduction of retail gasoline prices when crude oil prices fall, but raise prices as soon as possible when crude oil prices increase in order to maximise profits. The authors suggest that this is a consequence of the fact that the petrol market in Greece is highly regulated by the state and is non-competitive (Bragoudakis and Sideris 2012).

The issue of inflation and price increases is also a major concern, especially for fuels, as their price spills over and indirectly affects the prices of other goods and services. In contrast, this is not observed when petrol prices fall (Sugár 2011), as prices are sticky downwards. The price of gasoline and diesel is not determined by the cost of production. The factors that indirectly influence retail price increases are the world market price of crude oil and the tax content of the product. Henceforth, it is directly influenced by the exchange rate and stability of the HUF and the price of manufactured products. The population spends between 4 and 4.4 percent of its total expenditure on fuel (Sugár 2011). At EU level, Hungarian petrol prices are not considered high (below average, around the median), but this depends mainly on the tax rate, which in 2010 was 54 percent in Hungary compared to an EU average of 58 percent.

Farkas and Czigány (2017) studied the indirect effects of motorways on fuel prices. The fact that highway well prices are significantly higher than those of on-road and urban filling stations due to the monopoly situation caused by the lack of competition is considered as substantial evidence (Farkas and Czigány 2017). However, the authors find that gasoline prices in the municipalities studied became higher after the construction of motorways, and this is also true for settlements near motorway on-ramps and exits. Motorways therefore also increase indirectly the margins of petrol stations. A similar result was previously found by Meerbeck (2003), who claims that the further a filling station is from a motorway, the lower the price it offers. The number of services provided by a well also has a positive effect on pricing (Farkas and Czigány 2017).

Békés, Koren, and Zsohár (2011) investigated the effects of demand factors and geographical characteristics on petrol prices in Hungary. Similarly to the present paper, they relied on the *holtankoljak.hu* website as the source of fuel prices for petrol stations, but the analysis was carried out only for one point in time, i.e. in a cross-section manner. His results show that the supply prices set by service stations can be described by the following function:

gasoline price = f(well characteristics, competition and concentration, demand factors, control variables),

where demand is captured by population, number of businesses and number of tourists arriving

in the area, since demand is affected not only by the number of inhabitants in the area but also by the amount of traffic passing through.

The study also points out that in higher income, more densely populated areas, higher demand is typically accompanied by stronger competition, as more petrol stations are present in the market due to the supply-demand nexus (Békés, Koren, and Zsohár 2011). The competition effect is therefore greater in these areas and the margins charged by petrol stations are therefore lower, so that an increase in demand leads to an indirect price reduction (Békés, Koren, and Zsohár 2011). However, demand is determined not only by the local population but also by transit traffic as mentioned before. Békés, Koren, and Zsohár (2011) point out that the number of businesses has a negative impact on prices at petrol pumps, while the number of tourists has a positive impact, but the most important pricing factor is the strength of competition, which may lead to differences in local pricing between some businesses within a given area. It is important to note, however, that wells located along motorways set significantly higher prices, which is a result of their local monopoly position. In addition, the proximity of national borders can also raise petrol market prices, especially in Eastern Hungary. The cheaper wells are clustered in the western and central parts of the country (Békés, Koren, and Zsohár 2011) since income also has a positive impact on retail price margins in the fuel market.

Given the influence of geographical factors on gasoline prices (Békés, Koren, and Zsohár 2011), (2017) used spatial econometric models among other methods in his analysis of the fuel market on data from 2006 to 2008. According to his models, retail margins are also determined by the pricing of competitors, i.e. neighbouring wells, unlike in Békés, Koren, and Zsohár (2011). Neighbouring wells in the different model structures were considered to be the 5 nearest filling stations or those located within 1 km. The two different definitions of adjacency did not yield substantially different results. According to Alderighgi and Baudino (2015), the pricing of competing wells only has a significant effect within a 1 km radius.

In the model run at the sub-regional level by Farkas et al. (2009), distance from the Százhalombatta refinery and competitive conditions appear as significant variables in addition to concentration and other control variables. The authors identify a weak negative relationship between retail petrol prices and local market concentration. Each additional competitor in the sub-regions reduces well margins by an average of 0.3 to 1 HUF. They also point out that the prices of large gasoline networks (MOL, Shell, OMV) can be slightly more expensive than the national average, while wells located along the motorway can be up to 3 percent more expensive than the national average. Petrol stations along motorways behave as a distinct geographical market (Farkas, Csorba, and Koltay 2009).

Gautier, Marx, and Vertier (2022) also point out that the fuel market is considered to be rather homogeneous and that the strength of competition has a significant impact on pricing. Retail gasoline prices respond to the average price change of local competitors, but this effect is decreasing over time and significant up to a maximum of 3 weeks period. Henceforth, there is a strong correlation between the cumulative impulse response of petrol prices in France to cost shocks and the main moments of the distribution of price changes(Gautier, Marx, and Vertier 2022). The main results show that prices are sticky and do not change every day, unlike oil prices traded on international stock markets or wholesale gas oil prices, which can cause the operating costs of a station to vary from day to day. It takes about three weeks for gasoline prices to incorporate marginal cost shocks, with the costs being fully passed through to retail prices in the long run (Gautier, Marx, and Vertier 2022; Kim, Davison, and Ødegaard 2015).

The role of competition is a crucial aspect of the fuels market also in the Americas, where consumers are willing to travel extra distances to get cheaper fuel Luco 2019). The further away a cheaper filling station is, the less customers are tempted to choose that alternative, but within 3 kilometres, there is still a significant preference for cheaper stations among vehicle owners Luco 2019.

Although the crisis caused by the Covid-19 pandemic did not increase indeed even reduced fuel prices in the short term (Sansa 2020), the energy prices started to rise rapidly as the post-effect of the coronavirus epidemic, which has been further boosted by the outbreak of the Russian-Ukranian War. In order to control inflation and protect the citizens from rising energy prices, the Hungarian government introduced a price cap (Magyar közlöny 2021) for retail petrol (95 Octane E10) and diesel (gasoil B7) from 15 November 2021, officially limiting the price at the maximum of 480 HUF/l for these two types of fuel products. Since competition is a major determinant of retail fuel pricing, this study investigates wether the competition has intensified between the larges Hungarian retail petrol company (MOL) and its competitives by this government intervention.

The regulation at first affected mainly the highway petrol stations but as the crude oil price started to increase, more and more well had to cut back its prices and operate at a loss. However, at the end of 2021 there was a temporary period when the world market oil price dropped and most wells could again set their own retail margins. From mid January 2022 almost every station in Hungary offer gasoline and diesel for 480 HUF/l corresponding to the price cap, at least those who could survive and were not forced to close their station due to the unprofitable operation.

2. Methodology

Usually the vector autoregressive (VAR) models are applied when carrying out multivariate time-series analysis, but if two time series are cointegrated, the VAR structure will not be suitable for performing the analysis (Lütkepohl 2005). Cointegration is a strong, long term relationship between two unit root time-series which have a linear combination that results in a stationary process. Similarly to the principal component analysis, linear combinations are created from the eigenvectors which become stationary. In this case, an error correction must be introduced to describe the concurrent relations because changes within one period also have significant effects unlike in VAR, where there are only lagged explanatory variables. To decide wether cointegration is present in the time-series, generally the Johansen trace or maximum eigenvalue test (see: Dwyer 2015) is used but in bivariate case the Engle-Granger test can be also applied. This structure is called the vector error correction model (VECM) which is presented through the notation of Lütkepohl (2005).

The basic formula for a VECM which does not contain deterministic parts and lagged differences is the following:

$$\Delta y_t = \Pi y_{t-1} + u_t = \alpha\beta' y_{t-1} + u_t, \qquad t = 1, 2, ..., T,$$

where y_t is a vector of K dimensions (K equals the number of time series), Π is a matrix of $0 < rank < K$ α and β are $K \times r$ matrices and u_t represents a K-dimensional white noise process with zero mean and time independent variance. By introducing lags the general formula takes the form of

$$\Delta y_t = \Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + ... + \Gamma_{p-1} \Delta y_{t-p+1} + u_t, \qquad t = 1, 2, ..., T,$$

in which y_t represents a first order integrated process of K dimensions, $0 < \text{rank}(\Pi) = r < K$, therefore $\Pi = \alpha\beta'$, where α and β matrices of $(K \times r)$ size with the same r rank, Γ_j $(j = 1,2,...,p-1)$ are $(K \times K)$ matrices of parameters and the standard white noise process is represented by u_t.

The VECM models can be estimated by the usual ordinary least squares (OLS), the generalised least squares (GLS) or the maximum likelihood (ML) methods (Lütkepohl 2005). In this paper the OLS estimator is used since it can be easily inerpreted and there is no need for more advanced methodology as the provided results are appropriate. Using VECM, we are able to observe the immediate reactions of wells to deviations in the pricing of their competitors.

3. Database

The database used for the analysis consists of individual characteristics and prices of wells taken from the *holtankoljak.hu* website, which collects data regularly from almost every Hungarian petrol station and international fuel prices as well. This is an independent, comprehensive fuel price comparison site, where searching for wells is publicly accessible too. Not only their database is available, but they also provide a number of calculations and analysis on the situation of the Hungarian petrol market and make forecasts about possible prospects, as well as gathering news on fuels. Obviously, not all wells report information every day about their fuel prices to this website, but daily price changes are also not very common for retail petrol and diesel.

We collected data from the mentioned website for a total of 1334 available wells between 9 August 2021 and 8 March 2022 almost every day. The observed period when data was collected can be seen on Figure 1 together with the average prices by fuel the two most popular fuel types. For exact days of data collection see Appendix 1.

Eventually a large panel dataset was created. Since the address of each station is also public various distance based variables could be calculated such as distance from a highway exit and the number of competitors within 0.5, 2 and 5 kilometres. Moreover, we collected data about the market price of Ural crude oil – which is denominated in US dollar – from *investing.com*, since most of the crude oil imported to Hungary comes from Russia. Not only the crude oil price affects the retail gasoline prices in Hungary but the exchange rate of USD/HUF as well. Whereas the Hungarian currency can be quite volatile in recent days, we converted the oil price to HUF using the official daily exchange rates of the Hungarian National Bank. The changes in the price of crude oil and the exchange rate is presented on Figure 2 from January 2021.

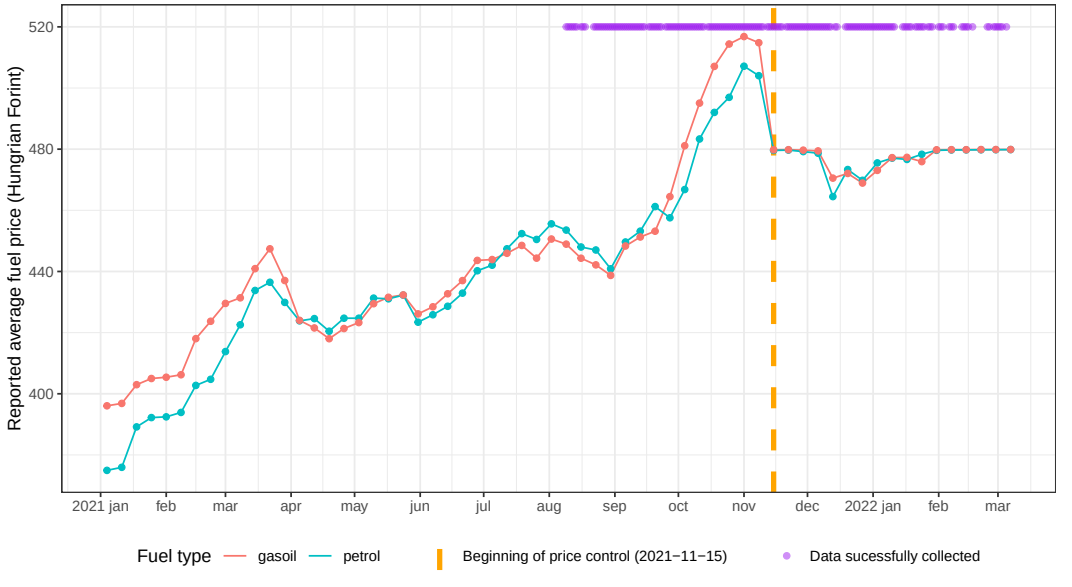


Figure 1. Average prices of diesel and petrol type fuels and the beginning of price control

Source: Hungarian Energy and Public Utility Regulatory Authority (MEKH)

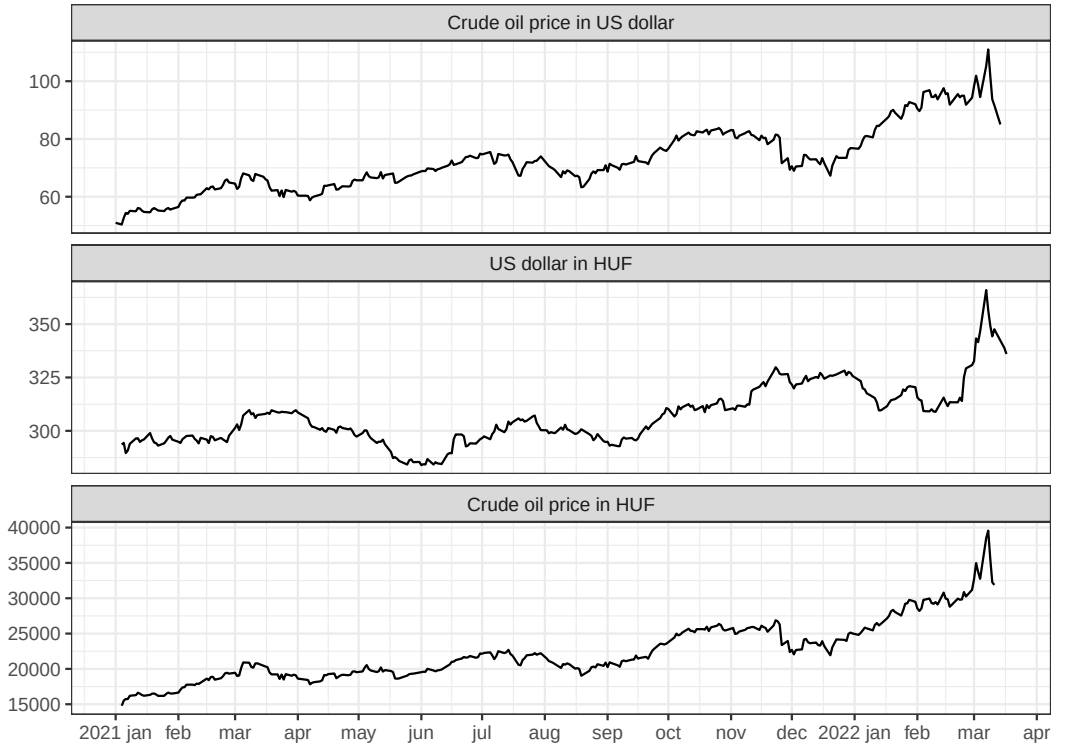


Figure 2. Crude Oil urals europe CFR Spot price and the exchange rate of US dollar

Source: Hungarian National Bank, investing.com

4. Empirical results

In this study, we ran error correction models (VECM) for four different periods in three specification. The first period is the pre-regulation phase before 15 November 2021, the second is 30 days after the introduction of price cap, the third is the period when both the crude oil price and the USD/HUF exchange rate have fallen, and the fourth is the period after 15 January 2022 when energy prices started to rise rapidly. As there is a very close correlation between petrol and diesel prices, only model results run at petrol prices are presented.

MOL is considered to be the market leader due to its dominant position in the Hungarian fuel market, and all other networks' petrol stations were considered as its competitors, together with the white wells within 2 kilometres distance. We wanted to see how the introduction of the price cap changed their market positions. To investigate this, we regressed the price of MOL wells by the average price of its competitives for the different time periods, and vice versa, and used the error term extracted and the differences in the average prices of the two MOL and non-MOL wells in the model to decide wether really MOL stations lead the market or they only follow others. The results of the four models are shown in Figure 3. For more details see Appendix 2.

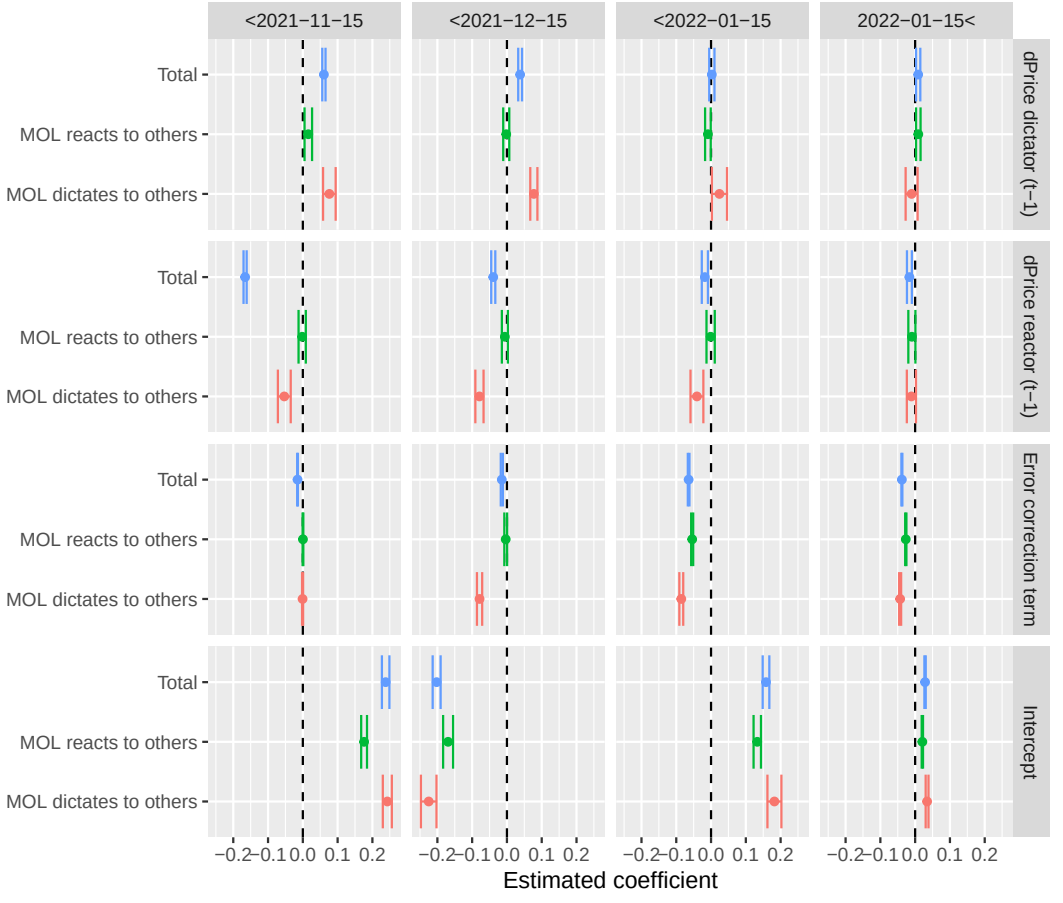


Figure 3. Result of VECM models for MOL and non-MOL petrol stations

Source: self calculation based on holtankoljak.hu data

In the first model specification, we do not distinguish between brands of wells, but only consider

stations belonging to different chains as competitors. The second model is when the MOL stations react to the pricing of their competitives and in the third specification the MOL dictates and the other stations are the followers.

The main aspect of this model structure is the error correction term for the various models in the different phases. The result shows, that before the introtuction of price control the MOL stations were not willing to change their prices rapidly when a competitor sets new retail prices, but in the two models where MOL can dictate pricing strategy competitors adjust and work off about 1.5 percent of the shift within a period regarding the whole market.

In the second period, directly after the regulation was introduced MOL's position as market leader strengthened. As it changed prices other stations corrected their pricing by almost 15 percent of its change. And in the third period, by which most wells had adapted to the new economic environment, MOL had lost some of its leadership due to increased competition created by lower margins and had started to adapt to the pricing strategy of its competitor wells. However, MOL's deviation still implied a larger correction. By the last phase the distance between the reaction of MOL stations to competitors' price changes and the price correction of non-MOL wells to the market leader's pricing deviation further reduced.

5. Conclusion

The Hungarian fuel market is characterized by large-scale vertical integration. The MOL company is the most important wholesale trader of petrol and diesel and the largest retail fuel chain also belongs to this firm by more than 1/3 of all stations. The company's leading position is almost unquestionable. Although the introduction of the price cap on 15th November 2021 has changed the previous conditions of competition, MOL could adapt to the new environment the most rapidly thus further strengthening its leader position on the market. MOL has become ten times more influential on the pricing of other wells directly after the regulation than it was before. As almost every station accepted the new market situation by mid December 2021 the positions have started to recover to the pre-price control levels. The competition did not intensify by the regulation of fuel prices but the largest Hungarian oil company strengthened its position and its competitives started to follow its pricing strategy in this period of uncertainty.

References

Alderighi, Marco, and Marco Baudino. 2015. The pricing behavior of italian gas stations: some evidence from the cuneo retail fuel market. *Energy Economics* 50:33–46.

Békés, Gábor, Miklós Koren, and Péter Zsohár. 2011. Benzinárak földrajzi meghatározása, no. MT-DP-2011/30.

Borenstein, Severin, A Colin Cameron, and Richard Gilbert. 1997. Do gasoline prices respond asymmetrically to crude oil price changes? *The Quarterly journal of economics* 112 (1): 305–339.

Bragoudakis, Zacharias, and Dimitrios Sideris. 2012. Do retail gasoline prices adjust symmetrically to crude oil price changes? the case of the greek oil market. *Economic Bulletin,* no. 37.

Csorba, Gergely, Gábor Koltay, and Dávid Farkas. 2011. *Separating the ex post effects of mergers: an analysis of structural changes on the hungarian retail gasoline market.* Technical report. IEHAS Discussion Papers.

Dwyer, Gerald P. 2015. The johansen tests for cointegration. *White Paper,* 1–7.

Farkas, Dávid, Gergely Csorba, and Gábor Koltay. 2009. Árak és koncentráció a magyar kiskereskedelmi üzemanyagpiacon. *Kozgazdasagi Szemle/Economic Review* 56.

Farkas, Richárd. 2017. Empirikus reakciógörbe-becslés a magyar kiskereskedelmi benzinpiacon. *Közgazdasági Szemle* 64 (3): 267–284.

Farkas, Richárd, and Gábor Czigány. 2017. Az autópályák indirekt hatása a kiskereskedelmi benzinárakra. *Statisztikai Szemle* 95 (3): 278–296.

Farkas, Richárd, and Biliana Yontcheva. 2019. Price transmission in the presence of a vertically integrated dominant firm: evidence from the gasoline market. *Energy policy* 126:223–237.

Gautier, Erwan, Magali Marx, and Paul Vertier. 2022. How do gasoline prices respond to a cost shock?

Hosken, Daniel S, Robert S McMillan, and Christopher T Taylor. 2008. Retail gasoline pricing: what do we know? *International Journal of Industrial Organization* 26 (6): 1425–1436.

Hungarian Central Statistical Office. 2021. *Közúti gépjármű-állomány, december 31. (2000–).* https://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_ode006c.html.

Kim, Daero, Matt Davison, and Fredrik Ødegaard. 2015. Do retailers set optimal prices in the case of the retail gasoline market? *International Journal of Revenue Management* 8 (3-4): 241–259.

Leung, Abraham, Matthew Burke, Jianqiang Cui, and Anthony Perl. 2019. Fuel price changes and their impacts on urban transport–a literature review using bibliometric and content analysis techniques, 1972–2017. *Transport Reviews* 39 (4): 463–484.

Luco, Fernando. 2019. Who benefits from information disclosure? the case of retail gasoline. *American Economic Journal: Microeconomics* 11 (2): 277–305.

Lütkepohl, Helmut. 2005. *New introduction to multiple time series analysis.* Springer Science & Business Media.

Magyar közlöny. 2021. *Az üzemanyagok hatósági áras forgalmazására vonatkozó részletes szabályokról,* November.

Noel, Michael D. 2007. Edgeworth price cycles, cost-based pricing, and sticky pricing in retail gasoline markets. *The Review of Economics and Statistics* 89 (2): 324–334.

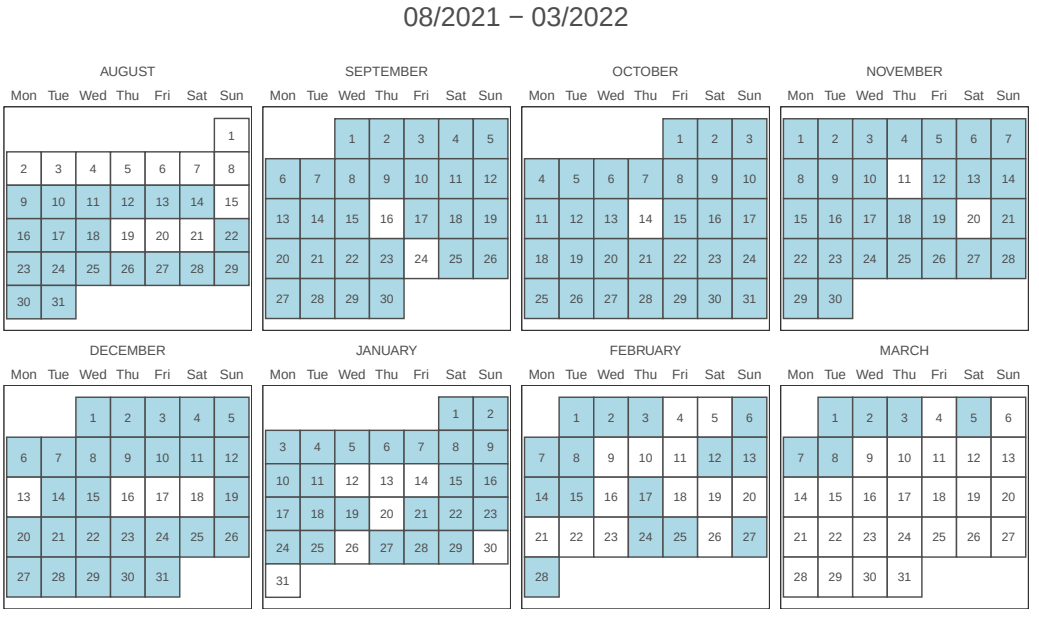
Sansa, Nuhu A. 2020. Analysis for the impact of the covid-19 to the petrol price in china. *Available at SSRN 3547413.*

Sugár, András. 2011. A benzin és a gázolaj magyarországi árszintjének és árazásának empirikus elemzése. *Statisztikai Szemle* 89 (6): 624–643.

Szomolányi, Karol, Martin Lukáčik, and Adriana Lukáčiková. 2019. Analysis of asymmetry in slovak gasoline and diesel retail market. *Entrenova-Enterprise Research Innovation* 5 (1): 306–313.

Van Meerbeeck, Wim. 2003. Competition and local market conditions on the belgian retail gasoline market. *De Economist* 151 (4): 369–388.

Appendix 1. Download dates



Starting in mid-August 2021, We were able to run the data download code on a personal server, so the daily download became more regular from then on.

Appendix 2. Estimated coefficients

Table 2. Estimated coefficients in the three VECM model containing the total observations.

time	term	estimate	std.error	statistic	p.value
<2021-11-15	dPrice dictator (t-1)	0.0605867	0.0023920	25.3293596	0.0%
<2021-12-15	dPrice dictator (t-1)	0.0379469	0.0028096	13.5061771	0.0%
<2022-01-15	dPrice dictator (t-1)	0.0022895	0.0038513	0.5944893	55.2%
2022-01-15<	dPrice dictator (t-1)	0.0087205	0.0031159	2.7987370	0.5%
<2021-11-15	dPrice reactor (t-1)	-0.1659627	0.0023064	-71.9573098	0.0%
<2021-12-15	dPrice reactor (t-1)	-0.0393070	0.0029845	-13.1703389	0.0%
<2022-01-15	dPrice reactor (t-1)	-0.0177660	0.0044980	-3.9497674	0.0%
2022-01-15<	dPrice reactor (t-1)	-0.0164929	0.0035970	-4.5851135	0.0%
<2021-11-15	Error correction term	-0.0152082	0.0005344	-28.4571236	0.0%
<2021-12-15	Error correction term	-0.0147407	0.0015302	-9.6331133	0.0%
<2022-01-15	Error correction term	-0.0644274	0.0012154	-53.0113209	0.0%
2022-01-15<	Error correction term	-0.0381686	0.0007151	-53.3744689	0.0%
<2021-11-15	Intercept	0.2381625	0.0055128	43.2021060	0.0%
<2021-12-15	Intercept	-0.2021029	0.0058466	-34.5673846	0.0%
<2022-01-15	Intercept	0.1580538	0.0048700	32.4543680	0.0%
2022-01-15<	Intercept	0.0284993	0.0009742	29.2541590	0.0%

Table 3. Estimated coefficients in the three VECM model when MOL reacts to other stations.

term	time	estimate	std.error	statistic	p.value
dPrice dictator (t-1)	<2021-11-15	0.0157560	0.0055155	2.8567007	0.4%
dPrice dictator (t-1)	<2021-12-15	-0.0019467	0.0044503	-0.4374339	66.2%
dPrice dictator (t-1)	<2022-01-15	-0.0089889	0.0041392	-2.1716652	3.0%
dPrice dictator (t-1)	2022-01-15<	0.0090972	0.0032933	2.7623317	0.6%
dPrice reactor (t-1)	<2021-11-15	-0.0018505	0.0053349	-0.3468586	72.9%
dPrice reactor (t-1)	<2021-12-15	-0.0059701	0.0044150	-1.3522170	17.6%
dPrice reactor (t-1)	<2022-01-15	-0.0011703	0.0060719	-0.1927341	84.7%
dPrice reactor (t-1)	2022-01-15<	-0.0094137	0.0051781	-1.8179734	6.9%
Error correction term	<2021-11-15	0.0003506	0.0005263	0.6661611	50.5%
Error correction term	<2021-12-15	-0.0035143	0.0020339	-1.7278712	8.4%
Error correction term	<2022-01-15	-0.0542035	0.0014819	-36.5776288	0.0%
Error correction term	2022-01-15<	-0.0269056	0.0009003	-29.8840661	0.0%
Intercept	<2021-11-15	0.1761418	0.0042773	41.1808052	0.0%
Intercept	<2021-12-15	-0.1691693	0.0073148	-23.1269269	0.0%
Intercept	<2022-01-15	0.1329109	0.0054389	24.4372542	0.0%
Intercept	2022-01-15<	0.0207019	0.0009812	21.0978354	0.0%

Table 4. Estimated coefficients in the three VECM model when other stations react to MOL.

term	time	estimate	std.error	statistic	p.value
dPrice dictator (t-1)	<2021-11-15	0.0605867	0.0023920	25.3293596	0.0%
dPrice dictator (t-1)	<2021-12-15	0.0379469	0.0028096	13.5061771	0.0%
dPrice dictator (t-1)	<2022-01-15	0.0022895	0.0038513	0.5944893	55.2%
dPrice dictator (t-1)	2022-01-15<	0.0087205	0.0031159	2.7987370	0.5%
dPrice reactor (t-1)	<2021-11-15	-0.1659627	0.0023064	-71.9573098	0.0%
dPrice reactor (t-1)	<2021-12-15	-0.0393070	0.0029845	-13.1703389	0.0%
dPrice reactor (t-1)	<2022-01-15	-0.0177660	0.0044980	-3.9497674	0.0%
dPrice reactor (t-1)	2022-01-15<	-0.0164929	0.0035970	-4.5851135	0.0%
Error correction term	<2021-11-15	-0.0152082	0.0005344	-28.4571236	0.0%
Error correction term	<2021-12-15	-0.0147407	0.0015302	-9.6331133	0.0%
Error correction term	<2022-01-15	-0.0644274	0.0012154	-53.0113209	0.0%
Error correction term	2022-01-15<	-0.0381686	0.0007151	-53.3744689	0.0%
Intercept	<2021-11-15	0.2381625	0.0055128	43.2021060	0.0%
Intercept	<2021-12-15	-0.2021029	0.0058466	-34.5673846	0.0%
Intercept	<2022-01-15	0.1580538	0.0048700	32.4543680	0.0%
Intercept	2022-01-15<	0.0284993	0.0009742	29.2541590	0.0%