# ASYMMETRIC PASS-THROUGH OF OIL PRICES IN UKRAINIAN WHOLESALE AND RETAIL MARKET

by

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# LIST OF ABBREVIATIONS

**A-80** Gasoline octane 80

**A-92** Gasoline octane 92

**A-95** Gasoline octane 95

**A-98** Gasoline octane 98

**ADF** Augmented Dickey-Fuller

**ADJ** Adjustment coefficient

**AIC** Akaike Information Criterion

**AMCU** Antimonopoly Committee of Ukraine

**ARDL** Autoregressive distributed lags model

**Brent** Brent Crude Oil index

**ECT** Error Correction Term

**ECM** Error Correction Model

**FRED** Federal Reserve Bank of St. Louis

**JODI** Joint Oil Data

**ICP** Information Criterion Procedure

**LM** Lagrange multiplier test

**LPG** Liquefied petroleum gas

**NARDL** Non-linear autoregressive distributed lags model

**OLS** Ordinary least squares regression

**POS** Retail petroleum point of sales

**RP** Retail prices

**UAH** Ukrainian Hryvna

**USD** United States dollar

**VAR** Vector autoregressive model

**WP** Wholesale prices

**WTI** West Texas Intermediate index

# CHAPTER 1. INTRODUCTION

Crude oil price has become an established benchmark unit not only for its derivative products such as gasoline, diesel, and other types of petrochemical products but also for setting commodity prices. Oil price changes can result in global economy shockwaves overall. Transmission of crude oil prices to other commodity prices, petrol prices, particularly, is a subject of a number of market efficiency studies. The difference in response to an oil price increase or decrease by market chain participants is referred to asymmetry, which can be measured by both magnitude and speed and their combination. Price transmission asymmetry could indicate market structure non-competitiveness and the market power of producers or distributors; thus, it can be a signal to political intervention to protect consumers from losses. Opening the market to new companies, investigating potential mergers to reduce market concentration can increase competition.

Generally, the linkage between the world oil index and petroleum product prices has been investigated in many studies. Although there is a controversial discussion about factors that influence the market players' behavior, the number of studies proves asymmetry using econometric modeling. It states that it reflects the players' market power, both wholesalers or retailers.

In this study, the pass-through of world oil prices to gasoline prices in Ukraine is investigated for the period 2017 - 2020, which captures upward and downward movements, allowing to investigate the market players' behavior in both cases. The analysis adds to an open-ended discussion of the petrol market prices' symmetric and asymmetric movement in different countries. According to Frey and Manera (2005), asymmetric behavior is very likely to occur in a wide range of markets, and 33 out of 69 studies from the scope of their analysis investigate the crude oil-petroleum relationship, highlighting the importance of this market. Although there are studies of the U.K., Italian, Spanish, Japanese markets, and some developing countries, the most frequent ones are for the U.S. market. As for Ukraine, there is a study by Gienko (2009) who proves asymmetric price patterns for the petrol market in Ukraine in the short run, but market participants do not cover the research. Therefore, I assume no statistically measured explanation of the stage where this asymmetry arises in the Ukrainian gasoline market.

There is a high level of interest in price fluctuation by all participants of the Ukrainian market. Firstly, end-users, as gasoline is a necessary commodity, secondly, intermediate agents, which have to hedge risks on the relatively uncertain market with the scope of affecting factors and retailers, and finally, authorities, which regulates the market to establish sufficient transparency. Moreover, a recent drop in the world crude oil prices invigorates the interest in this topic as even from the customer point of view, and there was no expected reflection by retailers.

Analysis of the latest event on the petroleum market shows several cases during the last five years when the Antimonopoly Committee of Ukraine [1] (AMCU) opened a discussion with market players and gave prescription as for retail price level. More importantly that these recommendations were accepted by participants later. According to AMCU [2], in 2017, players like WOG, OKKO, and Socar (which together constitute 880 POS 15% of the branded market) increase prices for A-95 by 5% 2 weeks, which was far above the average level on the market. They also highlight the simultaneous increase pattern during September 2017, which may indicate the presence of market participants' anti-competitive collusive actions. At the end of 2019, the regulator[3] gave a prescription to participants namely WOG, OKKO, Ukrnafta, AMIC, Shell, Socar, UPG, and Glusco to lower prices in line with the wholesale market, which showed a steady downward pattern. Moreover, it is stated that three majors (WOG, OKKO, Ukrnafta) kept their prices on the

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1 www.amcu.gov.ua

2 https://amcu.gov.ua/news/amku-doslidzhue-situatsiyu-na-rinkakh-benziniv-ta-dizelnogo-paliva

3 https://amcu.gov.ua/news/cini-na-benzin-rekomendaciyi-amku-reakciya-rinku-j-podalshi-kroki

same level, and other retailers lowered only by 5.0 - 5.6%, while the wholesale market went down by 20%. There is a conclusion that, based on hryvnia strengthening, the retailer market overall did not mirror the price change, which showed wholesalers.

Nevertheless, the opinion by the general public of an asymmetric relationship between gasoline and crude oil prices as evidence of a monopolistic retail market should be taken with precautions. There is a relatively long chain between crude oil and the end-users: transportation – processing - transportation - gas station, which is also influenced by tax related to the euro exchange rate if import and currency volatility on the market. Thus, the range of factors that can affect the price should be accounted.

Considering vertical relationship, the latest case[4] acquisition of the company which controls the Kherson oil-transmission complex by a retailer, namely OKKO (one of the market leaders which constitute 405 petroleum stations) can be an example of possible market power on the gasoline market of storage and wholesale trade. Such integration can create barriers for entering the market by others participants and restrict the competition.

Also, high dependence from the import made players sensitive to any shortage on the intermediate market (in accordance to AMCU[5] 80% from the total petroleum products comes from the Belarusian and the Russia federation); thus, the resource balance is directly related to the stability in these countries. Since June 2019, the import from the Russia federation is only possible with the Ministry of economic development [6] permission. This decision enlarged the Ukrainian market dependence from the Belorussia source. Additionally, announce a possible shortage of import from Belarus since August 2020 is a

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4 https://amcu.gov.ua/news/amku-pochav-rozglyad-spravi-pro-koncentraciyu-mizh-grupoyu-okko-ta-tov-nafta-transshipment

5 https://amcu.gov.ua/news/amku-zasterigae-uchasnikiv-rinku-naftoproduktiv

6 http://oilers.org.ua/wp-content/uploads/2019/04/460-25.pdf

case that can find the reflection in the form of artificial fuel shortage and unjustified fuel price increases.

These examples are forces of possible collusion behavior on different levels of the market chain. Therefore, the understanding reaction of retail prices to oil price fluctuations by levels is crucial for all market participants to manage risks. This research aims to fill the gap by studying relationships by levels and comparing responses to positive and negative shocks between price-formation participants.

The debates about the most popular framework to investigate asymmetry are still opened. An extended review made by Frey and Manera (2005) revealed the high popularity of ARDL modeling (21 out of 69 papers) with a low percentage of no rejection of asymmetry. In our research, we apply an autoregressive distributed lag approach proposed by Pesaran (2001) and a non-linear autoregressive distributed lag model (NARDL), proposed by Shin (2014). Generally, the ARDL model base on the idea that some or all explanatory variables may have a linear impact, and if not, we apply non-linear ARDL, which copes with this problem. With the first one, we check long- and short-run symmetry and examine the impact at different periods while the second allows testing short- and long-run nonlinearities decomposed into both positive and negative partial sum. Applying both models can investigate the relationship between economic variables without knowing whether our variables are integrated of order zero or one (Pesaran and Shin, 2001).

To structure the research, in Chapter 2, an industry overview is focused on distribution chain price-makers starting from the refinery and importers, wholesalers, and retailers, including price relationships. Following Gilbert and Hastings (2001), we look at factors that affect the petroleum market price setting. That is a cost (crude oil and export price), seasonality and taxes, mergers, changes in gasoline stations' density, and vertical relationship, which affect market power.

Chapter 2 also presents the relevant literature review with key takeaways important for our studies to answers to the questions regarding a sufficient period of time, time-series frequency, models, testing procedures.

Chapter 3 describes the methodology, analysis procedure, provides details about the variables that are used in modeling.

To specify analysis, three types of data are collected and are described in Chapter 4: oil prices, wholesale prices, retail prices as representative of three level through which price transmission occurs (world market, primary distributor, and retailers). For the estimation reason Brent crude index (daily closing prices), and wholesale and retail prices (average unit value) for the period 2017:01 – 2020:04 are collected and transformed into weekly ones.

The results quantifying the degree at which world oil prices, as an external factor, are passed through the players of the market chain are described in Chapter 5. Based on this analysis the competitiveness of the Ukrainian gasoline market is assessed and recommendations are provided in Chapter 6.

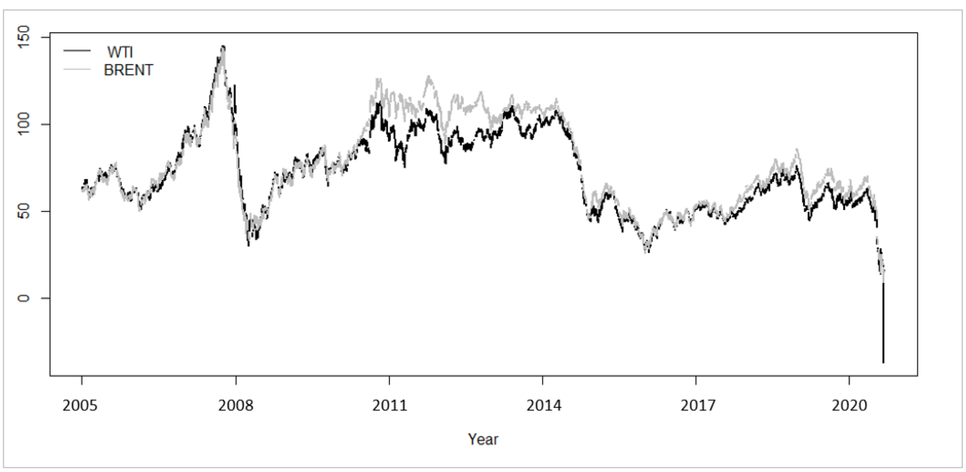
To foreshadow findings, market analysis shows that despite the absence of formal signs of collusion, several vertically and horizontally integrated players can dictate the price setting. The retail distribution analysis shows a low point of sales concentration in some areas or dominance of some brands; thus, market power can also be driven locally. Our estimation suggests that wholesalers pass-through oil change relatively full, with some sign of risk managing in both cases (decrease and increase). In the case of retailers respond to a wholesale price change, the evidence of the long-run asymmetry detected in favor of the positive change. In the short-run, there is no statistically significant response when a downward trend, but there is a cumulative contemporaneous effect when upward. It can be said that retailers pass-through wholesale price change partially, which affects consumers who especially do not benefit when a downward trend.

## CHAPTER 2. INDUSTRY OVERVIEW AND RELATED STUDIES

The chapter reviews relevant literature, but first, we look at the Ukrainian petroleum market features to proceed further to the theoretical underpinning of the pass-through mechanism as the central theme of this study.

To evaluate the gasoline market, we define the research market as the oil and gasoline supply chain, including its participants, and the traded products. As this research aims to capture time-varying relationships between world oil market prices and the gasoline market in Ukraine, we use the oil price futures indices: Brent (Brent Crude Oil), and WTI (West Texas Intermediate) indices. The WTI-Brent spread varies over time as the supply or demand of crude indices changes (Figure 1). In 2019 the average price of crude oil stood at USD 71.3 per barrel, while 2020 saw an unprecedented drop in April by both indices with by far the biggest ever gap between them. The reason is that the demand decreased in most countries because of the COVID-19 lockdown and the further reduction of global economic activity, consequently made oil prices hit the plateau.

Figure 1. WTI and Brent Crude oil spot prices volatility (USD/barrel), 2005:01 - 2010:04.

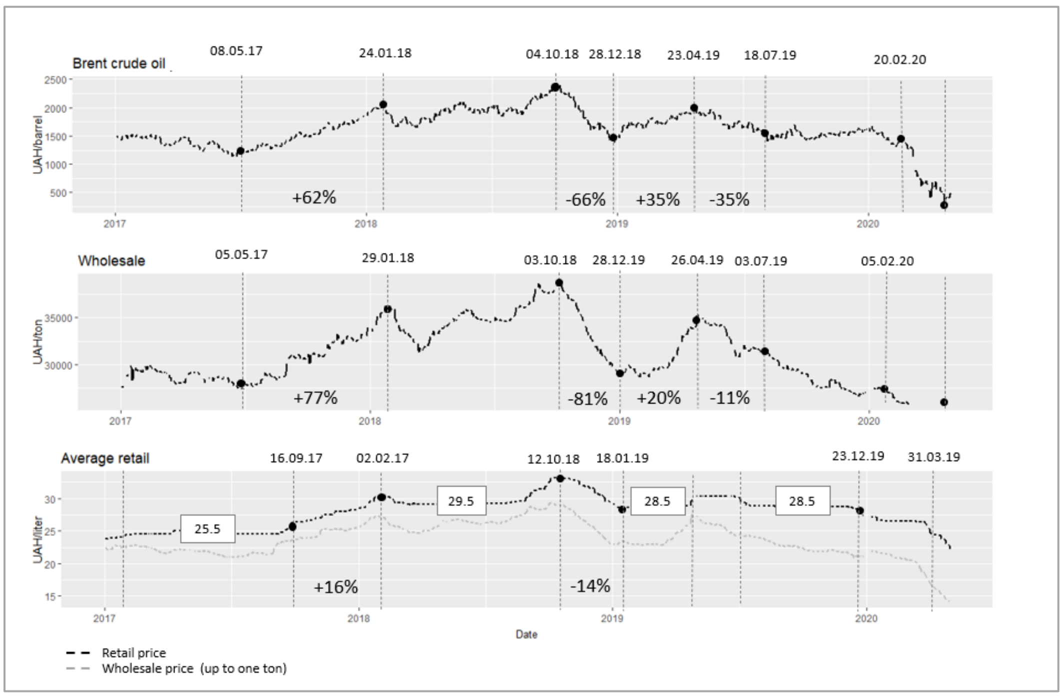



*Source*: Federal Reserve Bank of St. Louis [7]data.

[7] https://fred.stlouisfed.org/

Next, we inspect the dynamic of oil price in relationship with the Ukrainian local petroleum market prices at wholesale and retail level over the period 2017-2020, when oil price exhibited both the upward and downward trend (Figure 2). The prices are defined as follows: world crude oil market (crude oil prices), wholesale market (quotation up to one ton and over one ton), and the retail market (retail petroleum price).

Figure 2. Daily average closing price for Brent crude oil price index (UAH/barrel), petroleum wholesale prices (UAH/tons), and petroleum retail prices (UAH/ltr), 2017:01 2020:03.




*Source*: authors' calculations based on data sources: Federal Reserve Bank of St. Louis [8] for Brend crude oil, Consulting agency Nefterynok[9] for wholesale prices, Consulting agency A-95[10] for retail prices.

*Note:* Brend crude oil – daily closing price for Brent crude oil; wholesale prices – average market daily price for petroleum product type A-95; retail price - average daily market price for petroleum product type A-95.

[8] https://fred.stlouisfed.org/

[9] http://www.nefterynok.info/

[10] https://index.minfin.com.ua/markets/fuel/

As can be seen from the graph, wholesale prices move more in line with Brent crude prices with a minor time gap for adjustment. Considering the retail prices, one can notice that retailers seem to keep prices within certain boundaries regardless of the oil price movements (both upward or downward) differently from the wholesale market. The visual analysis also allows identifying four periods in the oil price dynamic. The first one is June-December 2017, when the oil price rose steadily (+62% over the period), which was over-passed through wholesale prices (+77%), while retailers reacted with a four-month gap making positive price adjustment by 16%. The second period concerns 2018, specifically the last four months of 2018 when the oil price moved down sharply by 66%. As observed in the middle graph, the Ukraine distributors quickly reacted to the drop in the oil market price and adjusted wholesale prices by 81% during the last months of 2018. The retailers with a one-week lag reduced the prices slightly, allowing the retail price to go down by 14% by the end of the year. The third and fourth periods concern 2019, when oil price increased and fell again within the year (+35% and -35%), in contrast to the wholesale market that moves asymmetrically, with price increase by 20%, and decrease by 11%. The retail market kept prices nearly at the same level (within the range of 28-31 UAH per/ltr) throughout 2019. Revealed "stability" is in line with AMCU findings[11] that several major players, the biggest are WOG[12], OKKO[13], and Ukrnafta[14], kept their prices at the same level, when other retailers lowered their prices on average by 5.0 - 5.6%, while at the same period the wholesale market went down by 20%.

To extract exchange rate volatility, we compare retail prices in local currency and being converted in USD. Figure A.1. shows that the retail price level is sensitive to the exchange rate dynamic. Considering that import goods are related to the currency exchange

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11 https://amcu.gov.ua/news/rekomendaciyi-amku-uchasnikam-rinku-torgivli-benzinom-ta-dizpalivom-shchodo-vstanovlennya-cin

12 https://wog.ua

13 https://www.okko.ua/galnaftogas

14 https://azs.ukrnafta.com/?

rate, we look at the imported goods in detail. To answer the question how deep the market depends on import, we analyses the first level of the market chain in Ukraine where price is potentially formed. We access local oil extraction and refining in parallel with the dynamic of imported oil and oil derivative products.

Generally, oil comes from the internal market and imports. In 2008 there were six national wide refineries in Ukraine that processed oil and produced its derivatives. By now, only Kremenchuk[15] and Shebelynsky oil refineries are active on the market and share nearly 20% of the supply (Appendix, Figure A.2). The local production shortage is covered by imported petroleum goods (Appendix, Figure A.3). Kremenchuk refinery has the greatest capacity with nearly half of the local supply. Since 2007 it is in partial ownership by the same group as the several retail networks (totally account for more than 1000 points of sales). Such a vertical relationship between gasoline refiners and distributors can be associated with price manipulation, according to Gilbert and Hastings (2001).

Additionally, it is revealed that product shortage, broadly represented by Belorussian products (Mozyr oil refinery[16]), finds reflection on the local market. May 2018 was a good example when the refinery was close to planning repairing activities. Despite the announcement that all contracts will be covered, the local market (wholesalers and retailers) have a nearly immediate reflection, and the market saw an increase.

Rising dependence from import (Figure A.3), excise tax linked to the euro, made currency exchange rate stability a critical factor on the intermediate agents' level. Prices for oil being extracted on the local market technically are also linked to the oil index; therefore, any fluctuation in the exchange rate influences the domestic price on producers' level.

The price being formed by wholesalers is pass-through to the retailers where the estimated margin is 7-16%, depending on the product type and fuel source (Appendix,

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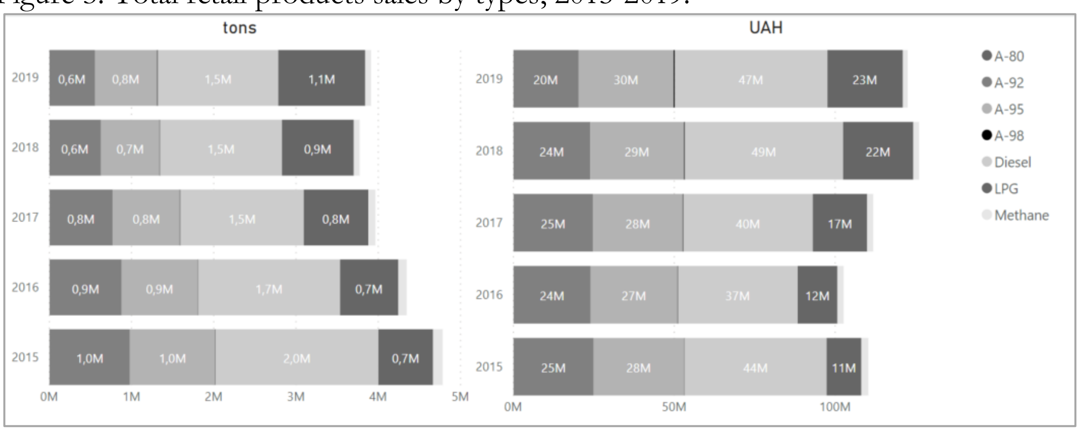
15 http://www.ukrtatnafta.com/

16 https://www.mnpz.by/

Figure A.10). Notably, the average value is the lowest for gasoline type A-92, and the margin for Diesel fluctuates differently than the margin for gasoline products. Several players (most commonly market leaders) import petroleum products for their retail network to gain price advantages.

To observe the retail market in details, as a first step, we evaluate it through petroleum products' sales. Figure 3 shows that 2019 was a year when the downward trend was broken as for the amount of fuel being sold mostly by the increasing popularity of liquefied petroleum gas products (LPG) and decreasing sales for gasoline type A-92 (as a lower quality then A-95). Although the shares of A-80 and A-98 fuel products are negligible, with respect to the product range, it is essential to mention that the sales of the A-80 nearly stopped in 2019 and in contrast to A-98, whose sales increased four times.

Figure 3. Total retail products sales by types, 2015-2019.



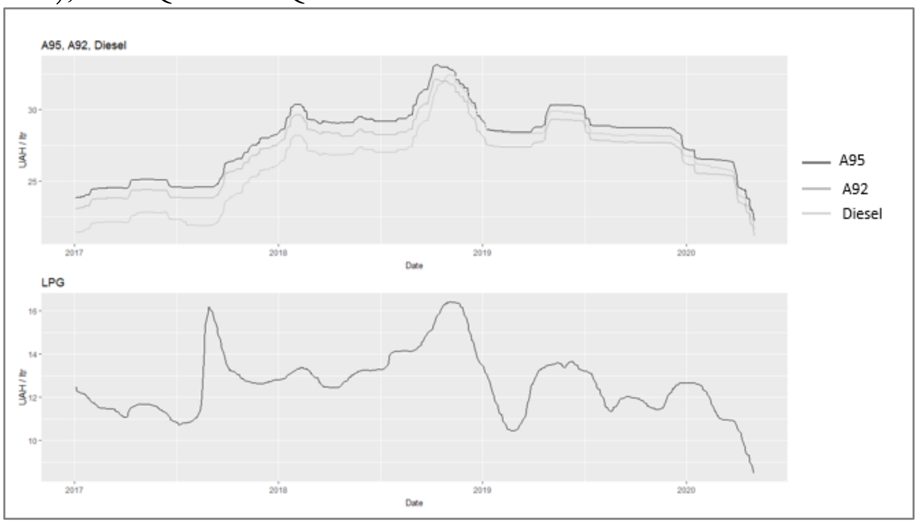

*Source*: authors' calculations based on data source of State Statistics Service of Ukraine[17].

The figure above suggests a gradual shift in customer preferences to consume quality products. Besides, Figure 4 shows a narrowing price gap between A-92 and A-95

17 http://www.ukrstat.gov.ua/

and lowering LPG price in the period 2019-2020, which also fueled customer preferences for LPG and A-95.

Figure 4. Retail price dynamic for the A-95, A-92, Diesel, and LPG products (UAH/liter), 2015:Q1 - 2020:Q1.




*Source*: authors' calculations based on data web source of Consulting agency A-95[18].

Seasonal factor analysis shows that, on average, summer has a lower price. (Figure A.4). Association analysis using Goodman and Kruskal tau measure (L. Goodman, Kruskal, W. H., 1963) shows that the price level is highly explained by the seasonal factor (0.84).

The second step of the retail market analysis is to evaluate the retail petroleum point of sales (further - POS) concentration. Based on Chouinard and Perloff's paper, it is inferred that retailers can exercise more market power, the fewer the point of sales per square mile. [Chouinard and Perloff, 2002].

[18] https://index.minfin.com.ua/markets/fuel/

In accordance with the State Statistics Service of Ukraine, as of March 2020, their total number was 7064 (includes all types of petrol and LPG, branded and unbranded POS). To get a better picture, it is collected raw data for the companies, who propose petroleum products in the retail market, and their POS location using their official websites. Companies with at least ten POS, have defined brand name, and propose more than one petroleum product type are included in the analysis. As a result, the dataset includes 38 unique brand names and the location of 4087 points of sales.

The difference between the official number and collected primary data can be explained by the next. It is found out there are approximately 700-800 unbranded LPG points of sales (most of them mono-product POS) and some local gasoline networks do not have open-source information about their location (most commonly, the number of POS is relatively small). Needless to add, that there are groups of so-called "illegal" gasoline stations, and their estimated number is close 1000-1500 points according to the different sources of information. This group is not taken into account. Because the paper focuses on petroleum products only, we exclude LPG of different types from the analysis and rely further on the collected data rather than official statistics, assuming that it makes roughly 64% of the total fuel market. This market can be named as a branded retail petroleum market.

As for retailer distribution, visual inspection shows Dnipropetrovsk, Kharkiv, and Lviv oblast are the densest administrative units (Appendix, Figure A.5). Although, as for analysis purposes, Kyiv city statistic is presented separately, Kyiv administrative unit remains a leader as for the number of POS. Geospatial analysis reveals that 58% of POS are located within the city boundary, while 30% and 12% are within or near the border of villages or settlements, respectively (Appendix, Figure A.6). The spatial analysis also shows that one fourth of the POS is located within international or national roads (Appendix, A.7).

To inspect POS concertation statistically, we first use the Lorenz curve and Gini coefficient to compare the population to POS distribution (Figure A.8). Presented empirical distributions differ from an equal distribution.

During the analysis, we have identified 29 towns where branded stations are no presented. A more thorough investigation revealed that 9 out of 29 towns have small, local or no-name retailers, others provide services out of side town boundaries (most common close to international or national roads). 43% of POS is distributed with the rate 5 000 - 10 0000 habitants per POS. Among top populated cities, as for the number of inhabitants per POS, Chernihiv is the leader leaving behind Kyiv, Ivano-Frankivsk, Kharkiv, Lviv, and Zhytomyr, while Rivne has the lowest number of habitants per POS (Appendix, Figure A.9). High POS concentration in Rivne can be explained by its location as important international and national transport links. Additionally, the same analysis is conducted for each administrative unit to define areas with high and low POS concentration. As an example, Figure A.10 in Appendix shows cities with more than 20 000 people per one POS. In these areas, it is more likely that gasoline stations can exercise more market power. Consumers tend to limit their price search for inexpensive gasoline to their immediate areas because of travel costs. [Chouinard and Perloff, 2002].

For the spatial statistics, we measure the distance between the points and estimate intensity, as an expected number of POS per unit area (Equation 1).

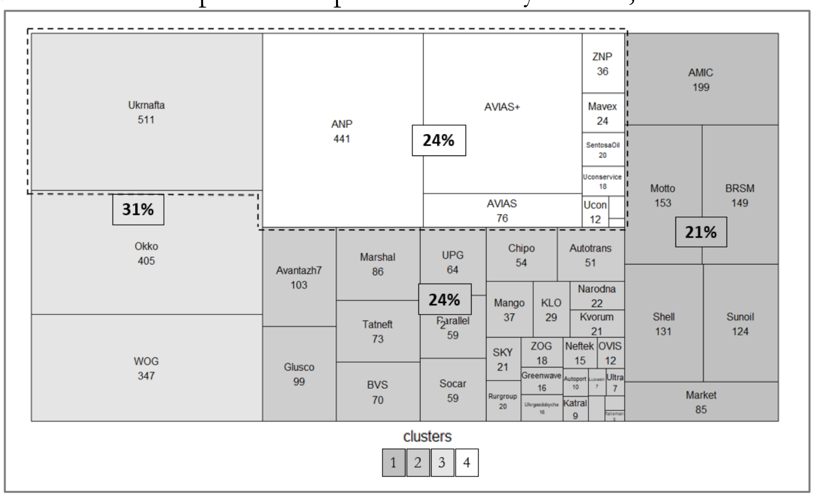
$$\lambda = \frac{n(\boldsymbol{X})}{area(W)} \qquad (1)$$

Where X is a vector of POS, W is a total area.

Using a quadrant counting test, we reject H0 of the homogeneous Poisson process. We can state that intensity is inhomogeneous with a very dense concentration of sales points in some parts of the survey areas, which support our previous findings. The estimated mean intensity is 17 per square kilometer.

Exploring dependence between the points in a spatial point pattern dataset, the Morishita plot is used, which confirms that POS tend to be clustered (Appendix, Figure A.11). Based on this output, cluster analysis is applied to group retailers by their distribution for further inspection (Appendix, Figure A.12). As a result, it is obtained four clusters with the number of POS and its shares presented in Figure 5.

Figure 5. Number of retail petroleum points of sale by brands, 2020:06.




*Source*: authors'estimation based on collected data of POS.
*Note*: dash line group brands which under one group.

Cluster 1 consists of 6 players with 841 POS, which do not cover all administrative units but have a high concentration in Kyiv, Zakarpattia, Odesa oblasts. Also, their presence is high near the main routs (international and national level). 28 brands are grouped in Cluster 2 and account for 991 POS, 11 brands from which are present only in one administrative unit, and 7 cover two-four administrative units, others have high distribution in Kyiv city and Kyiv oblast. Cluster 3 includes only three brands, but the number of POS is the highest 1263. The main feature of this group is the covering of all administrative units in Ukraine. Cluster 4 includes 10 brands, which belong to or under control of the same group-owner. It includes 2 leading brands that account for 875 POS, and others are small local retailers in a specific location where leading brands are not widely presented; thus, we can say that the covering of this group is relatively even through

Ukraine. It should be noted that this cluster has the lowest number of POS in Kyiv administrative units.

Generally, analysis shows that 1503 POS, which constitute nearly 37% of the branded market, are one owner legal entities. POS from this group are distributed in most administrative units; they are located in big cities and remote areas and quite often in low concentrated areas.

To proceed to the literature review, we clarify the time-frequency and model specifications applied previously on the global scale and some specific countries.

The number of studies investigating asymmetric price transmission tests is collected in the survey by Meyer and Cramon-Taubadel (2004). The study contains a comprehensive literature review of the asymmetry as an issue, describes terminology, and applied methods. In relevance to this paper, in our research, we focus on vertical asymmetry, i.e., on asymmetry in price transmission between different stages of the market chain. Additionally, we adapt to our research proposed form of visual representation of the price transmission (speed and magnitude).

The case of vertical asymmetry is explored in the research by Akira Yanagisawa in relevance to the gasoline market in Japan [Yanagisawa, 2012]. He is studying the introduction of a market-linked pricing system and market reflection. The study shows that the wholesale market exhibits slight asymmetry in favor of rising. At the same time, retailers, nevertheless of fierce competition, exceed full pass-through in the period of rising wholesale prices and show a significantly lower rate in the period of falling prices. This analysis adds to a practical understanding of how participants of the market chain can contribute to asymmetry.

Although the regional price difference is out of our research, in the mention above paper, it is also checked the assumption of local market power. It made us thoroughly look at least at regional retail distribution in Ukraine.

To clarify market participants, we investigate a distribution chain that is especially relevant as there has been no such research for Ukraine. In the study of Borenstein, Cameron, and Gilbert (1992) who described market players and defined several steps that gasoline prices went through, we adopt the framework for the current paper focusing on the gasoline market in Ukraine.

An extended discussion about factors that affect pass-through among others is placed in Chouinard and Perloff's (2002) research. They determine the relative importance of factors that affect retail and wholesale gasoline prices variation over time and across the geographic location. They define that tax variation and mergers (producers and retail) contribute greatly to geographical variations of the wholesale and retail prices. It is proved that anticompetitive mergers have relatively large price effects.

Market power is the greatest concern to researches who observe oil – gasoline relationship. Brown and Yucel (2000) cast doubt that asymmetric relationships between gasoline and crude oil prices are evident regarding monopoly on the petroleum market. Their study is based on the period of the Gulf War in 1990 for the U.S. market. It provides the evidence that complete monopolization is unlikely to happen because of retail players. Alternative explanations include different markups related to the business cycle, consumers who tend to increase their purchases facing further price increase, and inventory costs, which rise with the increase in inputs' price. An additional explanation is provided for the refineries that ought to decrease supply when crude oil prices fall, which leads to a decrease in supply and increases of the final price for the consumers. Meanwhile, with crude oil supplies rise, refineries do not have to increase their output fast, so that the decrease is delayed.

The research of Borenstein and Shepard (2002) provides evidence of slower price adjustment for powerful players rather than for those who act on a perfectly competitive market. This behavior is detected on the wholesale market, and it is shown that wholesale gasoline prices are adjusted slower than crude oil prices with higher market margins.

Moreover, the branded gasoline point of sales tends to respond more slowly than unbranded ones in the same markets.

In the survey of Frey and Manera (2005), 69 studies dealing with price transmission for different types of products are collected by the researches. Taking collected articles into account, they provide analysis with the usage of autoregressive distributed lag (ARDL) and ECM models to assess the relationship between input and output prices. Based on their research, the ARDL model is employed in this paper. It also considers definitions of the main types of asymmetry. According to Frey and Manera, short-run asymmetry compares the intensity of output variation to positive or negative changes in input prices, while long-run asymmetry computes the reaction time, fluctuation length, and the speed of adjustment towards equilibrium [Frey and Manera (2005)].

As an extension of the ARDL approach, we look at modeling asymmetric co-integration and Dynamic Multiplier in a non-linear ARDL (NARDL) framework developed by Shin, Yu, and Greenwood-Nimmo (2013). The model is based on a single-step estimation and provides a possibility to extract asymmetric dynamic multiplier, which shows the adjustment speed.

This non-linear method is investigated in detail through the paper of Apergis and Vouzavalis (2018). They estimate an asymmetric pass-through of oil prices to gasoline prices for the U.S., the U.K., Spain, Italy, Greece, for 2009 - 2016. As countries present different retail markets (the level of competition varies), it allows comparing pass-through between countries and our obtained results for Ukraine.

Also, Kocaarslan and Soytas show NARDL model application by questioning the possibility of asymmetric linkage between oil prices, interest rate, and the stock of prices of clean energy and technology firms. They define long-run asymmetric and negative impact on clean energy stock prices and speculative behavior in an upward trend in oil prices.

Considering that the NARDL approach is relatively new adopted by the researches, an additional source of knowledge as model implications from other markets has become a paper of Salim and Shin (2019). They studied the co-integration of the exchange rate using NARDL models and Kalim, Faiz, Arshed (2019) in their application of the NARDL model to investigate investor confidence and asymmetric effects of terrorism in Pakistan.

Among the others who studied asymmetric responses applying another statistician method is Radchenko (2004). He employs a vector autoregressive model (VAR) and explains retailers' oligopolistic behavior. Grasso and Manera (2005) study the asymmetry using asymmetric Error Correction Modeling (ECM), threshold ECM, and ECM with a threshold co-integration model for France, Germany, Italy, Spain, and the U.K. for 20 years starting from 1985.

The question of data aggregating is investigated through the papers. We find out that higher frequency data is more likely to provide reliable results [Frey and Manera, 2005]. In their research of the Dutch gasoline market by Bettendorf et al. (2003), daily data do not show significant inference, in contrast to weekly data. We apply both methods, but leave weekly analysis as a core of estimation.

Though the issue of levels or logs is studied in all the papers reviewed, the work of Bachmeier and Griffin (2003) is interesting because, in contrast to Bacon (1991) and others who used the first difference modeling, they managed to find out that the asymmetry effect was statistically significant when working with levels.

As a part of spatial analysis, a detailed set of notes collected as research of Baddley (2010) is used. It provides a range of practical techniques for the statistician analysis of spatial point patterns in R.

# CHAPTER 3. METHODOLOGY

This chapter is designed to clarify econometric estimation strategies employed to ascertain the relationship between oil prices, wholesale and retail prices. Based on research made by Frey and Manera (2005), where it is broadly evaluated applied econometric models for price asymmetries in different markets, we focus on autoregressive distributed lag models (ARDL) developed by Pesaran (2001) to observe the symmetric effect of independent variables and non-linear autoregressive distributed lags (NARDL) by Shin (2014) to examine asymmetric behavior. These models' choice arises from the fact that they allow investigating the short- and long- relationship between variables in a single-equation time-series setup, simplifying the models' practical implementation. Secondly, they work with I (0) or I (1) series, which is typical for economic variables. Finally, the non-linear approach allows decomposing the total effect on positive and negative to reach the study objective and compare the pass-through rate by levels of the market chain.

Therefore, in the research, we employ both models to check generally symmetric cointegration and, if the relationship between variables is not linear, we utilize non-linear ARDL (NARDL) model. The analysis is based on defined in Chapter 2 market chain prices: oil, wholesale, and retail. Therefore, we get two pairs of upstream and downstream prices for estimation: oil and wholesale prices, wholesale and retail prices. Additionally, we check the oil and retail prices to investigate respond by retailers on oil price changes. We compare the responses between levels to positive and negative shocks of upstream prices in the short- and long-run to interfere with the Ukrainian market's competitiveness.

Before estimation, we check whether the series are stationary employing Augmented Dickey-Fuller tests (1979) and if not, the series can be made stationary by the first differencing. To apply ARDL and NARDL models, we check whether the variables are integrated of order zero or one to continue our analysis.

Since the oil market has experienced the global shock during the estimated period, we check whether our variables have a unit root with unknown structural break accounting for both intercept and trend using Zivot Andrews test (Zivot and Andrews, 1992). Under the test, the break date is estimated but not inferred from the data. The null hypothesis is that series has a unit root without any exogenous structural change, and the alternative hypothesis is a stationary process that allows for a one-time unknown break in intercept and or slope. The same as Dicky-Fuller test, we run it for all variables in levels and at differences and obtained Z statistic and critical values for all cases. The detected structural break can be taken into account by introducing a dummy as independent variables into models. To continue estimation with ARDL or NARDL models, the variables should not be integrated of order two in a structural break.

As the first part of estimation, following Frey and Manera (2005), we employ the ARDL model to investigate linear cointegration. According to their research, in ARDL a variable $y_t$ , for t = 1, …n, depends on its lags (autoregressive part) and a vector of variables **X**, which are allowed to be purely I (0) or I (1) or cointegrated. We can generally specify the linear ARDL model and its error correction representation (ECM) to test for speed of adjustment in a form as outlined in Equation 2 (a-b).

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-i} + \alpha_2 x_{t-i} + \sum_{i=1}^{p} \gamma_1 \, \Delta y_{t-i} + \sum_{i=0}^{q} \gamma_2 \, \Delta x_{t-i} + \varepsilon_t \qquad (2\ a)$$

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \gamma_1 \, \Delta y_{t-i} + \sum_{i=0}^{q} \gamma_2 \, \Delta x_{t-i} + \lambda \, \mathrm{ECT} + \varepsilon_t \qquad (2\ b)$$

Where t=max (p, q),… T, with lag length for p (used for dependent variables), q (used for exogenous variable) may not necessarily be the same. The lags are obtained by minimizing a model selection criterion, e.g., the Akaike information criterion (AIC) or the Bayesian information criterion (BIC) also knows as the Schwarz-Bayesian information criterion. Vector $\boldsymbol{x}_t$ is the k-dimensional variables that are not cointegrated among themselves, $\boldsymbol{\varepsilon}_t$ is a vector of error terms serially uncorrelated or independent. $\gamma$ refers to the short-run coefficients of the model and $\alpha$ represent the long-run coefficients for the varibles. $\lambda$ a speed of adjustment coefficient and ECT is the Error Correction Term, which derives from residuals.

Following the bounds-testing procedure (Pesaran and Shin, 1998 and Pesaran et al., 2001), we use F-bounds statistics to test linear cointegration with null hypotheses as $H_o^F : \alpha_1 = \alpha_2 = 0$ against $H_A^F : \alpha_1 \neq \alpha_2 \neq 0$.

Compared with bounds (Pesaran, 2001), we can conclude about linear cointegration. The lower and upper bounds value depending on the number of regressors, their order, and deterministic components. If computed F-statistics falls below the lower bound, the null hypothesis of no level effect (no co-integration) cannot be rejected; if the statistics lie above the upper bound, the null hypothesis of no level effect is rejected; thus, variables are co-integrated. The case when F-statistic is between the bounds means the test is inconclusive. The case when F-statistic is between the bounds means the test is inconclusive. As a result, we can interfere about exitance of a conditional long-run relationship if $H_o^F$ are rejected.

The linear ARDL models for the relationship between variables, which represent the oil and gasoline market defines as follow: $F_{ARDL}$ (RP t/ Oil t), $F_{ARDL}$ (WP t / Oil t), $F_{ARDL}$ (RP t / WP t) respectively (Equation 3 (a-c)).

$$\Delta RP_t = \alpha_0 + \alpha_1 RP_{t-1} + \alpha_2 Oil_{t-1} + \sum_{i=1}^{p-1} \gamma_1 \Delta RP_{t-i} + \sum_{i=0}^{q-1} \gamma_2 \Delta Oil_{t-i} + u_t \qquad (3\ a)$$

$$\Delta\, WP_t = \alpha_0 + \ \alpha_1 WP_{t-1} + \alpha_2 Oil_{t-1} + \sum_{i=1}^{p-1} \gamma_1\, \Delta\, WP_{t-i} + \sum_{i=0}^{q-1} \gamma_2 \Delta\, Oil_{t-i} + \ u_t \qquad (3\ b)$$

$$\Delta\, RP_t = \alpha_0 + \ \alpha_1 RP_{t-1} + \ \alpha_2 WP_{t-1} + \sum_{i=1}^{p-1} \gamma_1\, \Delta\, RP_{t-i} + \sum_{i=0}^{q-1} \gamma_2\, \Delta\, WP_{t-i} + \ u_t \qquad (3\ c)$$

Where RP is a logarithmic retail price, WP is a logarithmic wholesale price, Oil is a logarithmic crude oil price. The coefficient $\gamma_{1,}\ \gamma_2$ refers to the short-run coefficients of the model and $\alpha_{1,}\alpha_2$ represent the long-run coefficients for the variables. $\Delta$ is the first difference and $u_t$ is an error term.

In case of detecting linear cointegration through the mentioned above F-bounds test procedure, first, we evaluate the speed of adjustment coefficient, which generally measure how strongly a dependent variable reacts to a deviation from the equilibrium relationship in one period, or in other words, how quickly such an equilibrium distortion is corrected. It is expected to fall into the range [-1,0], and being negative and significant confirms that a short-run disequilibrium price is adjusted to the long-run equilibrium. Also, the higher the absolute value of the coefficient, the faster the adjustment process takes place.

Next, we look at the long-run effect, which indicates how large the effect of change in exogenous variables on an indigenous variable in the long-run equilibrium.

After, we examine the short-run dynamic coefficients $\gamma_1$ , $\gamma_2$ of the model through the t-statistics. If it is statistically significant, we can say that the variable's lag value has a significant causal effect on the endogenous variable. Adding all coefficient gives the contemporaneous short-term effect a change in the endogenous variable on the exogenous variable's change. Insignificant short-run lagged coefficients mean zero effect.

Next, we check the robustness of estimated coefficients running the next post-estimation tests. Jarque-Bera goodness of fit test of whether sample data have the skewness and kurtosis matching a normal distribution. The null hypothesis is not rejected if the p-value is lower than the Chi2 value. Breusch-Pagan test to confirm homoskedasticity with the null hypothesis of constant variance. Dublin-Watson test for first-order autocorrelation and Breusch Godfrey Lagrange multiplier test for higher-order autocorrelation to confirm that there is no serial correlation.

In the case of rejecting linear cointegration, we move to the next part, utilizing the non-linear ARDL model with long-run cointegration regression outlined accordance to Shin et.al. (2014) and presented in Equation (4).

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + u_t \qquad (4)$$

In the equation above long-run parameters are $\beta^+$and $\beta^-$; $\mathbf{x}_t$ is a k*1 vector of regressors defined as $\mathrm{x_t} = \mathrm{x_0^+}\ \mathrm{x_t^+} + \mathrm{x_t^-}$ , where $x_0$ as initial value, and $\mathrm{x_t^+}$ and $\mathrm{x_t^-}$ are partial sum processes of positive and negative changes in $\mathrm{x_t}$. These decomposed independent variables can be presented respectively (Equation 5 (a – b)).

$$Positive:\ x_t^+ = \sum_{i=1}^{t} \Delta\, x_i^+ \ = \sum_{i=1}^{t} max(\Delta\, x_i, 0) \qquad (5\ a)$$

$$Negative: x_t^- = \sum_{i=1}^{t} \Delta\, x_i^- \ = \sum_{i=1}^{t} min(\Delta\, x_i, 0) \quad (5\ b)$$

In case of the estimation petroleum market pass-through $x_t$ denotes upstream prices (oil and wholesale) in their pair relationship with downstream prices (wholesale, retail respectively).

Proceeding modeling approach proposed by Shin (2014), the linear ARDL, in accordance to Equation 2, is extended by the asymmetric distributed-lag parameters and presented in Equation 6.

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \rho_i^+ x_{t-1}^+ + \rho_i^- x_{t-1}^- + \sum_{i=1}^{p} \gamma_i \Delta y_{t-i} + \sum_{i=0}^{q} (\beta_i^+ \Delta x_{t-i}^+ + \beta_i^- \Delta x_{t-i}^-) + \varepsilon_t \qquad (6)$$

Where $\alpha_1$ is the autoregressive parameter, the long-run impact of the lagged shock (increase and decrease) is defined as $\mu_1^+ = -\frac{\rho_1^+}{\alpha_1}$ , $\mu_2^- = -\frac{\rho_1^-}{\alpha_1}$ and $\sum_{i=0}^{q-1} \beta_i^+$ , $\sum_{i=0}^{q-1} \beta_i^-$ capture the sort-run dynamic of downstream priced to upstream prices shocks. $\Delta$ is the first difference and $\varepsilon_t$ is an error term.

Similarly, first, we employ tests for cointegration between pairs of variables. We start with the Banerjee et al. (1998) t-bounds procedure with a null hypothesis $H_o^t: \alpha_1 = 0$ , against $H_A^t: \alpha_1 < 0$ and, the same as for ARDL model, run Pesaran et.el (2001) F-bounds procedure to test the null hypothesis of no cointegration that is $H_0^F: \alpha_1 = \rho_1^+ = \rho_1^- = 0$ against $H_A^F: \alpha_1 \neq \rho_1^+ \neq \rho_1^- \neq 0.$

Second, standard Wald test is used for testing short-run symmetry (Shin et.al., 2014), where null hypothesis is expressed as $\sum_{i=0}^{q-1} \beta^+ = \sum_{i=0}^{q-1} \beta^-$ against alternative $\sum_{i=0}^{q-1} \beta^+ \neq \sum_{i=0}^{q-1} \beta^-$ . Finally, the long-run symmetry is tested through the Wald test with the null hypothesis $\mu_1^+ = \mu_2^-$ against , $\mu_1^+ \neq \mu_2^-$.

If both long- and short-run null hypotheses fail to be rejected, it implies that no asymmetry is detected between pair of varibles and the model is transformed into traditional linear Error Correction Model (ECM), which does not take into account short and long asymmetric behavior (Equation 7).

$$y_t = \alpha_0 + \sum_{i=1}^{p-1} \gamma_1 \, y_{t-i} + \sum_{i=0}^{q-1} \gamma_2 \, x_{t-i} + \varepsilon_t \qquad (7)$$

If only one type of symmetry is rejected, the NARDL model is transformed to a reduced form with respect into confirmed short or long-run asymmetry (Equation 8 a-b respectively).

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 x_{t-1}$$
$$+ \sum_{i=1}^{p} \gamma_1 \, \Delta y_{t-i} + \sum_{i=0}^{q} (\beta_i^{+} \Delta x_{t-i}^{+} + \beta_i^{-} \Delta x_{t-i}^{-}) + \varepsilon_t \qquad (8\,a)$$

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \rho_i^{+} x_{t-1}^{+} + \rho_i^{-} x_{t-1}^{-}$$
$$+ \sum_{i=1}^{p} \gamma_1 \, \Delta y_{t-i} + \sum_{i=0}^{q} \gamma_2 \, \Delta x_{t-i} + \varepsilon_t \qquad (8\,b)$$

The same as for ARDL modeling, we estimate the speed of adjustment coefficient which shows the dynamic of movement corrected during one period. The long-run coefficients represent the equilibrium effect on the dependent variable on the independent variable's positive and negative change. Contemporaneous short-term fluctuation is estimated for each type of impact; therefore, a cumulative significant effect can be measured in the short-term. Needless to add, that statistically significant long-run coefficients, both negative and positive change, highlights that all lags in the short-run are jointly significant.

As the last step of the estimation procedure, we quantify positive and negative upstream price shocks, constructing the dynamic multiplier following Shin et al. (2014). The asymmetric cumulative multiplier of 1% increase and 1% decrease in an exogenous variable on an endogenous variable is calculated as given in Equation 9.

$$m_h^+ = \sum_{j=0}^{h} \left( \frac{\partial\, y_{t+j}}{\partial\, x^{\,+}} \right) = \sum_{j=0}^{h} \lambda_j^+ \ , \quad m_h^- = \sum_{j=0}^{h} \left( \frac{\partial\, y_{t+j}}{\partial\, x^{\,-}} \right) = \sum_{j=0}^{h} \lambda_j^- \ , h = 0,1,2 \ldots \ (9)$$

When $h \rightarrow \infty$, $m_h^+ \rightarrow \beta^+$ and $m_h^- \rightarrow \beta^-$, where $\beta^+$ and $\beta^-$ are asymmetric long-run coefficients.

To show the pattern of adjustment of the endogenous variable to its new long-run equilibrium, we plot the cumulative effect with a predefined forecast horizon. Thus, we visualize positive and negative curves to show the downstream prices' adjustment path to positive and negative shocks of upstream prices. Additionally, upper and lower confident bands are provided as a measure of the statistical significance of asymmetry. If the zero lines are between the lower and upper bands, the asymmetric effects are not statistically significant at a 5% confidence level.

As a part of the post-estimation procedure, we run a series of diagnostic tests. We verify whether the residuals from the model are serially uncorrelated (Breusch-Godfrey test), also we test residual for homoscedastic (Breusch-Pagan-Godfrey), and test for normality of errors (Jarque-Bera).

To cover all our modeling findings, we visualize the pass-through dynamic by levels of the market chain so that speed and magnitude of adjustment can be compared.

As for oil and petroleum prices NARDL form is presented in Equation 10 (a-c): $F_{NARDL}$ ($RP_t$ / $Oil_t$), $F_{NARDL}$ ($WP_t$ / $Oil_t$), $F_{NARDL}$ ($RP_t$ / $WP_t$) respectively.

$$\Delta\, RP_t = \alpha_0 + \alpha_1\, RP_{t-1} + \rho_i^+\, Oil_{t-1}^+ + \rho_i^-\, Oil_{t-1}^- + \sum_{i=1}^{p} \gamma_1\, \Delta\, RP_{t-i}$$

$$+ \sum_{i=0}^{q} (\beta_i^+\, \Delta\, Oil_{t-i} + \beta_i^-\, \Delta\, Oil_{t-i}) + \varepsilon_t \qquad (10\, a)$$

$$\Delta\, WP_t = \alpha_0 + \alpha_1\, WP_{t-1} + \rho_1^+\, Oil_{t-1}^+ + \rho_1^-\, Oil_{t-1}^- + \sum_{i=1}^{p} \tau\, \Delta\, WP_{t-i}$$

$$+ \sum_{i=0}^{q} (\beta_1^+\, \Delta\, Oil_{t-i} + \beta_1^-\, \Delta\, Oil_{t-i}) + \varepsilon_t \qquad (10\, b)$$

$$\Delta\, RP_t = \alpha_0 + \alpha_1\, RP_{t-1} + \rho_1^+\, WP_{t-1}^+ + \rho_1^-\, WP_{t-1}^- + \sum_{i=1}^{p} \tau\, \Delta\, RP_{t-i}$$

$$+ \sum_{i=0}^{q} (\beta_1^+\, \Delta\, WP_{t-i} + \beta_1^-\, \Delta\, WP_{t-i}) + \varepsilon_t \qquad (10\, c)$$

Where RP is a logarithmic retail price, WP is a logarithmic wholesale price, Oil is a logarithmic crude oil price. The coefficient $\beta^+$, $\beta^-$refers to the short-run coefficients of the model and $\rho_1^+, \rho_1^-$ stand for the long-run coefficients for the varibles. The optimal lag length for p and q is obtained using Akaike Information Criteria (AIC).

## CHAPTER 4. DATA

Given the research objective of analyzing three levels of market chain participants, it is collected three datasets that represent world oil market, wholesale and retail market in Ukraine.

The first dataset includes two types of the oil prices in the form of Brent crude and WTI oil closing prices which denote in U.S. dollar per barrel (USD/b). Brent and WTI closing prices are obtained from the Federal Reserve Bank of St. Louis (FRED webpage[19]). Generally, WTI as a benchmark is widely used in the USA, while the rest of the world mostly relies on Brent indices; therefore, in our work, we estimate Brent prices. To extract currency exchange rate volatility factor, Brent crude oil index is converted to a local currency hryvnia (UAH/b) using historical exchange rates downloaded from the webpage of the National Bank of Ukraine (NBU webpage[20]). As a result, for our assessment oil price index is denoted in UAH.

The second dataset is the wholesale prices, collected on a daily basis for three commonly used types of fuel: A92, A95, and Diesel as daily average prices by participants in the wholesale market. As mentioned in Chapter 2, there are two commonly used quotations in the market: small wholesales and big wholesale. The first type covers deals limited approximately to one ton, and prices are provided in liters (UAH/ltr); the second type covers deals of more than one ton and quoted per ton (UAH/ton). Big wholesale prices correlate less with retail petroleum prices, and hence can be viewed as a representation of the intermediate agents and proxy for import prices. (Appendix, Figure A14). Thus, in our economic analysis we employ big wholesale prices.

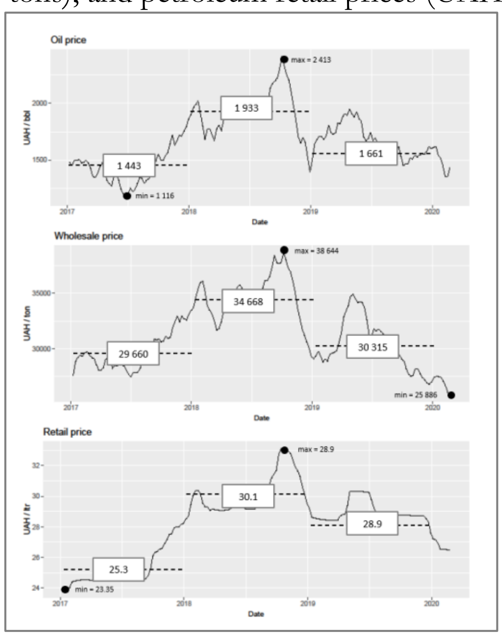
19 https://fred.stlouisfed.org/

20 https://bank.gov.ua/ua/markets/exchangerate-chart

The third data set presents retail market, and, in this case, it is collected retail prices as a daily average of three types of fuel with quotation per liter (UAH/ltr). Retail prices are downloaded from the web source minfin.com.ua [21]. Price market analysis in the Chapter 2 shows that petroleum A-95 is the most popular type of fuel in the retail market, and its price movement are highly correlated with the type of fuel A-92 prices (Appendix, Figure A.15). Therefore, further estimation relies on A-95 type as a representative of retail and wholesale petroleum market.

The three types of daily prices are converted to a weekly frequency as an average value so that 164 weeks of observations are obtained, covering 2017:03 - 2020:03. The updated dynamic of weekly oil and petroleum prices is presented in Figure 6.

Figure 6. Weekly average dynamic for Brent crude oil price (UAH/barrel), petroleum wholesale prices (UAH/tons), and petroleum retail prices (UAH/ltr) 2017:01 2020:03.




*Note:* wholesale prices and retail price for petroleum product type A-95. “max”, “min” – maximum and minimum values in the estimated period; dash line – average value in the respective year.

[21] https://index.minfin.com.ua/markets/fuel

As can be seen, significant changes in oil prices are reflected in corresponding changes in Ukraine's petroleum market with a relatively smoother pattern as for the retail market. The unconditional correlation coefficient confirms the positive relationship between variables, with the strongest correlation between oil prices and wholesale prices (0.89), then with retail prices (0.79). The correlation between wholesale and retail prices is lower and equal to 0.68 (Table 1).

Table 1. Unconditional correlations between varibles.

| Variables | Oil | WP | RP |
|---|---|---|---|
| Oil | 1.000 | - | - |
| WP | 0.892 | 1.000 | - |
| RP | 0.791 | 0.681 | 1.000 |

*Source*: authors' culculation.
*Note*: Oil, RP and WP represent the price for crude oil, petroleum wholesale retail prices.

The analysis shows that within 164 weeks of observation, oil price averaged at the level of 1669.99 UAH/barrel with its high record in October 2018 at the point of 2413.92 UAH/barrel. The same as oil prices, the maximum point is estimated for retail and wholesale prices. The descriptive statistics are presented in Table 2.

Table 2. Descriptive statistics for the variables included to the model.

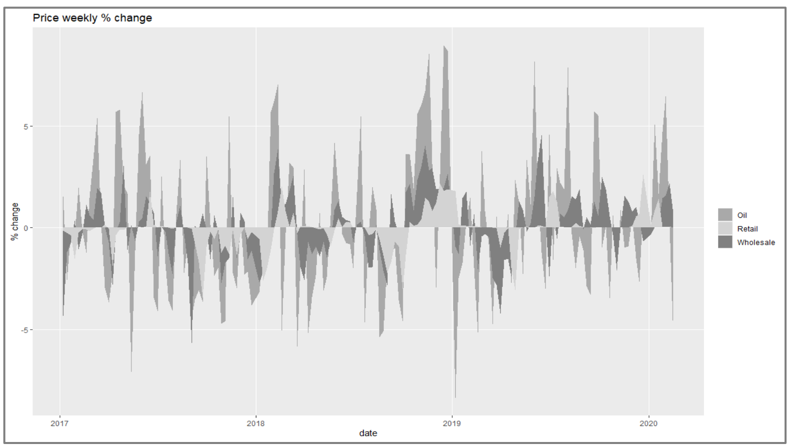
| Statistics | Brent crude index | Wholesale prices | Retail prices |
|---|---|---|---|
| | Oil | WP | RP |
| Mean | 1669.99 | 31323.09 | 28.08 |
| Minimum | 1161.35 | 25887.93 | 23.35 |
| Maximum | 2413.92 | 38664.22 | 33.12 |
| Standard Deviation | 262.67 | 3124.23 | 2.30 |
| Observation | 164 | 164 | 164 |

*Source*: authors' estmates.
*Note*: Oil, RP and WP represent the price for Brent crude oil, A-95 wholesale retail prices.

Generally, there are two trends in the observed period. In 2018 three estimated indices showed positive growth with, on average, 34% increase for oil and 17% and 19% for wholesale and retail, respectively. In contrast, in 2019 inverse pattern is established with the lowest average decrease for retail prices (3,85%), and considerably larger year to year drop for oil and wholesale prices (14.5% and 12.5%).

Additionally, based on the analysis, it can be said that retail prices are less volatile than upstream prices (wholesale or oil) (Figure 7).

Figure 7. Percentage price change for petroleum retail, wholesale prices, and oil price index, 2017:01 2020:03.




*Source*: authors' estimates.

To reduce the excess volatility, series are expressed in logarithms; therefore, our dataset for estimation includes weekly logarithmic Brent oil price, the weekly logarithmic wholesale, and retail prices for A-95.

# CHAPTER 5. RESULTS

Following the methodology described in Chapter 3, we apply the general-to-specific procedure to obtain the final model specification. After checking procedures for the unit root in each series to reject that variables are integrated of order two, we investigate the presence of symmetry with application linear ARDL (Pesaran and Shin, 1998). If symmetry is rejected, we test for the asymmetric cointegration relationship between pairs of variables described in Chapter 4 using nonlinear ARDL models (Shins et al., 2014). With each model, we proceed with conclusion concerns price pass-through mechanism to assess competitiveness. Following the stated above, the empirical tests are presented in three parts: pre-estimation, ARDL, NARDL models.

## 5.1. Pre-estimation tests.

As ARDL and NARDL models are based on the assumption that the variables are integrated of order zero or one, as a pre-estimation part, we test each variable for stationarity. For this purpose, firstly, we use the Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979). The optimal number of lag length is estimated using the Schwarz information criterion. Corresponding findings are presented in Table A.1, where we observe that all the variables in levels are non-stationary (stationary is rejected at 1% significance level). After applying first differences, stationarity has been confirmed at 1% level of significance.

Secondly, we apply the Zivot-Andrews unit root test for time-series, which allows to test three cases: one structural break in the in intercept, trend, or both (Zivot-Andrews 1992). The obtained results for the three employed variables in levels and at first differences are presented in Table A.2. Accounting for structural break, tests show that all variables become stationary at first difference. Hence, the variables are integrated of order one. Therefore, we can proceed with the linear and nonlinear ARDL models to detect a possible long-run relationship between crude oil prices, wholesale prices, and retail prices, representative of three levels of the petroleum price-generated steps.

5.2. Autoregressive distributed lags model.

Considering the linear ARDL model, using the Bound test approach (Pesaran and Shin, 1998 and Pesaran et al., 2001), we estimate the regressions accordance to Equation 3 (a-c). The optimal lag length is determined using the Schwarz Information criterion. As a result, F-statistics are obtained to test the symmetric cointegration relationship between pairs of variables (Tables 3).

Table 3. F-test results for the ARDL models.

| Model | F-bounds statistics | critical values | | Conclusion |
|---|---|---|---|---|
| | | I(0) | I(1) | |
| $F_{ARDL}$ ($RP_t$ / $Oil_t$) | 14.167 | 4.94 | 5.73 | cointegration |
| $F_{ARDL}$ ($WP_t$ / $Oil_t$) | 1.003 | | | no cointegration |
| $F_{ARDL}$ ($RP_t$ / $WP_t$) | 4.409 | | | no cointegration |

*Source*: authors'estimates.
*Note*: Oil, RP and WP represent the logarithmic price for crude oil, petroleum wholesale retail prices. Critical values at K=1 for unrestricted intercept and no trend (case 3) at 5% level of significance (Pesaran et.al., 2001)

The bound test fails to reject the null hypothesis of no cointegration relationship in models $F_{ARDL}$ (WP t / Oil t) and $F_{ARDL}$ (RP t / WP t) as obtained statistics smaller than the lower bounds, while this is not true for variables in model $F_{ARDL}$ (RP t / Oil t). Thus, we can state that there seems no linear cointegration relationship between the pairs of variables oil and wholesale prices and wholesale and retail prices. Nevertheless, that we are focusing on the first two relationships, considering the confirmed linear cointegration relationship between oil and retail prices, we look at this relationship to make a comparison (Table 4).

We run ARDL regression corresponding to the first-difference equation. The adjustment coefficient is negative, as it should be, means that if retail price is moving out of long-run equilibrium in one direction, they are pulled back to equilibrium and the estimated value. It is significant, but its value shows that the adjustment is weak (6% is a rate of weekly correction). Considering the fact that the long-run coefficient is a function of the speed of adjustment coefficient, its small value implies that the long-run coefficients necessary become large. The statistically significant long-run coefficient highlights that there is a long-run relationship between oil prices and retail prices. One percent increase in oil prices is associated with a 0.52 % increase in retail prices. Additionally, there appears no significant contemporaneous short-run effect on the retail prices when oil price changes.

Table 4. Estimated results for model $F_{ARDL}$ (RP t / Oil t).

| Number of observations | | | 160 | |
|---|---|---|---|---|
| R-square | | | 0.50 | |
| Adj R-squared | | | 0.49 | |
| Var. | Coeff. | Std error | t-value | p-value |
| Adjustment coefficient | | | | |
| $RP_{t-1}$ | -0.06 | 0.01 | -1.69 | 0.000 |
| Long run (LR) | | | | |
| Oil | 0.52 | 0.58 | 9.06 | 0.000 |
| Short run (SR) | | | | |
| $\Delta RP_{t-1}$ | 0.432 | 0.064 | 6.69 | 0.000 |
| $\Delta Oil_t$ | 0.027 | 0.016 | 1.72 | 0.087 |
| Const. | -0.035 | 0.025 | -1.40 | 0.164 |

*Source*: authors' estimates.
*Note*: Δ denotes first difference.

We carry out diagnostic tests to validate the estimated results. The obtained results show no serial correlation, homoskedasticity, or non-normality of the error terms in the estimated series.

Table 5. Diagnostic tests for model F ARDL (RP t / Oil t).

| Test | statistics | p-value | Conclusion |
|---|---|---|---|
| Breusch Godfrey serial correlation test | 0.914 | 0.34 | no serial correlation |
| Breusch Pagan Heteroscedasticity test | 2.25 | 0.13 | homoskedasticity |
| Jarque-Bera test | 12.85 | 0.46 | normally distributed |

*Source*: authors' estimates.

The model corresponding to the linear relationship between retail prices and oil prices in the long- and short-run can be specified as presented in Equation 11 (a-b), respectively.

$$ln\ RP = 0.52 * ln\ Oil \qquad (11\ a)$$

$$\Delta\ ln\ RP = -0.06 * \ ECT_{t-1} + 0.432 * \ \Delta\ ln\ \ RP_{\ t-1} + 0.027 * \ \Delta\ ln\ Oil_{\ t} - 0.035 \qquad (11\ b)$$

5.3. Non-linear autoregressive distributed lags model.

As one of the focal points of this study is to examine pass-through on two levels, we proceed with the next estimations: (1) how oil price change affects wholesale prices and (2) how wholesale price influences the retail price. The absence of the linear relationship between these pairs leads us to the application of the non-linear cointegration relationship. The asymmetric movement, which stands behind the NARDL model, is estimated following Equation 10. To arrive at a decision for the long-run relationship, the t-statistics and F-statistics are compared with the lower and upper bounds, respectively (Table 6).

The results suggest the non-linear cointegration relationship between retail prices as endogenous variables and oil and wholesale prices as exogenous variables. As for wholesale and oil price interaction, we have no evidence to reject the null hypothesis of no asymmetric cointegration based on both F-bounds and t-bounds approaches. In other words, while wholesale prices in Ukraine are more likely to respond similarly to oil price increase and decreases, retail prices move asymmetrically, at least in the long- or short-run.

Table 6. Bound test results for the NARDL models.

| Model | t-statistics | critical values | | F-statistics | critical values | | Conclusion |
|---|---|---|---|---|---|---|---|
| | | I (0) | I (1) | | I (0) | I (1) | |
| $F_{NARDL}$ ($RP_t$ / $Oil_t$) | -4.04 | -2.86 | -3.22 | 6.52 | 4.94 | 5.73 | cointegration |
| $F_{NARDL}$ ($WP_t$ / $Oil_t$) | -2.77 | | | 2.89 | | | no cointegration |
| $F_{NARDL}$ ($RP_t$ / $WP_t$) | -4.70 | | | 8.91 | | | cointegration |

*Source*: authors' estimates.
*Note*: Critical values at K=1 for unrestricted intercept and no trend (case 3) at 5% level of significance (Pesaran et.al., 2001)

Further, we test all models for potential short- and long-run asymmetry applying the Wald test (Table 7).

Table 7. Wald test for long- and short-run symmetry for NARDL models.

| Model | Long-run | | | Short-run | | |
|---|---|---|---|---|---|---|
| | F-stat | p-value | Conclusion | F-stat | p-value | Conclusion |
| $F_{NARDL}$ ($RP_t$ / $Oil_t$) | 5.81 | 0.017 | asymmetry | 2.29 | 0.132 | symmetry |
| $F_{NARDL}$($WP_t$ / $Oil_t$) | 9.06 | 0.003 | asymmetry | 0.05 | 0.825 | symmetry |
| $F_{NARDL}$ ($RP_t$ / $WP_t$) | 42.54 | 0.000 | asymmetry | 1.41 | 0.237 | symmetry |

Source: authors' estimates.

The null of symmetry is rejected with the only long-run test but in all pair-wise relationships under study. The detected long-run asymmetry is measured through obtained coefficients of a positive and negative effect (Table 8).

We cannot interpret the coefficients as convergence is not confirmed in the case of a failed asymmetric cointegration relationship between wholesales and oil prices. As for the impact on retail prices, our results suggest that the wholesale prices and oil prices have a positive and significant effect on retail prices in the short- and long-run, and the effect is asymmetric in the long-run. The wholesale price increase has a greater effect on retail prices compared to the wholesale price decrease.

Table 8. Wald test for long-run effect (positive and negative) for NARDL models.

| Model | Long-run effect (+) | | | Long-run effect (-) | | |
|---|---|---|---|---|---|---|
| | Coef. | F-stat | p-value | Coef. | F-stat | p-value |
| $F_{NARDL}$ ($RP_t$ / $Oil_t$) | 0.477 | 92.87 | 0.000 | -0.449 | 66.55 | 0.000 |
| $F_{NARDL}$ ($WP_t$ / $Oil_t$) | 0.585 | 49.62 | 0.000 | -0.646 | 52.82 | 0.000 |
| $F_{NARDL}$ ($RP_t$ / $WP_t$) | 0.803 | 138.8 | 0.000 | -0.680 | 95.4 | 0.000 |

*Source*: authors' estimates.
*Note*: Long-run effect (-) refers to a permanent change in exogenous variable by -1.

Estimate parameters for the short- and long-run relationship between retail and wholesale prices are presented below (Table 9).

Table 9. Estimated results for model $F_{NARDL}$ (RP t / WP t).

| | | | | |
|---|---|---|---|---|
| Number of observations | | | 162 | |
| R-square | | | 0.52 | |
| Adj R-squared | | | 0.49 | |
| Var. | Coeff. | Std error | t-value | p-value |
| Constant | 0.28 | 0.06 | 4.71 | 0.000 |
| Adjustment coefficient | | | | |
| $RP_{t-1}$ | -0.09 | 0.019 | -4.70 | 0.000 |
| Long run (LR) | | | | |
| WP + | 0.073 | 0.019 | 4.93 | 0.000 |
| WP - | 0.062 | 0.014 | 5.04 | 0.000 |
| $\Delta RP_{t-1}$ | 0.379 | 0.065 | 5.77 | 0.000 |
| Short run (SR) | | | | |
| $\Delta WP_t +$ | 0.108 | 0.056 | 1.92 | 0.050 |
| $\Delta WP_{t-1} +$ | 0.070 | 0.055 | 1.26 | 0.211 |
| $\Delta WP_t -$ | - 0.003 | 0.063 | -0.60 | 0.954 |
| $\Delta WP_{t-1} -$ | -0.024 | 0.066 | 0.37 | 0.712 |

*Source*: authors' estimates.
*Note*: Δ – first difference; "+" denotes to positive change, "-" denotes to negative change of exogenous variables.

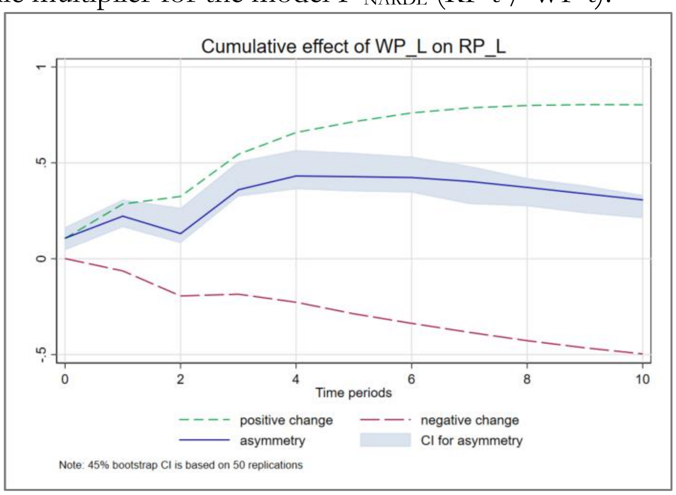
The adjustment coefficient is negative and significant, and within the economically meaningful range, which supports our finding for cointegration. We can say that for every short-run disequilibrium, about 9% is corrected within one week; thus, it takes on average more than three months to revert back to equilibrium level if price is pushed off by a shock (in this case by wholesale price change). Therefore, convergence is weak and slow.

Decomposed long-run coefficients (of a negative and positive change in oil price) are significant and show a positive relationship between variables. The response of retail prices to wholesale prices increases is larger than to decrease. One percent increase (decrease) in wholesale prices is associated with the increase (decrease) in retail prices by 0.073% (0.062% respectively) in the long run on average.

The regression results, with decomposed short-run parameters, illustrate that retail prices are mostly affected by wholesale price changes when the former increases. The additive contemporaneous rise of the retail price is estimated at the level of 0.39% and no significant effect if wholesale prices decrease within one week).

To assess the adjustment, a dynamic multiplier is plotted for the relationship between wholesale prices and retail prices in the Ukrainian market (Figure 8).

Figure 8. Dynamic multiplier for the model F $_{NARDL}$ (RP t / WP t).




Source: authors' estimates.
*Note*: horizon = 10 weeks.

Although the previous test suggests no short-run asymmetry, the shape shows a sign that rection is more rapid when the wholesalers increase prices than decrease. The market exhibits a different pattern, especially after two weeks with increasing asymmetry in time in favor of a positive shock. It can be said that up to 90% of the adjustment towards the long-run equilibrium is achieved within ten weeks.

To summaries the obtained results, it can be stated that pass-through from wholesale prices to retail prices is slow and partially with a tendency to faster price increase relative to a price decrease. Remarkably, if intermediate agents decrease their prices, there is no statistically significant response within six weeks in the retail market. This finding reveals that consumers do not benefit from the downward trend in oil prices.

We check the dynamic specification's adequacy based on diagnostic statistics such as normality, the serial correlation, the heteroscedasticity tests, which results are presented in Table 10.

Table 10. Diagnostic test for the model $F_{NARDL}$ (RP t / WP t).

| Test | Stat. | p-value |
|---|---|---|
| Portmanteau test up to 40 lag (chi2) | 36.67 | 0.6210 |
| Breusch-Pagan heteroskedasticity test (chi2) | 4.612 | 0.0317 |
| Jarque-Bera test on normality (chi2) | 15.56 | 0.0004 |

*Source*: authors' estimates.

Although the estimated model appears to pass the post-estimation specification tests for homoskedasticity and absence of serial correlation, there is evidence of non-normality in residuals.

The model corresponding to the non-linear relationship between wholesale prices and retail prices in the long- and short-run is presented in Equation 12.

$$\Delta RP_t = 0.28 - 0.09\, RP_{t-1} + 0.073\, WP_{t-1}^{+} + 0.062\, WP_{t-1}^{-} + 0.379\, \Delta RP_{t-1} + (0.108\, \Delta WP_t^{+} + 0.070\, \Delta WP_t^{+}) + u_t \qquad (12)$$

Next, turning back to the relationship between crude oil and the Ukrainian gasoline intermediate market. Although there is no evidence of nonlinear cointegration (which can be attributed to the frequency of the data), the Wald test reveals asymmetric behavior in the long-run and symmetric in the short-run (Table 7). The contemporaneous terms within the first and the second-period lagged increase and decrease are not statistically significant, but cumulatively the effect is greater when increase. More thoroughly, a 1% increase in upstream prices (oil index) makes wholesalers surpass even more (1.1%) in downstream prices. In contrast, the magnitude of the contemporaneous downstream adjustment is not full and estimated at the level of 0.9% (Table 11).

Table 11. Estimated results for model F NARDL (WP t / Oil t).

| Number of observations | | | 161 | |
|---|---|---|---|---|
| R-square | | | 0.49 | |
| Adj R-squared | | | 0.45 | |
| Var. | Coeff. | Std error | t-value | p-value |
| Constant | 0.83 | 0.29 | 2.78 | 0.006 |
| Adjustment coefficient | | | | |
| WP t-1 | -0.08 | 0.029 | -2.77 | 0.006 |
| Long run (LR) | | | | |
| Oil + | 0.047 | 0.018 | 2.54 | 0.012 |
| Oil - | 0.051 | 0.019 | 2.61 | 0.010 |
| ΔWP t-1 | 0.181 | 0.078 | 2.31 | 0.022 |
| ΔWP t-2 | 0.084 | 0.069 | 1.20 | -0.054 |
| Short run (SR) | | | | |
| Δ Oil + | | | | |
| t | 0.275 | 0.063 | 4.34 | 0.000 |
| t-1 | 0.101 | 0.065 | 1.54 | 0.127 |
| t-2 | -0.029 | 0.064 | -0.46 | 0.643 |
| Δ Oil - | | | | |
| t | 0.109 | 0.053 | 2.03 | 0.044 |
| t-1 | 0.095 | 0.059 | 1.61 | 0.110 |
| t-2 | 0.107 | 0.060 | 1.79 | 0.076 |

*Source*: authors' estimates.
*Note*: Δ – first difference; "+" denotes to positive change, "-" denotes to negative change of exogenous variables.

The same as for the previous model, this specification passed all tests except the test for normality of error terms (Table 12).

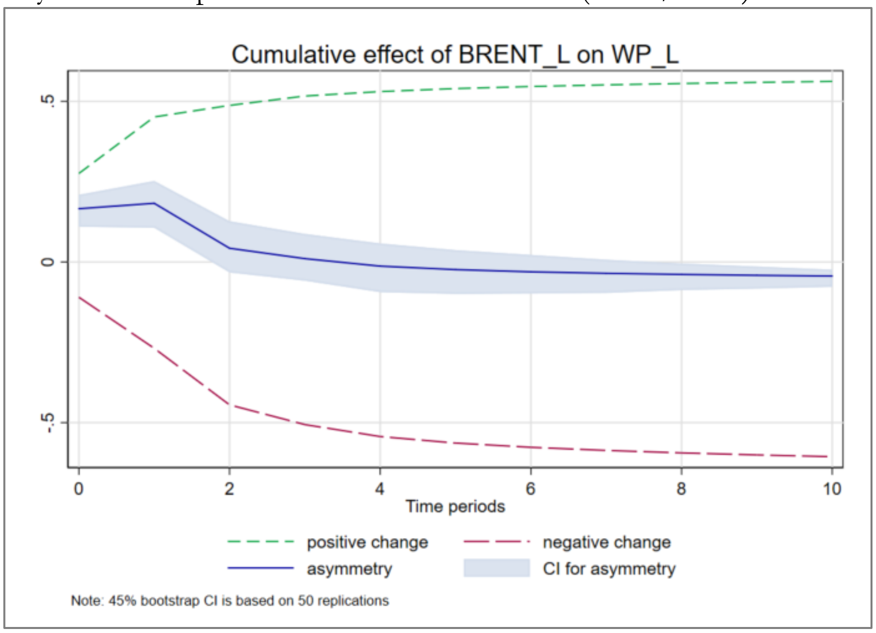
Table 12. Diagnostic test for the model F NARDL (WP t / Oil t).

| Test | Stat. | p-value |
|---|---|---|
| Portmanteau test up to 40 lag (chi2) | 41.32 | 0.4127 |
| Breusch-Pagan heteroskedasticity test (chi2) | 1.66 | 0.1976 |
| Jarque-Bera test on normality (chi2) | 17.52 | 0.0002 |

*Source*: own estimates.

As far as the dynamic multiplier for this relationship, it can be said that during the first week, the wholesale market exhibit a significant response (Figure 9).

Figure 9. Dynamic multiplier for the model F NARDL (WP t / Oil t).




Source: authors' estimates.
*Note*: horizon = 10 weeks.

The key inference from this model is the relatively quick reaction of petroleum wholesalers in Ukraine to oil world prices change with a higher magnitude if there is an upward trend. It can be assumed that such a fast and more than full positive pass-through originates from the general uncertainty on the market as possible future risks mitigation. The quick short-term adjustment confirms this behavior.

The corresponding model to the non-linear relationship between wholesale prices and oil prices in the long- and short-run can be specified as follows in Equation13.

$$\Delta WP_t = 0.83 - 0.08\, WP_{t-1} + 0.047\, Oil^{+}_{t-1} + 0.051\, Oil^{-}_{t-1} + 0.181\, \Delta WP_{t-1} + 0.084\, \Delta WP_{t-2} + (0.275 \Delta Oil^{+}_{t} + 0.109 \Delta Oil^{-}_{t}) + u_t \qquad (13)$$

To check the decomposed response of Ukrainian retailers when oil price change, we run the NARDL model as exogenous variables and retail prices as endogenous variables. Previously, based on previous bound test procedure and current estimation, we can infer that there is a long non-linear relationship between retail and oil prices (Table 6) with 0.47% and 0.44% change if positive or negative effects respectively (Table 8). The adjustment coefficient is highly significant and implies that about 8% of any retail price movement into disequilibrium is corrected within a week. To evaluate whether the lagged values of the oil price changes affect end-users considerably, we obtain decomposed parameters of the non-linear model (Table 13).

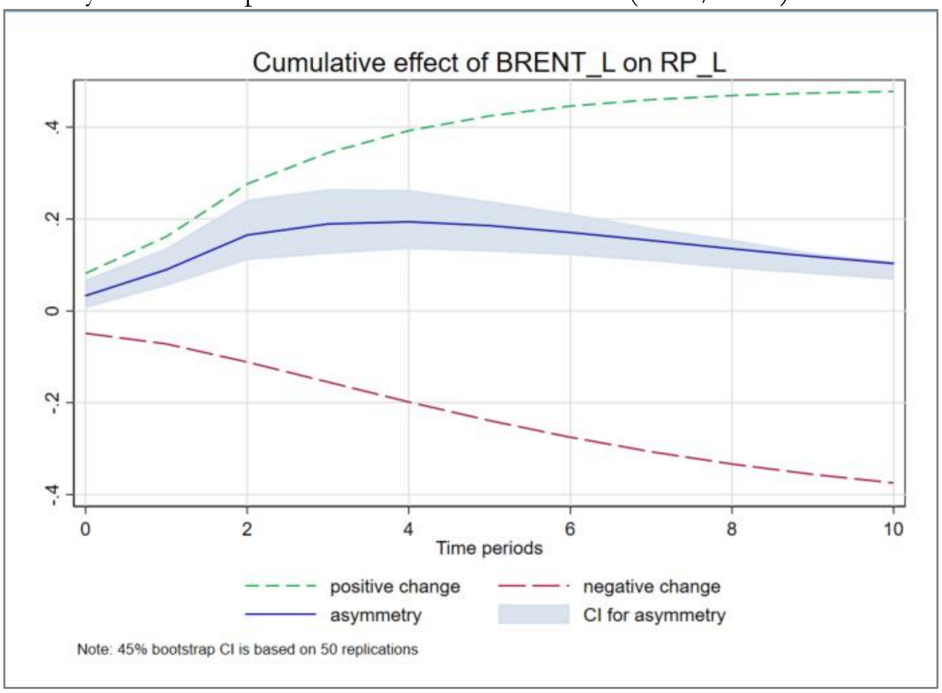
Table 13. Estimated results for model F NARDL (RP t / Oil t).

| Number of observations | | | 162 | |
|---|---|---|---|---|
| R-square | | | 0.52 | |
| Adj R-squared | | | 0.49 | |
| Var. | Coeff. | Std error | t-value | p-value |
| Constant | 0.24 | 0.06 | 4.01 | 0.000 |
| Adjustment coefficient | | | | |
| $RP_{t-1}$ | -0.08 | 0.019 | -4.05 | 0.000 |
| Long run (LR) | | | | |
| Oil + | 0.036 | 0.008 | 4.18 | 0.000 |
| Oil - | 0.034 | 0.008 | 4.24 | 0.000 |
| $\Delta RP_{t-1}$ | 0.379 | 0.065 | 5.77 | 0.000 |
| $\Delta RP_{t-2}$ | 0.106 | 0.076 | 1.39 | 0.168 |
| Short run (SR) | | | | |
| ΔOil + | | | | |
| $\Delta Oil_{t}$ + | 0.082 | 0.034 | 2.43 | 0.016 |
| $\Delta Oil_{t-1}$ + | 0.018 | 0.033 | 0.55 | 0.586 |
| $\Delta Oil_{t-2}$ + | 0.051 | 0.034 | 1.56 | 0.122 |
| ΔOil - | | | | |
| $\Delta Oil_{t}$ - t | - 0.048 | 0.029 | 1.67 | 0.096 |
| $\Delta Oil_{t-1}$ - | -0.026 | 0.032 | -0.82 | 0.412 |
| $\Delta Oil_{t-2}$ - | -0.003 | 0.031 | -0.12 | 0.908 |

*Source*: authors' estimates.
*Note*: Δ – first difference; "+" denotes to positive change, "-" denotes to negative change of exogenous variables.

The assessment revealed no contemporaneous and up to three weeks response on the retail market in Ukraine if oil prices go down. In contrast, the immediate cumulative response is estimated at the level of 0.33% if the oil price goes up by 1%. Observing bootstrap intervals and its shape in Figure 10, we can say that adjustment movement the same as in previous models; it is slow and weak. It roughly takes ten weeks to adjust retail prices by 80% after a shock.

Figure 10. Dynamic multiplier for the model F NARDL (RP t / Oil t).




Source: authors'estimates.

*Note*: horizon = 10 weeks.

The corresponding model for the non-linear relationship between retail prices and oil prices in the long- and short-run can be specified as presented in Equation 14.

$$\Delta\, PP_t = 0.24 - 0.08RP + \ 0.036\, Oil_{t-1}^{+} + 0.034Oil_{t-1}^{-} + 0.379\Delta\, RP_{t-1} + \ (0.082\,\Delta\, Oil_t^{+}\,) + \ u_t \qquad (14)$$

In relevance to the post-estimation diagnostic test, the asymmetric specification for the relationship between the oil and retail petroleum indices do not suffer from serial correlation, heteroscedasticity, and confirm that residuals follow the normal specification (Table 14).

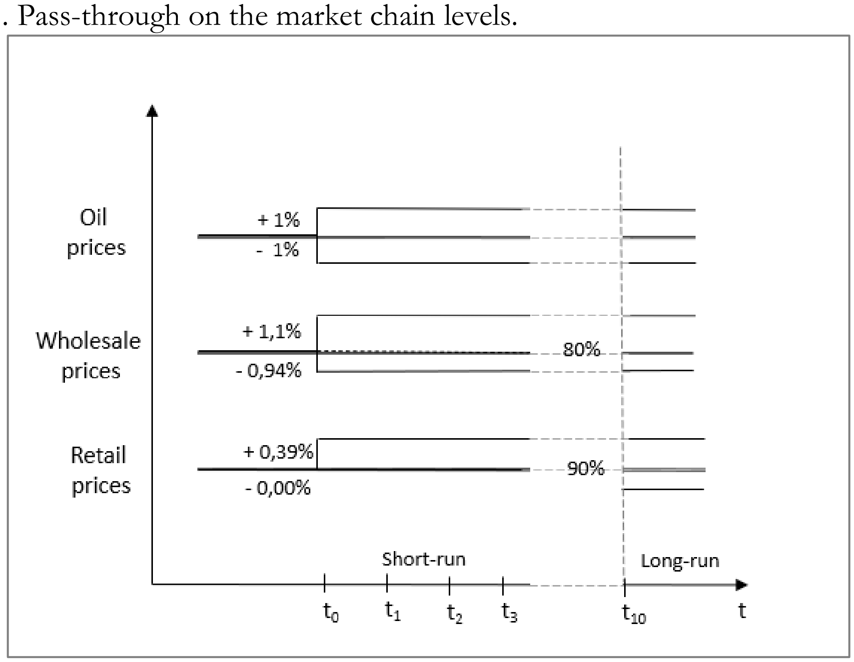
Table 14. Diagnostic test for the model F NARDL (RP t / Oil t).

| Test | Stat. | p-value |
|---|---|---|
| Portmanteau test up to 40 lag (chi2) | 38.65 | 0.5310 |
| Breusch-Pagan heteroskedasticity test (chi2) | 2.23 | 0.1353 |
| Jarque-Bera test on normality (chi2) | 10.32 | 0.0057 |

*Source*: authors' estimates.

To compare the pass-through mechanisms on the market chain by levels, we rely on the form proposed by Meyer and Cramon-Taubadel (2004), which allows visually present two criteria that are speed and magnitude. Figure 11 is a visual representation of our previous estimations.

Figure 11. Pass-through on the market chain levels.




*Source:* authors' estimates.

We can infer that if upstream prices exhibit change, relative disequilibrium is corrected faster by wholesalers, then retailers. Considering the short-term, in case of an upstream prices increase, downstream prices change contemporaneously on each market chain level. However, the full transmission defines only on wholesale levels. In the case of upstream prices decrease, the contemporaneous reaction is exhibit only by the wholesalers, and it is not full, while retailers more than a month do not show significant reactions and adjusting their prices only in the long-run.

# CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

This research investigates the price transmission on the Ukrainian gasoline market to addresses the problem of price-asymmetry widely discussed by researches. Under linear and non-linear autoregressive models, we decompose the path from the world crude oil to wholesale and retail level to compare price change in the short and long-run split into positive and negative ones.

It can be said that there are two contributions of this research to existing literature. The first is employing a relatively new non-linear cointegration approach to assess price asymmetry in the Ukrainian market. It helped to compare all types of gasoline price responses. The second is the market chain price-forming modeling approach (intermediate agents, retailers). The results add to the previous research, which covers the retail market only and picked the question of the stage from which asymmetry arises.

The market overview revealed that the gasoline market in Ukraine exhibits high dependence on imports; thus, it is sensitive to the oil prices and to the exchange rate fluctuations. Additionally, country importers' political and economic stability is a factor that affects price-makers on each level of the market chain in Ukraine.

Retail price change analysis shows a shift in consumers' preferences in favor of fuel products with higher quality and rising popularity of cheaper substitute for gasoline LPG.

Using weekly data for the period 2017:01 – 2020:03 we revealed that retail gasoline market in Ukraine is less competitive on retail than on wholesale market.

The pass-through analysis of the oil and wholesale relationship shows a relatively fast reaction of intermediate agents to upward and downward changes in oil price, which assume is a reflection of the effective competition in the wholesale petroleum market. Based on the analysis, we define that even though there is no co-integration between two commodities (oil and wholesale prices), in the short-run, the symmetric contemporaneous response is relatively full in both cases (positive and negative impact). A permanent increase in the oil price changes the wholesale prices by virtually the same amount. A more thorough investigation reveals minor asymmetry: 1.1% if oil price increases and 0.9% if price decreases. We can state that the explanatory power of the wholesale level of the market chain is minor.

The retail market's analysis revealed five market leaders' retails which cover half of the branded market with clear identity and dense covering and possibility to keep the same price strategy by nearly every third point of sales of the branded market as being under the same ownership. We assume that collusion is possible in this market. Moreover, there is evidence of horizontal market power within the group, enhancing market concentration. These facts add to the assumption for the possibility to gain control of the retail market, thus presence of different response.

Detected regional heterogeneity based on spatial analysis showed some areas with low density of point of sales which are more likely to be prone to local market power but generally, we can infer that complete monopolization is unlikely because none of the brands did not show absolute market power.

Pass-through analysis of the relationship between wholesale and retail prices confirms long-run asymmetry in favor of the positive change. A 1% increase by a wholesaler is associated with a 0.8% increase by a retailer in the long run, while a decrease in wholesale price by 1% pulls 0.68% decrease in retail price in the long run. We can say that detected asymmetry is for the profit secure by retailers. The convergence speed of wholesale prices shows that it takes nearly four months in the first case and five months in the second. The analysis shows a low pass-through in the short-run: retailers keep the same price-level for more than a month after the wholesale price is showing decrease. However, they tend to increase price contemporaneously by 0.4% when wholesale price rises. Since retailers adjust their prices with time-gap and not fully, consumers spend more than should when a price decrease for the oil and wholesale market. Based on this we can state that retailers in contrast to wholesalers contribute greatly to asymmetry.

All significant gasoline price manipulation in the market seems to match the AMCU interventions, clearly showing the vital role of the regulator. Without such interventions, the pass-through speed by retailers assume will be even longer, increasing the negative effect on end-users who bear the relevant changes. Nevertheless, the study shows the importance of the kind of assessment to reveal not only extreme cases of terminal delay but also any sign of price keeping by retailers. The proposed one-step modeling approach is one of the possible mechanisms to launch ongoing analysis, which lately gained popularity among researchers and applied for different markets.

It is relevant for further research to look precisely at price-respond by defined in this research market leaders in Ukraine and in spatially defined areas with high presence of some brand and/or areas where petroleum stations are scarce. As specific pattern concentration can be a source of market power, thus regional variance in the pass-through is possible. The stated above can be a part of a future investigation in the gasoline market in Ukraine.

REFERENCES

Apergis, N., and Vouzavalis, G. 2018. Asymmetric pass through of oil prices to gasoline prices: Evidence from a new country sample. *Energy Policy* 114 (January): 519-528.

Bachmeier, L. J., and Griffin, J. M. 2003. New evidence on asymmetric gasoline prices responses. *Review of Economics and Statistics* 85 (March): 772-776.

Bacon, R. W. 1991. Rockets and feathers: the asymmetric speed of adjustment of UK retail gasoline prices to cost changes. *Energy economics* 13 (July): 211-218.

Bettendorf, L., Van der Geest, S. A., and Varkevisser, M. 2003. Price asymmetry in the Dutch retail gasoline market. *Energy Economics*, 25 (November): 669-689.

Borenstein, S., Cameron, A. C., and Gilbert, R. 1997. Do gasoline prices respond asymmetrically to crude oil price changes? *The Quarterly journal of economics*, 112 (February): 305-339.

Brown, S. P., and Yucel, M. K. 2000. Gasoline and crude oil prices: why the asymmetry? *Economic & financial review* (Third quarter): 23 - 29.

Consulting agency A-95. https://index.minfin.com.ua/markets/fuel/

Consulting agency Nefterynok. http://www.nefterynok.info/

Chouinard, H. H., and Perloff, J. M. 2002. Gasoline price differences: Taxes, pollution regulations, mergers, market power, and market conditions. *The BE Journal of Economic Analysis & Policy,* 7 (September).

Federal Reserve Bank of St. Louis. https://fred.stlouisfed.org/

Frey, G., and Manera, M. 2007. Econometric models of asymmetric price transmission. *Journal of Economic surveys*, 21 (March): 349-415.

Gienko, S. 2009. Price relationship between crude oil and retail fuel in Ukraine. MA in Economics, Kiev School of Economics. Published: https://kse.ua/wp-content/uploads/2019/03/SGienko_Thesis2.pdf

Grasso, M., and Manera, M. 2007. Asymmetric error correction models for the oil–gasoline price relationship. *Energy Policy* 35 (November): 156-177.

Joint Oil Data Exercise. https://www.jodidata.org/oil/database/country-by-country-review.aspx

Kalim, R., Faiz, I., and Arshed, N. 2019. Investor Confidence and Asymmetric Effects of Terrorism-A case of Pakistan. *Journal Transition Studies Review* 26 (2): 113-124.

Kocaarslan, B., and Soytas, U. 2019. Asymmetric pass-through between oil prices and the stock prices of clean energy firms: New evidence from a nonlinear analysis. *Energy Reports* 5 (November): 117-125.

Kripfganz, S., and Schneider, D. C. 2016. ardl: Stata module to estimate autoregressive distributed lag models. *Stata Conference, Chicago* (July).

Meyer, J., and von Cramon-Taubadel, S. 2004. Asymmetric price transmission: a survey. *Journal of agricultural economics* 55 (November): 581-611.

Ministry of energy of Ukraine. http://mpe.kmu.gov.ua/minugol/#

National bank of Ukraine. https://bank.gov.ua/ua/markets/exchangerate-chart?cn%5B%5D=USD&startDate=01.01.2015&endDate=31.05.2020

Organization of Petroleum Exporting Countries. https://www.opec.org/

Pesaran, M. H., and Shin, Y. 1998. An autoregressive distributed-lag modelling approach to cointegration analysis. *Econometric Society Monographs* 31: 371-413.

Pesaran, M. H., Shin, Y., and Smith, R. J. 2001. Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics* 16 (June): 289-326.

Radchenko, S. 2005. Oil price volatility and the asymmetric response of gasoline prices to oil price increases and decreases. *Energy economics* 27(September): 708-730.

Salim, A., and Shi K. 2019. A cointegration of the exchange rate and macroeconomic fundamentals: The case of the Indonesian Rupiah vis-á-vis currencies of primary trade partners. *Journal of Risk and Financial Management* 12 (May): 1-17.

Shin, Y., Yu, B., and Greenwood-Nimmo, M. 2014. Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. *Econometric Methods and Applications New York: Springer*: 281-314.

State Statistics Service of Ukraine. Statistical information. http://www.ukrstat.gov.ua/

Trade statistics for international business development. https://www.trademap.org/

U.S. Energy Information Administration. https://www.eia.gov/

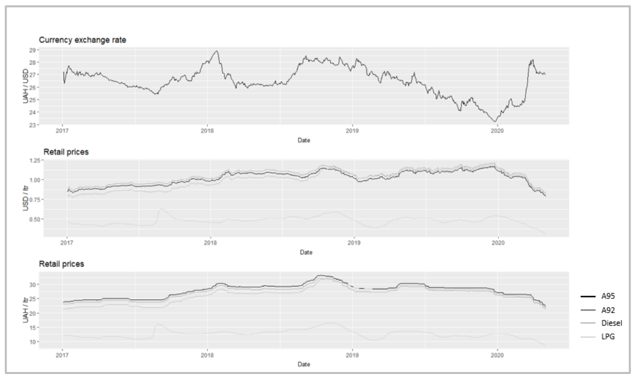
von Cramon-Taubadel, S., Loy, J. P., and Meyer, J. 2003. The impact of data aggregation on the measurement of vertical price transmission: evidence from German food prices. *The American Agricultural Economic Association Annual Meeting, Montreal, Canada* (July) (No. 376-2016-20526).

Yanagisawa, A. 2012. Structure for pass-through of oil price to gasoline price in Japan. *IEEJ Energy Journal*, 7 (August).

Zivot, E., and Andrews, D. W. K. 1992. Further Evidence on the Great Crash, the Oil Price Shock and the Unit Root Hypothesis. *Journal of Business and Economic Statistics* 10 (July): 251-270.

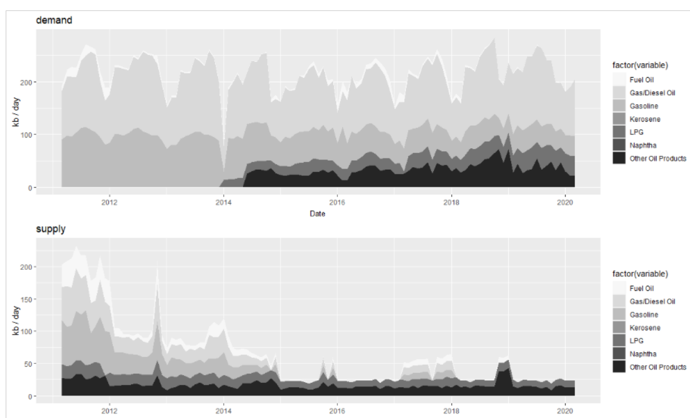
APPENDIX

Figure A. 1. Petroleum retail prices (UAH, USD) and currency exchange rate, 2017:01 2020:03.




*Source*: author's estimates based on currency exchange rate[22], retail prices [23](UAH/ltr), and own calculation for retail prices (USD/ltr).

Figure A. 2. Oil products demand and supply in Ukraine (thousand barrels per day), 2011:01-2020:03.



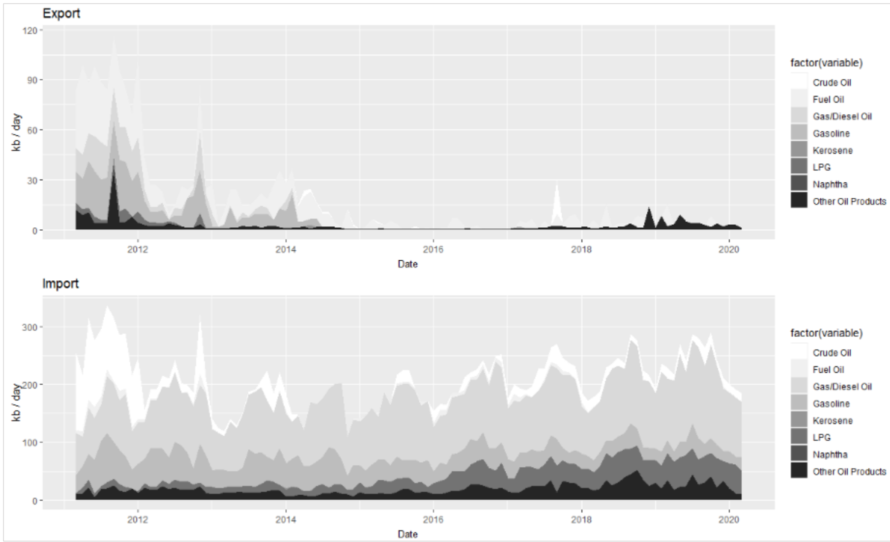

*Source*: author's estimates based on collected data JODI [24]

22 https://bank.gov.ua

23 https://minfin.com.ua

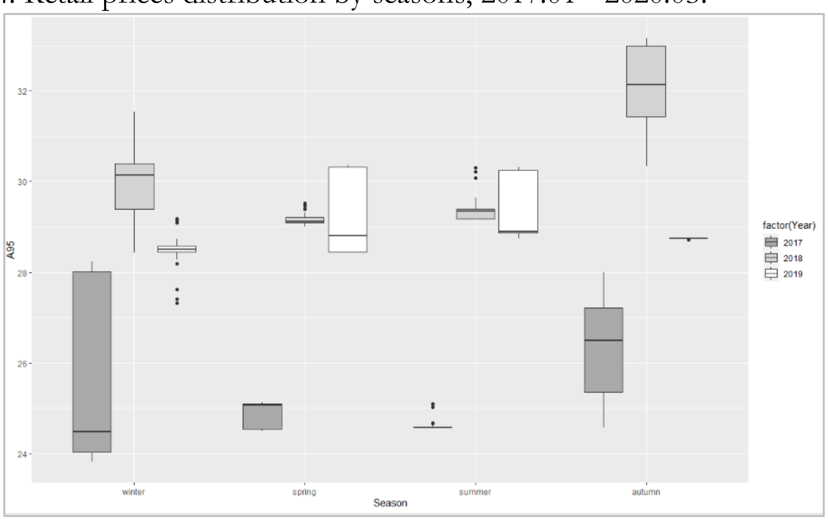
24 https://www.jodidata.org/oil/database/country-by-country-review.aspx

Figure A. 3. Oil products export and import in Ukraine (thousand barrels per day), 2011:03-2020:03.




*Source*: author's estimates based on collected data JODI [25]

Figure A. 4. Retail prices distribution by seasons, 2017:01 - 2020:03.

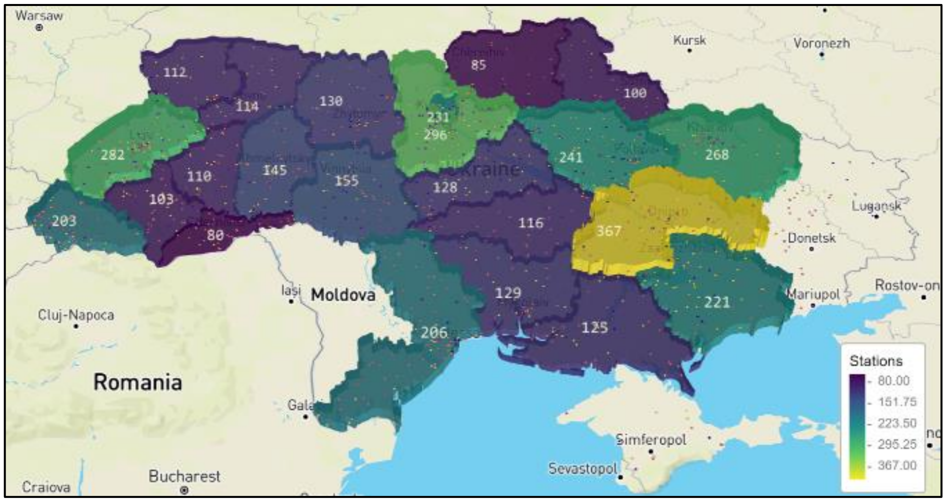



*Source*: author's estimates based on collected data for retail prices [26](UAH/ltr).

25 https://www.jodidata.org/oil/database/country-by-country-review.aspx

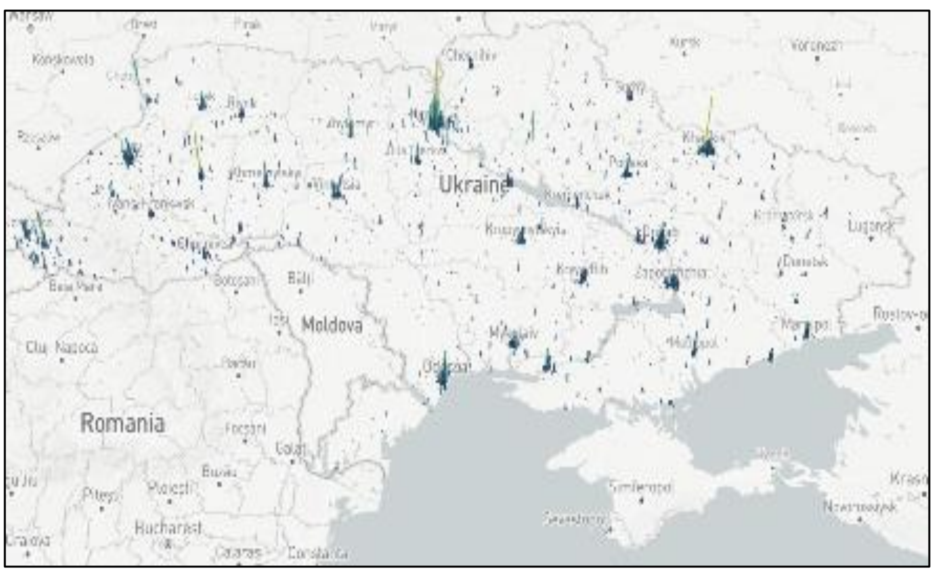
26 https://minfin.com.ua

Figure A. 5. Retail petroleum points of sales distribution (administrative unit level), 2020:06.




*Source*: own estimation based on collected data for POS.

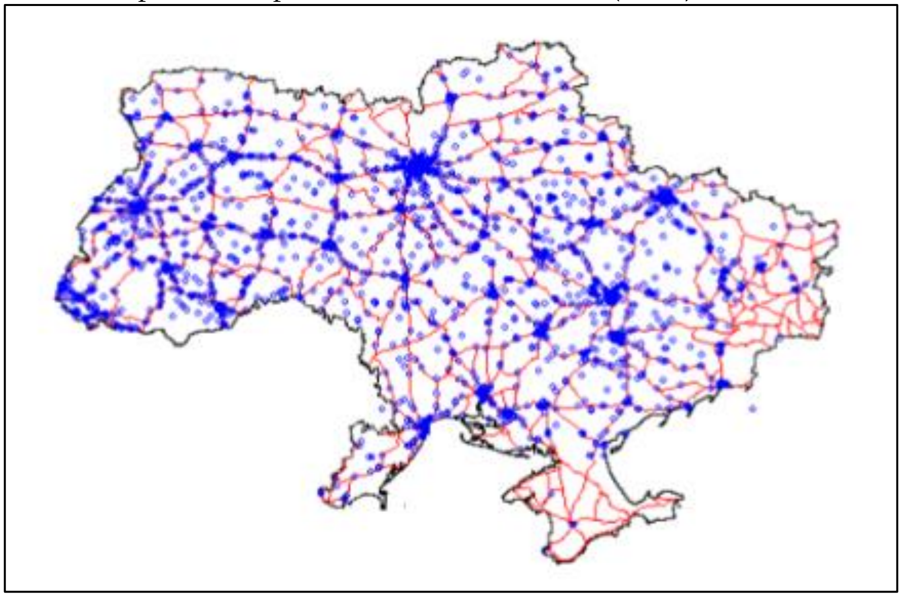
Figure A. 6. Retail petroleum points of sales distribution (city, village, settlement levels), 2020:06.




*Source*: own estimation based on collected data for POS.

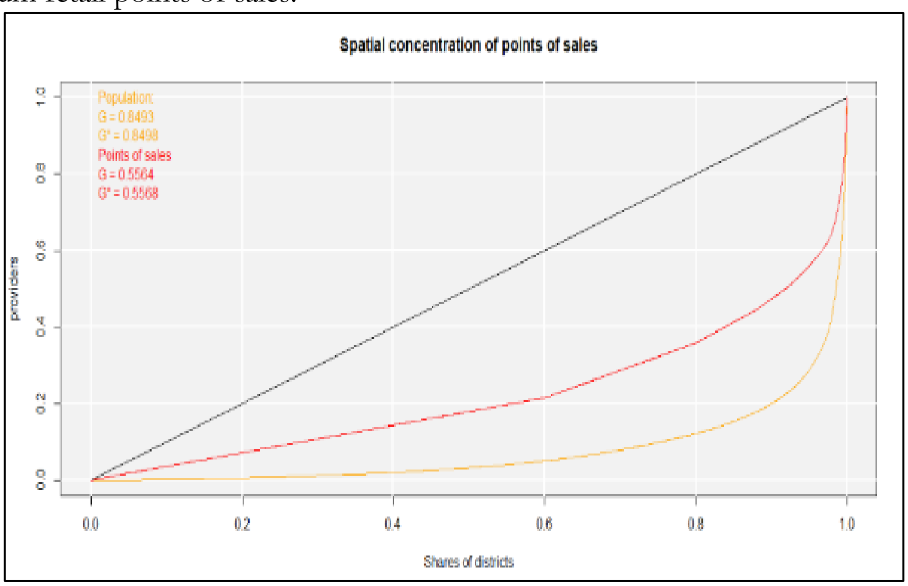
*Note*: The color and height of the hexagon is scaled by number of points it contains. The value to scale the elevations of the hexagons = 100.

Figure A. 7. Retail petroleum points of sales distribution (roads), 2020:06.



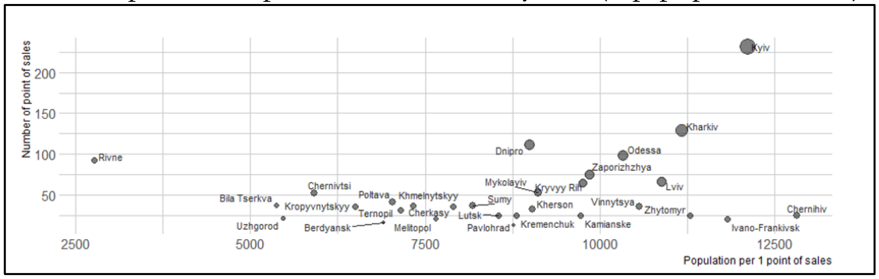
*Source*: own estimation based on collected data for POS.
*Note*: Layer are based on an array of POS projected on road map.

Figure A. 8. Gini coefficient and Lorenz curve for the number of inhabitants and petroleum retail points of sales.



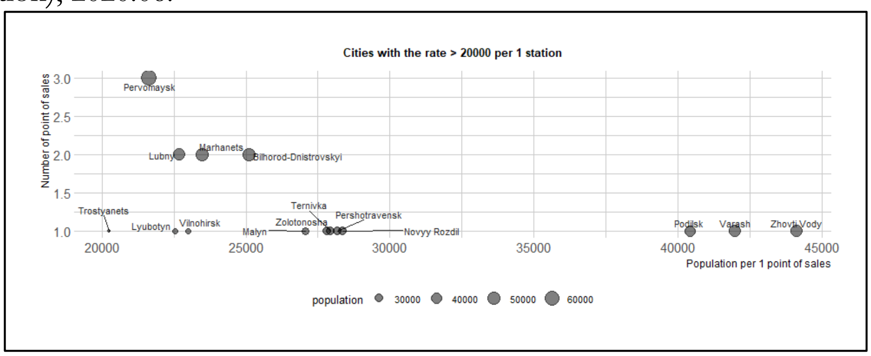

*Source*: own estimation based on collected data for POS.
*Note*: Lorenz curves (population - yellow, number of points of sales - red) and the line of equality (diagonal).

Figure A. 9. Retail petroleum points of sales density rate (top-populated cities), 2020:06.



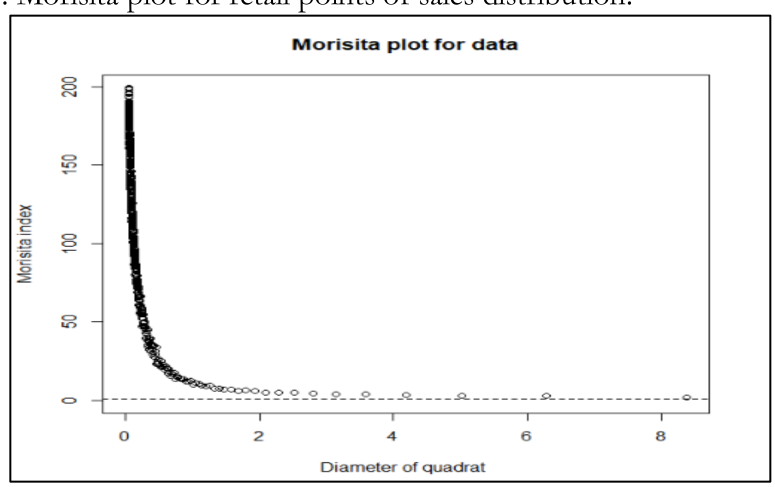

*Source*: own estimation based on collected data of POS.

Figure A. 10. Retail petroleum points of sales density rate (cities with the rate >20 000 per 1 station), 2020:06.



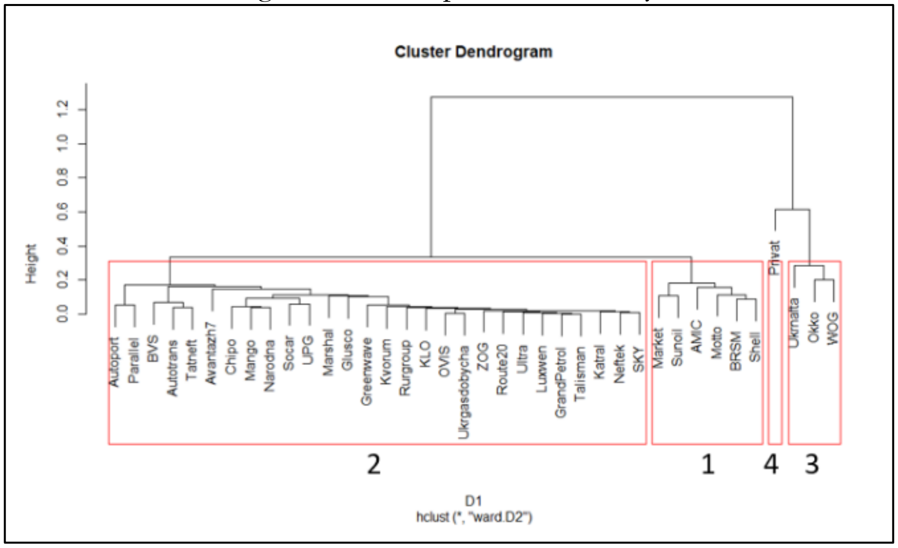

*Source*: own estimation based on collected data of POS.

Figure A. 11. Morisita plot for retail points of sales distribution.




*Source*: own estimation based on collected data of POS.

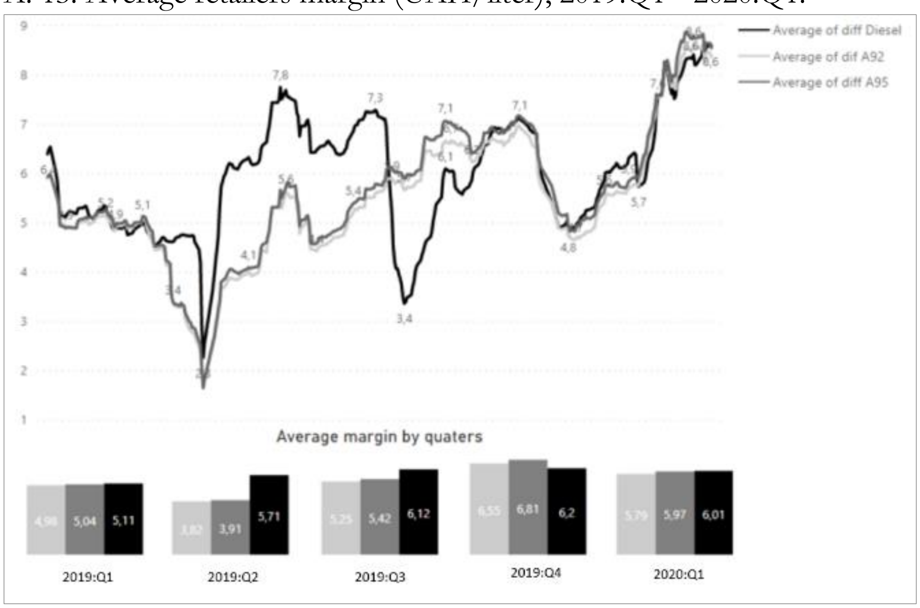
Figure A. 12. Cluster dendrogram for retail points of sales by their distribution.




*Source*: own estimation based on collected data of POS.

*Note*: Privat group includes ANP, AVIAS, AVIAS+, Mavex, Mavex+, Rubix, Sentosa, Ucon, ZNP, Uconservice brands.

Figure A. 13. Average retailers margin (UAH/liter), 2019:Q1 - 2020:Q1.

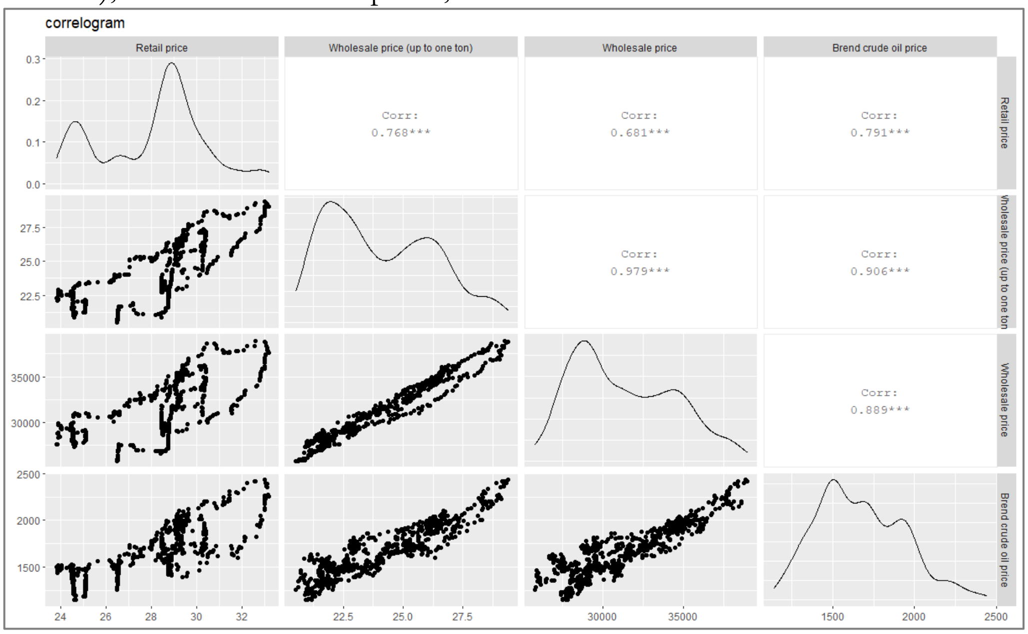



*Source*: own estimation based on collected data for retail prices [27](UAH/ltr) and for wholesale prices[28] (UAH/ltr).

27 https://minfin.com.ua

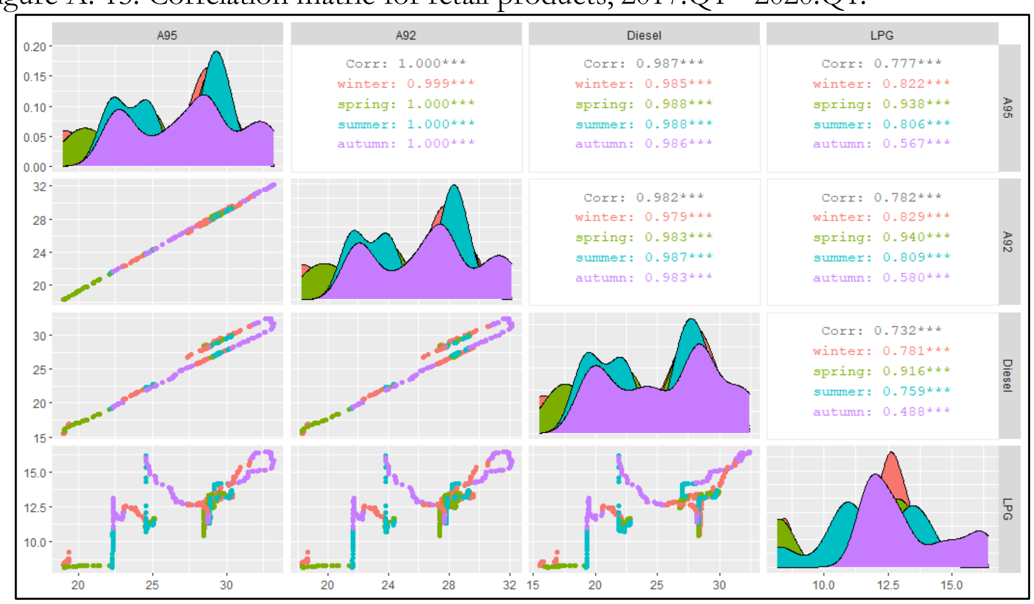
28 http://www.nefterynok.info/

Figure A. 14. Correlation matric for petroleum A-95: retail, wholesale (two types of quotations), and Brent crude oil prices, 2017:01 - 2020:03.




*Source*: own estimation.

Figure A. 15. Correlation matric for retail products, 2017:Q1 - 2020:Q1.




*Source*: own estimation.

Table A. 1. Augmented Dickey-Fuller unit root test.

| Varibles | Z(t) (p-value) | | Order of integration |
|---|---|---|---|
| | Levels | 1-st difference | |
| Oil | - 1.690 (0.436) | - 5.722 (0.000) | I(1) |
| WR | - 1.369 (0.597) | - 6.002 (0.000) | I(1) |
| RP | -0.535 (0.885) | -4.150 (0.000) | I(1) |
| critical values | -3.49, -2.88, -2.57 | | |

*Note:* H0 the time series has unit root. Dickey -Fuller critical values levels are at 1%, 5%, 10% respectively.

Table A. 2. Zivot-Andrews unit root test.

| Varibles | Test statistic | | | | | | Order of integration |
|---|---|---|---|---|---|---|---|
| | Break in intercept and trend | | Break in trend | | Break in intercept | | |
| | Levels | 1-st difference | Levels | 1-st difference | Levels | 1-st difference | |
| Oil | -4.02 (2018-W44) | -9.29*** (2018-W41) | -3.56 (2018-W20) | -9.06*** (2017-W37) | -3.38 (2018-W36) | -9.34*** (2018-W41) | I(1) |
| WR | -3.73 (2018-W44) | -4.82* (2018-W41) | -3.28 (2018-W28) | -4.65** (2017-W37) | -2.859 (2018-W35) | -4.83** (2018-W41) | I(1) |
| RP | -4.02 (2018-W34) | -7.14*** (2018-W41) | -4.35* (2018-W37) | -6.74*** (2017-W40) | -3.67 (2018-W37) | -7.18*** (2018-W41) | I(1) |
| critical values | -5.57, -5.08, -4.82 | | -4.93, -4.42, -4.11 | | -5.34, -4.80, -4.58 | | |

*Note*: estimated structural break week is in parentless; H0 the time series has unit root with structural break in the intercept, in trend, in intercept. Zivot-Andrews critical values levels at 1%, 5%, 10% respectively.