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# Studying Short-Term and Long-Term Effects of OPEC Oil Basket Prices and Natural Gas on Liquefied Petroleum Gas (LPG) Traded on Energy Exchange of Iran

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## Abstract

In this paper, we examine the short-term and long-term effects of OPEC oil basket prices and natural gas on liquefied petroleum gas (LPG) traded on Energy Exchange of Iran. tests of convergence (integration) and causality of variables have been used for 2-year period, from May 22, 2014 to July 21, 2016. The results of the study based on long-term relationship show that an increase of 1 percent in the logarithm of OPEC oil basket prices decreases 17.24 percent of the logarithm of the price of LPG. The direction of causality is from OPEC oil basket prices to LPG. Moreover, 1% increase in natural gas prices logarithm will increase 26.52 percent of the logarithm of the price of LPG. The direction of causality is from natural gas to LPG. Estimating the relationship between short-term error corrections for the logarithm of the price of LPG also confirms no statistically significant error correction component.

**Keywords:** K LPG price, natural gas price, OPEC oil basket price, tests of convergence (integration), VAR.

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## Introduction

Oil is a strategic commodity in international levels and activities of governments, agencies, and manufacturers are greatly dependent on its products and markets. Therefore, adopting any policies by governments and international organizations in the energy sector and financial markets set direct and indirect effects on the price of this commodity. Evidence shows that any changes in energy prices affect the prices of other goods as well as household consumption basket and welfare (Behradmehr, 2008). Thus, the realization of sustainable economic development depends on harmonized planning of production and utilization of energy along with other factors such as technology, human resources, raw materials, funds, and so on (Barbirolli, 2002).

Markets of crude oil and petroleum products are interconnected through two ways. On the one hand, crude oil is the main input of refineries, so its price changes greatly affect product prices as output of refineries. On the other hand, crude oil can be used only as petroleum products and its demand determines the demand for crude oil products. Thus, there is a high correlation between these two markets, and it is expected that information generated through trade in each of the two markets be one of the affective factors in determining supply and demand and therefore the price in another market (Jalali-Naini and Eskandari, 2009). Studying the relationship between crude oil prices and prices of petroleum products is very important in market analysis in terms of signaling and reaction of prices, and in the economics literature, many studies have been conducted on the interaction between crude oil prices and changes in the price of petroleum products.

On the other hand, after oil, natural gas, which is the main feed of petrochemical products, has the second most important status in the world's energy. Today, gas energy due to its many advantages, especially in terms of environmental indicators, has a major advantage compared to other energy carriers. The importance of natural gas is not simply because of its fuel value and low pollution, but this important basic raw material is of interest to users of industrial sector due to higher value-added. This means that by making chemical and physical changes on oil and gas hydrocarbons, one can increase product value as much as 10 to 15 percent (Pour Kazemi, 2006).

Despite the ups and downs of crude oil exports, with exploitation of new refinery projects, especially in South Pars region and increasing production capacity of LPG, export of this strategic gas product is on the agenda. Accordingly, it is predicted that due to complete abolition of sanctions and demand of European market requirements, this continent is first export destination of Iran LPG. Furthermore, due to start of operation of some refinery units and petrochemical projects in the Middle East, over the next few years, we will witness growth in supply of this product in this area.

Concerning the capacity of this trade of these products, it is expected that oil products demand growth from developing economies in Latin America and Asia increase more than ever. This will occur due to the growth of industrialization in these areas. On the other hand, reduced refining capacity in Europe, which has been associated with the closure of some refineries in the region, in addition to the development of the economy in the continent could lead to increased trade oil products in the region. In the field of chemical and oil products market, Asia is expected to be a key area for growth in demand in the short term. This occurs due to the process of industrialization in the region. In Europe, despite the fragility of the demand process, concerning the slow return of the economy, we will see a slight improvement in demand in the short and medium terms. On the supply side, the impact of shale gas production increase in the US supports the country's chemical products production and exports. In general, it seems that according to the available potential in the national and international levels, providing the space and infrastructure for the production of oil and chemical products to international destinations is a major step in the development of our economy, so what is studied in this research is to answer the following questions;

1. Is there a significant and sustainable long-term relationship between the prices of raw energies such as OPEC oil basket price and natural gas with LPG prices traded on Iran's Energy Exchange or not?

2. To what extent are the prices of raw energies such as OPEC oil basket price, natural gas, and LPG traded on Iran's Energy Exchange related?

3. Does the change in the price of OPEC oil-basket price and natural gas price make changes in LPG price traded on Iran's Energy Exchange or vice versa? In other words, which variable is the cause of the other variable and how is the causal relationship between these three variables?

4. In the event of a shock on OPEC oil basket price, natural gas, and LPG traded on Iran's Energy Exchange, will these variables return to their long-term path? How is the speed of adjustment?

Thus, the purpose of this study is to test the flow of information transfer between oil and natural gas markets and petroleum products. In the second part, the theoretical basics and previous studies; in third part, the status of LPG in Iran, in part four, the explanation of data and model estimation in the form of VECM models, dynamic causal relationship between the price of crude oil and natural gas and the price of products in the average level among the markets are given. Finally, in part five, conclusion of the study will be presented.

## Theoretical basics and previous studies

Energy plays a fundamental role in the economic life of industries in the communities. This means that whenever energy is available in sufficient quantities and on a timely basis, economic development will be possible as well. Meanwhile oil as the main source of human energy today is of particular importance (Romberg and Parsons, 2011).

However, in recent years with the increase in population and industry growth, the excessive use of energy resources is brought about and this has environmental impacts aftermath such as pollution of the environment, acid rain, holes in the ozone layer, global warming and climate change on the Earth's surface (Mahazab Torabi and Najafzadeh, 2011). Moreover, these consequences include economic consequences such as an increase in price caused by the scarcity of the resource (Dehgani, 2007), the need to increase investment for extraction of undetectable resource in the past with the help of new technologies (Kelt et al., 2007), and the political consequences such political crises and war.

Liquid Petroleum gas called LPG as an acronym is the by-product of the refining process and natural gas production and refining of crude oil, including propane, propylene, butane, and Butanediol in different ratios. The bulk of LPG is obtained from propane and butane with almost equal ratio. However, the composition of LPG is different for different places and at different seasons. LPG is a gas at normal temperature and pressure conditions and under pressure of 10-8 atmosphere and by lowering the temperature to about minus 160°C (minus 260 degrees Fahrenheit), its components become liquid. LPG has no color, smell, and taste is generally not harmful, but if a large amount of it is inhaled, it will cause anesthesia. Thus, considering the importance of this product, increasing demand, and interpretation of the quality of effect of OPEC oil basket and natural gas prices on the price of this product, with regard to the aims of this study and the findings of studies have been done will be discussed. The relationship between price of crude oil and natural gas prices with the price of LPG is clear because, as mentioned, natural gas and crude oil are the main feed of this product, which means that crude oil or natural gas is used in order to produce liquid gas. Therefore, any price increase of the crude oil and natural gas leads to increased production costs of LPG and thus increase in the price of this product. It should be noted that determining the type of relationship between crude oil and LPG, due to the complexity of the analysis of the oil market, is not simple and requires complete and comprehensive analysis. In the following chart, the changes in logarithm of prices OPEC basket of crude oil, natural gas, and LPG are provided in the period under study.

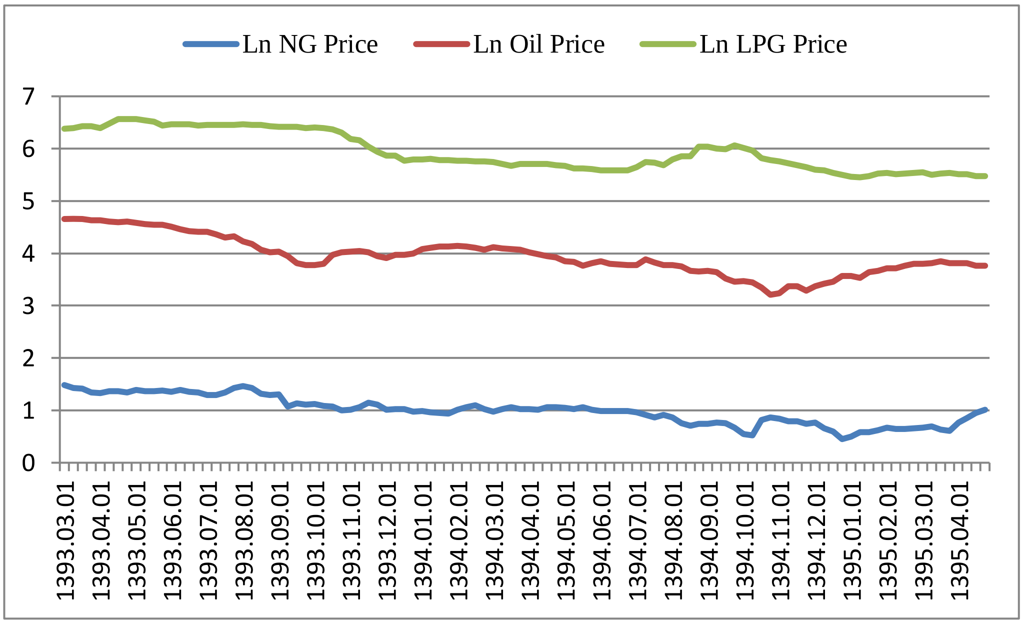


Figure1. Price logarithm trend of OPEC oil basket, natural gas and LPG in the study period

As can be seen in Figure 1, the price of LPG changes with significant correlations with OPEC basket price of crude oil and natural gas.

There exists a number of hypotheses regarding possible driving factors of the LPG price.The hypotheses are based on assumptions that directly or indirectly may affect the price. In general, the factors affecting the price of LPG can be divided as follows:

| | |
|---|---|
| Correlation between the price of LPG and natural gas prices | 82.71% |
| Correlation between the price of LPG and OPEC oil prices | 73.08% |

*Crude Oil*

The crude oil hypothesis, that the LPG price is related to the crude oil price, exists for two reasons. First, LPG is produced by refining crude oil. Second, oil can be seen as an alternative heating fuel in many applications, with the same flexibility as LPG. So if the price differs too much consumers will switch to the cheaper fuel. Almost all prices of energy sources has some connection to the oil price, making this a very natural hypothesis.

The crude oil hypothesis will be evaluated by examining the correlation between logreturnsof propane and crude oil.

*Natural Gas*

In the same way as one can assume that the LPG price is connected to the crude oil price one can assume that it is connected to the natural gas price; a little more than half of LPG is produced from natural gas. However, the alternative fuel hypotheses is not as strong in this case. Natural gas does not have the same flexibility as oil and LPG since it is harder to distribute. Natural gas often requires a gas network even though Liquefied Natural Gas (LNG) is becoming increasingly popular. Because of this, natural gas is not a competitive alternative fuel in markets without a gas network.

*Naphtha*

The naphtha hypothesis is particularly strong in regions with much petrochemical industry,like NWE. Naphtha, just like LPG, is one of the light distillates in the crude oil refining process. The main use of naphtha is as a high octane component in gasoline and as feedstock for cracking in petrochemical industry. Many crackers can alter their use of feedstock and chooses the most cost efficient according to the demand of petrochemical products. However, the choice of feedstock for cracking affects the outcome of products,so demand for different products may also influence the choice of feedstock. Since the petrochemical industry is a large consumer of LPG the demand from this sector may affect the LPG price. It is common that two parameters, naphtha-spreadand naphtha-ratio, are discussed in the LPG pricing. The naphtha-spread is the difference in price between LPG and naphtha

$$P_{LPG} - P_{Naphtha}$$

and the naphtha-ratio is the quotient

$P_{LPG}/P_{Naphtha}$

### *Seasonal Variation*

The seasonal hypothesis exists since the LPG price often is lower during spring and summer than during winter. When LPG is used for space heating, typically in the domestic sector, the consumption depends on outdoor temperature. Therefore, one expects a connection between the LPG price and temperature. Another reason for a seasonal variation is that the production of LPG is relatively constant throughout the year while demand varies. The storage shortage makes it hard to store LPG for later use, which sometimes forces producers to dump the LPG price when their storages are filled up during periods of low demand. Demand is typically low during summer months because of lower heating needs and lower industrial use due to vacations. Another possible reason for a seasonal variation is industrial and economical cycles. In good market conditions, demand from industry is high and companies are more willing to pay a higher price for feedstocks, such as LPG. In a bad economic environment, demand is typically low and companies are not willing to take the risk of purchasing LPG in large quantities. The market condition can be quantified using stock and industry indexes.

### *East-West Spread*

The East-West spread is a frequently discussed phenomenon in the LPG trading. It is defined as the difference in LPG prices between a western region, like NWE or Mediterranean,and an eastern region, like Japan or China

$P_{west} – P_{east}$

Sometimes, when the actual difference in prices are unimportant the East-West ratio is used instead

$P_{west}/P_{east}$

The strongest argument for its importance is that arbitrage opportunities will arise if the spread becomes too large. The arbitrage opportunity is to buy LPG in region with low price (western region) and sell in region with high price (eastern region).

### *Other Factors*

There are more hypotheses about driving factors of the LPG price. These other factors are not examined further in this thesis, but some of them are discussed shortly below.

- Changes in Supply and Demand
- Psychology
- Shipping Availability

On the other hand, prices in Outcry Markets are in Continuous Equilibrium form, so that at any moment, information on supply and demand enters the market and the equilibrium price is obtained. Studying the dynamic relationship between the price of crude oil and product prices in the past two decades has accounted for a significant part of the studies in the field of energy economics. The focus of these studies varies according to the following areas: The type of model used, period, type of data, market under study, and the production-distribution chain. The first study was conducted by Bacon (1991) to evaluate different reaction of gasoline prices to crude oil prices rise and fall. This study was conducted for gasoline market in England in 1982-1989. The result of this study showed that full transfer of price rise of crude oil to gasoline prices is faster than price reductions. Manning (1991) has studied the British gas market with an ECM model for the period 1973-1988 and found a weak asymmetry. Karrenbrock (1991) conducted the first study for market of America using monthly data for the period 1983-1990 and with a distributed lag model showed that the wholesale price increase transfer to the consumer is faster than the decline in prices.

The study by Borenstein et al. (1997) is the most notable one conducted in America's gasoline market for the period 1986-1992 by using weekly data and an ECM a model. The results confirmed the public perception that faster response of gasoline prices to the rise in oil prices against reduction. Balke et al. (1998) expanded the study by Borenstein et al. using three models VAR, EKM, and a general model for weekly data of period 1987-1997. They concluded that in all cases, the origin of shock is from upstream to downstream and asymmetry was observed in all models, but asymmetry in ECM model was several times morer than VAR model.

Frank Asche et al. (2003) in the framework of the multivariate model VECM and the monthly data for the period 1992 to 2002 studied the relationship between the price of Brent crude oil four main products (diesel, naphtha, kerosene, and heavy fuel oil) in Europe. Results of the study show that there is a long-term relationship between the price of crude oil and petroleum products except heavy fuel oil. Moreover, a long-run relationship was observed between the price of diesel, kerosene, and naphtha in the market.

Using weekly data, Denni and Frewer (2006) examined the relationship between crude oil price volatility and the price of six products in Europe market within ECM framework for the period 1990 to 2005 and showed that the price of Brent crude oil compared to every exogenous six product is weak. In this study, taking into account the profit margin of the refineries, it was observed that this variable has a meaningful and important effect on asymmetric reactions of gasoline prices to crude oil price changes.

Using data from the monthly prices of crude oil and liquefied natural gas (LNG) in Japan for 1995 to the first quarter of 2008, Mansour Kiai (2008) examined the relationship between the price of crude oil and LNG. The results show that in short-term in Asian Southeast market (Japan), per dollar change in the price of crude oil, LNG price will change $ 0.0256. Moreover, coefficient of error correction component shows that at any time if the prices of oil and gas get away from their long-term relationship, gas price moderates the gap emerged at a rate of 10 percent per month that means with every shock in oil prices, the adjustment of 90% will take 12 months.

In another study, using econometric techniques of Vector Autoregressive (VAR) and monthly data from January 2001 to February 2009, Mohammadi and Taherkhani (2009) reviewed and identified the relationship between crude oil prices and natural gas, taking into account its consumption. They concluded that one percent shock in OPEC oil price basket in the long-term would change the price of natural gas by 4 percent. Moreover, with a 100,000 units change in the consumption of natural gas, a change of 0.443 unit increase in the price of gas would be created.

In a study, using VECM model and data of period from January 18, 2009 to September 18, 2011, Nikuegbal, Gandali Alikhani, Naderi (2013) examined the short-term and long-term relationship between crude oil prices and methanol prices in Iran. The results show that there is a significant relationship between Iranian crude oil price and the price of methanol in long-term and this despite the fact that these variables do not have a significant relationship in short-term.

The studies conducted have mainly examined the behavior of gasoline prices and the quality of transfer of crude oil price changes to the price of gasoline in retailer markets, and in few studies, the mutual relationship between crude oil prices and prices of products have been investigated. Results of the studies show that the long-term causal relationship between crude oil prices and the price of petroleum products is always from crude oil prices and the price of products has an asymmetrical response to changes in crude oil prices. In studies conducted mainly the impact of crude oil prices on gasoline prices has been examined and shown that causality is always from the price of crude oil to the price of petroleum products. On the other hand, a great part of studies in relation to crude oil prices and products have been to test the asymmetric reaction of products price and mainly for gasoline, and nearly two-thirds of the studies have confirmed the existence of asymmetry in the response of gasoline prices to crude oil price changes. In 2003 and 2004, with a sharp reduction in storage of petroleum products in America and Europe and problems on the supply side, the product market could not perform Quantitative Adjustment so the price adjustment was towards increase the price of products followed by increase in the price of products, psychological atmosphere was created in the market for crude oil price increase. Thus, it is expected that products price changes in recent years affect the crude oil price changes (Jalali Naini, Keshavarz Haddad, Eskandari Zanjani, and Zamani, 2009).

## Examining the status of LPG in Iran

Until a few years ago, despite LPG production in order to meet the domestic needs of the country, Iran was forced to import this oil product. Now, it provides not only its domestic needs, but it has also joined the exporter of oil products. LPG production is done in refineries, crude oil, gas refineries and petrochemical plants. At the beginning of Iran's joining to LPG exporting countries, Iran could export only about 600 to a thousand tons per day, but with increase in production during refinery-expansion in the country, excess of domestic consumption needs has increased. If domestic consumption of oil products is

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managed, the possibility of its export to more than 4 tons per day will be granted. In recent years, and even before Geneva deal, some Asian countries such as South Korea despite opposition from the West have joined to Iran's gas customers. The basic demand from Asian countries is very strong. This applies in particular to China and India, whose imports had an increasing trend in recent years. Part of this is due to increased use of domestic LPG gas (capsules). Import has been relatively low among OECD countries. Japan, as the largest traditional LPG importer, has not had a great increase in imports. The Asia Pacific is the world's largest importer of LPG cargoes. As seen in Table below, from the beginning of trading of LPG in the Energy Exchange market to the end of July of 2016, 185.145 tonnes of LPG is traded to the approximate value of 1.817 billion riyals, of which 77% of the total value of transactions, the equivalent of 149. 010 tons, valued at 1.402 billion riyals in the international ring has been imported to Pakistan, Afghanistan, Armenia, Iraq and Georgia.

Table 1 Traded value, Traded volume and Relative to the total

| Year | Traded value (billion) | Traded volume (tons) | Relative to the total |
|---|---|---|---|
| 2013 | 28.8 | 1,200 | 0.65% |
| 2014 | 424.0 | 28,750 | 15.53% |
| 2015 | 871.3 | 87,000 | 46.99% |
| To the end of July 2016 | 492.8 | 68,195 | 36.83% |
| Total | 1,816.9 | 185,145 | 100% |

Source: Statistics of Iran Energy Exchange trading www.irenex.com

Table2. Traded value, Traded volume and Relative to the total

| | Traded value (billion) | Traded volume (tons) | Relative to the total |
|---|---|---|---|
| International ring | 1,402 | 149,010 | 77.16% |
| Domestic ring | 415 | 36,135 | 22.84% |
| The total market. | 1,817 | 185,145 | 100% |

Source: Statistics of Iran Energy Exchange trading www.irenex.com

Moreover, refineries of Shazand, Abadan, Lavan and Bandar Imam (almost 90 per cent of supply) have the highest supply of LPG, respectively, in Iran's energy exchange to Pakistan, Afghanistan, Georgia and so on. During investigations, Pakistan and Afghanistan, respectively, have been identified as the most desirable target markets for LPG products during the period under review by Iran's Energy Exchange market were identified.

## Specify the model

In this study, time series of oil basket price for organization of the petroleum exporting countries (OPEC) that includes weighted average of light and heavy oil prices of member states, is considered as time series of oil price and its impact on the price of LPG is used as an important and effective variable. The impact of crude oil price in the price of LPG and subsequently the supply of gas to the energy markets is very important and can be the results of this research. Also, the time series of Henry Hub Natural Gas Spot Price has been used as another independent variable affecting the price of liquefied gas. Here, it should be noted that merely the prices discovered in Iran's energy stock exchanges that mainly conducted (almost 77 percent) to export to neighboring countries were used for calculating the price of liquefied petroleum gas (LPG). The data used in this study is from the first week of June 2014 until the final week of July 2016 on a weekly basis. Econometric model in this research is Vector Auto Regressive (VAR) technique and then long-run relationship and convergence (co-integration) of the model data using Johansen-Juselius method will be investigated. Error correction mechanism (ECM) to review the short-run balance as well as short-run behavior associated with long-run behavior will be used in this study.The variables used in this model are:

1) Logarithm of LPG price (LnLPG) traded on the Iran's energy stock exchange: as dependent variable

2) Logarithm of OPEC basket price (LnOil): as independent variable

3) Logarithm of natural gas price (LnNG): as independent variable

### *Description of data*

As mentioned above, weekly data of logarithm of LPG price (LnLPG) traded on the Iran's energy stock exchange, OPEC oil basket (LnOil) and natural gas (LnNG) from the first week of June 2014 until the final week of July 2016 was used in the study.

### *Unit Root Tests*

Since most macroeconomic variables are nonstationary and all variables of model should be integrated from the first grade in Johansen-Juselius co-integration models to be used in this method, so we initially show that these three variables logarithm of OPEC oil price (LnOil) and logarithm of natural gas price (LnNG) and logarithm of LPG price (LnLPG) have this feature and therefore, the use of above method in this paper is permitted. This section examines the stationary (stability) properties of variables using Augmented Dicky- Fuller (ADF) and Phillips-Perron (PP) unit root tests. A time series variable is stationary when mean, variance and autocorrelation coefficients remain constant over time. In other words, if the shock imported, the shock will have lasting effect in a stationary time series and then again time series returns to its mean. Augmented Dicky- Fuller (ADF) and Phillips-Perron (PP) tests for time series logarithm of OPEC oil price (LnOil) and logarithm of natural gas price (LnNG) and logarithm of LPG price (LnLPG) indicate that all three variables at data level are nonstationary. When nonstationarity of a time series variable was proved, random shocks will have lasting effect on the variable; i.e. if a shock to variable time series to be imported, it will be able to change the variable level, because the impact of the shock is permanent and variable level of the previous trend away. Lack of stationary occurs in the case of most economic data, especially macroeconomic variables that have a random trend. In the following Table, the results of Augmented Dicky- Fuller (ADF) and Phillips-Perron (PP) tests.

Table 4 Stationary test of variables using ADF and PP tests

| Variable | Level | | Once differencing | |
|---|---|---|---|---|
| | ADF | PP | ADF | PP |
| LnOil | -2.004 | -1.91 | -7.59*** | -7 .71*** |
| LnLPG | -0.83 | -0.9 | -7.51*** | -7.99*** |
| LnNG | -1.92 | -1.92 | -8.46*** | -8.32*** |

* Significant at 10% level ** Significant at 5% level *** Significant at 1% level

After a once differencing of the intended time series variables in the model, all became stationary. So nonstationary hypothesis in the first subtraction is rejected in 3 critical levels. All of variables presented in the model, as shown in the Table below, are stationary order (1) I; in other words, the data have difference stationary trend. Although the stationary condition of time series variables in a regression equation can be provided through differencing, certain work for long-run data retention in conjunction with a variable level cannot be performed, because we lose valuable information about level of variables in the long-run by differencing. Here, co-integration of time series should be proved, so that a regression to be estimated without fear of being false. The economic concept of co-integration is that when two or more time series on theoretical grounds are linked together to form a long run relationship. Although the time series may have random trend (to be nonstationary), they well follow each other over time, so that the difference between them is stable (stationary). In this case, co-integration component provides valuable information for long-run relationships which the lack of considering it can be inefficient estimates or long-run relationship between the variables in estimating to be ignored. Engle and Granger (1987) stated that if they perform Dicky- Fuller test on the model residuals and time series residuals are stationary, then combination of series are stationary and two series are co-integrated, that is, with a long-run. Engel-Granger co-integration test results on the logarithmic price series residual show that series residual is stationary and consequently combination of series is co-integrated.

Also before the estimate of long-run relationship between several variables, we must make sure that these variables can explain each other, in other words, causality relation between variables and its direction have been identified. Causal relationship between the two variables shows that changes in one variable will lead to a change in another variable. To know how is the direction of causality relation between price logarithmic series, we have used Engel-Granger causality test. Engel-Granger causality test suggests that causality relation between price series is one-way; in other hand, the hypothesis "the price of LPG is not Granger cause of OPEC oil prices" cannot be rejected, but the hypothesis "OPEC oil prices is not Granger cause of price of LPG" at a significance level of below 5 percent is rejected. So, causality relationship is one-sided and from direction of OPEC oil prices to the price of LPG. In other words, it can be expected that OPEC oil price data in explaining changes and forecasting LPG price data can be helpful. Thus the hypotheses "natural gas price is not Granger cause of price of LPG" at significant level of under 13% and "the OPEC oil price is not Granger cause of natural gas prices" at significance level below 5% are rejected. Therefore, another one-way causality relation, based on the impact of natural gas price on the price of LPG and impact of OPEC oil price on the natural gas price in accordance with hypotheses stated in the part of theoretical principles is confirmed.

Table 5. Granger causality test results

| | | | |
|---|---|---|---|
| Pairwise Granger Causality Tests | | | |
| Date: 02/05/17 Time: 11:14 | | | |
| Sample: 1 104 | | | |
| Lags: 2 | | | |
| Null Hypothesis: | Obs | F-Statistic | Prob. |
| LOIL does not Granger Cause LLPG | 102 | 4.04443 | 0.0206 |
| LLPG does not Granger Cause LOIL | | 0.98582 | 0.3768 |
| LNG does not Granger Cause LLPG | 102 | 2.11118 | 0.1266 |
| LLPG does not Granger Cause LNG | | 1.08993 | 0.3403 |
| LNG does not Granger Cause LOIL | 102 | 0.31865 | 0.7279 |
| LOIL does not Granger Cause LNG | | 8.19909 | 0.0005 |

*Specify the VECM model, examine the short-run dynamics and extraction of long-run relationship*[2]

In this section, extraction and evaluation of long run relationship between the logarithm of LPG price and variables affecting on it, i.e. logarithm of OPEC oil price and logarithm of natural gas price, as well as the effect of shocks and long run shocks on this

[2] For further study in the field of VAR model, see to the following resources:

Enders (1995), Greene (1997), Patterson (2000) variable will be investigated. Determining the optimum lag, evaluation of long run relationship of Johansen-Juselius method are subdivisions of this part. Since the variables of model are not at stationary level, but are co-integrated, so it is better to use a VECM model instead of using VAR model. But before the estimate, the number of optimum lag should be determined.

*Determine the optimal lag using the VAR model*

To estimate the VECM model, determining the optimal lag of model is very important. For this purpose, the Akaike information criterion (AIC), Schwartz-Bayesian information criterion (SC), final prediction error (FPE) and sequential modified likelihood ratio test statistic (LR) are used to determine appropriate lag using VAR model. These statistics are presented in the Table below to determine the optimal lag. But due to proper accuracy, Bayesian-Schwartz information criterion has been used in this study as criterion for choosing the optimal lag that the test results based on this criterion indicate a lag for the model.

Table 6 the test results based on this criterion indicate a lag for the model.

VAR Lag Order Selection Criteria
Endogenous variables: LNLPG LNOIL LNNG
Exogenous variables:
Date: 02/05/17 Time: 11:42
Sample: 1 104
Included observations: 92

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 1 | 424.0155 | NA | 2.42e-08 | -9.022076 | -8.775379* | -8.922507* |
| 2 | 435.5630 | 21.58888 | 2.29e-08 | -9.077457 | -8.584064 | -8.878319 |
| 3 | 443.7130 | 14.70543 | 2.34e-08 | -9.058979 | -8.318889 | -8.760272 |
| 4 | 454.5660 | 18.87482 | 2.25e-08* | -9.099262* | -8.112475 | -8.700986 |
| 5 | 458.7667 | 7.031469 | 2.51e-08 | -8.994927 | -7.761444 | -8.497083 |
| 6 | 469.0806 | 16.59200 | 2.46e-08 | -9.023492 | -7.543311 | -8.426078 |
| 7 | 477.0125 | 12.24264 | 2.54e-08 | -9.000271 | -7.273394 | -8.303289 |
| 8 | 489.6824 | 18.72947* | 2.37e-08 | -9.080052 | -7.106478 | -8.283501 |
| 9 | 498.2285 | 12.07605 | 2.44e-08 | -9.070185 | -6.849915 | -8.174065 |
| 10 | 506.7598 | 11.49869 | 2.51e-08 | -9.059996 | -6.593029 | -8.064307 |
| 11 | 509.2877 | 3.242256 | 2.97e-08 | -8.919297 | -6.205633 | -7.824040 |
| 12 | 516.7322 | 9.062944 | 3.17e-08 | -8.885483 | -5.925123 | -7.690657 |

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

*Investigate the long run relationship using Johansen- Juselius method*

This method is used to extract the long-run relationship between the variables. First, using the two statistics the maximum Eigen value statistic and trace statistic, convergence and number of convergence relations are characterized. Determining the two mentioned statistics is possible in five different modes, from most non bounded mode to most bounded mode. The main difference of these scenarios is to consider or not consider the intercept or trend in VAR model and long run relationship. However, according to the results obtained, mode the most significant mode occurs when long-run relationship has intercept and without trend. In the maximum Eigen value statistic, null hypothesis of the non-existence of convergence relation against the existence of a convergence relation and existence of one or less than one convergence relation against existence of two convergence relations and… will be tested respectively. In the trace statistic, the hypothesis non-existence of convergence relation against the existence of one or more convergence relations and existence of one or less than one convergence relation against existence of two or more than two convergence relations and… will be tested respectively. If the test statistics of the variables exceed the critical values at 5% level, opposite hypothesis is accepted. Based on what mentioned, results of trace and maximum Eigen value statistics along with the zero and one hypotheses (opposite hypothesis) have been summarily provided in the following Tables.

*Investigate the number of convergence relationships using trace statistic and maximum Eigen value statistic*

Table 7 Rejection of the null hypothesis and acceptance of opposite hypothesis regarding the existence of one long run relationship

| Test Method | Test of non-existence long run relationship (r = 0) | | Test of existence of at least one long run relationship (r≥1) | |
|---|---|---|---|---|
| | Test statistic | Critical values (at 95 percent) | Test statistic | Critical values (at 95 percent) |
| Trace statistic | *38.18 | 29.79 | 11.30 | 15.49 |
| Maximum Eigen value statistic | *26.88 | 21.13 | 6.29 | 14.26 |

The results presented in the above Tables confirm the existence of a convergence (co-integration) vector by both trace statistic and maximum Eigen value statistic in the ideal case with intercept without trend.With regard to the issues raised above, the fulfilled long run relationship is obtained as follows:

$$LnLPG = -47.57 \underset{(4.99)}{- 17.24 * LnOIL} + \underset{(5.55)}{26.52 * LnNG}$$

As can be seen, the obtained long run relationship has a positive coefficient of 26.52 and negative coefficient of 17.24 for the logarithm of natural gas price and the logarithm of OPEC oil price which are statistically significant. (The number in parentheses indicates the t-student statistic that because it is larger of the 2 as a rule of thumb, therefore, the null hypothesis of zero slope of the equation is rejected at the 95% confidence level and values of obtained coefficients are significant). Interpretation of the above extracted model is as follows:

1. According to sign of coefficients, the increase in OPEC oil price has a negative effect on liquefied petroleum gas (LPG) price in the long run.

2. According to sign of coefficients, the increase in natural gas price has a positive effect on liquefied petroleum gas (LPG) price in the long run.

3. If the logarithm of the OPEC oil price increases by 1 percent, the logarithm of the liquefied petroleum gas (LPG) price is reduced at a rate of 17.24 percent.

4. If the logarithm of the natural gas price increases by 1 percent, the logarithm of the liquefied petroleum gas (LPG) price is increased at a rate of 26.52 percent.

## Convergence and Error Correction Mechanism (ECM)

Existence of convergence (co-integration) between a set of economic variables provides statistic basis for using error correction pattern. So that according to Granger case, there should be a short-run relationship as error correction mechanisms to achieve long-run equilibrium corresponding to each long run economic relationship. This concept was first introduced by Philipps, P.C.B. and Perron, P. “stabilization policy and time form of lagged responses” in 1957. As the study showed that variables of the model including logarithm of the price of LPG and logarithm of OPEC's oil price are convergent (co-integrated) and existence of a short-run relationship between them is confirmed. To check the short run equilibrium, it is essential to relate the short-run behavior with long-run behavior using the equilibrium error term. The operation is called error correction mechanism (ECM).

Usually an estimate of the residual is used as equilibrium error term in the model. This term with a period of time lag is inserted in the right-hand side of the model. This case shows short-run main variables of the model and error correction term reflects the long-run changes in the model. If coefficient of the error correction term is statistically significant, indicating how much of an imbalance of dependent variable in a period will be corrected in the next period. According to the description provided, the results of the relationship between model variables of LPG were obtained as follows:

Table 8 results of the relationship between model variables of LPG

| Error Correction: | D(LNLPG) | D(LNOIL) | D(LNNG) |
|---|---|---|---|
| CointEq1 | 0.001 | -0.001 | 0.008 |
| | [ 0.93] | [-0.73] | [ 4.87] |
| D(LNLPG(-1)) | 0.287 | 0.104 | -0.235 |
| | [ 2.89] | [ 0.87] | [-1.82] |
| D(LNOIL(-1)) | -0.141 | 0.282 | -0.231 |
| | [-1.61] | [ 2.68] | [-2.02] |
| D(LNNG(-1)) | 0.056 | -0.051 | 0.159 |
| | [ 0.78] | [-0.59] | [ 1.72] |
| C | -0.008 | -0.006 | -0.007 |
| | [-1.656] | [-1.04] | [-1.25] |
| R-squared | 0.11 | 0.09 | 0.22 |
| Adj. R-squared | 0.08 | 0.05 | 0.19 |
| Sum sq. resids | 0.19 | 0.27 | 0.31 |
| S.E. equation | 0.04 | 0.05 | 0.06 |
| F-statistic | 3.06 | 2.32 | 7.03 |
| Log likelihood | 176.98 | 158.50 | 150.55 |

| | | | |
|---|---|---|---|
| Akaike AIC | -3.37 | -3.01 | -2.85 |
| Schwarz SC | -3.24 | -2.88 | -2.73 |
| Mean dependent | -0.01 | -0.01 | 0.00 |
| S.D. dependent | 0.05 | 0.05 | 0.06 |

Accordingly, the estimated short-run equation can be identified as follows:

$$D(DLP\ LPG) = -0.0075 + 0.28 * D(LNLPG(-1)) - 0.14 * D(LNOil(-1)) + .056 * D(LNNG(-1)) + .0012 * CointEq1$$

Results of short-run pattern show that coefficient of the error correction term estimated was not statistically significant, thus the null hypothesis based on zero slope of the equation cannot be rejected at the 95% confidence level. Although the size of the coefficient represents the speed of adjustment towards long-run equilibrium, in the studied model, a short-run relationship between the variables examined in this study cannot be imagined, due to the lack of statistical significance.

## Estimation of error correction model

### *Examine the dynamics of the variables in VAR model*

Among the applications of VAR model is that it can examine the dynamics of variables (their response) to the imported shock over time. The effect of this shocks on i-th variable not only directly affects the variable, but also affects all the endogenous variables in a dynamic structure of VAR. We use two criteria of Impulse response function and variance decomposition.

### *A) Impulse Response Function (IRF)*

Impulse response functions show the dynamic behavior of the model variables during an impulse (momentum) unit to each of the variables over time. These impulses are usually selected in the size of a standard deviation, so they are called momentum or impulse unit. Coordinates origin or starting point of response variable is the values related to steady-state of device (without momentum). Using impulse response function, response of the device dynamics impulse unit imposed by any of the device variables is identified.

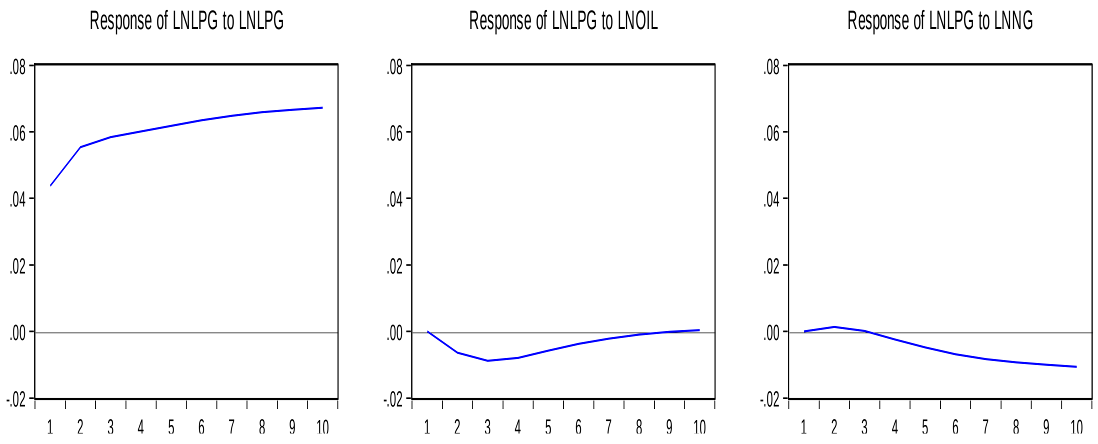


Figure 2 Response of logarithm of LPG price (LNLPG) to one standard deviation of shock imported by explanatory variables in ten periods

As we can see in the figure above, the change in one standard deviation of both explanatory variables of model has effect on logarithm of LPG price (LNLPG). Accordingly, change to the size of one standard deviation in the logarithm of the OPEC oil price (LNOIL) has no effect on logarithm of the price of LPG in the long run. Although the response after the first period to the seventh period initially decreased and then to the level of lack of change increased. Hence it can be concluded that the deviation happened in the logarithm of the price of LPG to the seventh period was corrected and eighth period to the next would be unaffected. Also, a change of one standard deviation in the logarithm of the natural gas price (LNNG) to the third period does not affect the logarithm of LPG price and then will be negatively effective on the logarithm of the price of LPG until the end of the period. But more striking point is the most considerable influence of the logarithm of the price of LPG on itself. So that, with the change of one standard deviation of the logarithm of the price of LPG after a period, we witnessed a positive and growing impact on the price of this product that continues for a long run period. And this confirms that traders and activists in this area carefully review and consider price trends of previous periods of this product mainly to study the volatility and price shocks of LPG. Although findings of this research are not very compatible with theoretical expectations regarding the impact and shock release from the logarithm of prices of oil and natural gas to the logarithm of the price of LPG, it reflects the reality of trading strategies in the Iran's energy stock new market.

### *B) Variance decomposition*

Unlike impulse response functions which indicate the impacts of a shock on an endogenous variable and other variables of VAR, variance decomposition gives information about the relative importance of each random change on variables of VAR. Like before state, this criterion also imposes an impulse (shock) in the size of one standard deviation of each variable on the variable and other variables of the model, and then specifies that how much is the relative importance of each of the variables in changes of other variable (s). In Table 1, we can observe the result of this criterion to change in a standard deviation of each of the explanatory variables.

Table 9 Variance decomposition of the logarithm of the LPG price

| Variance Decomposition of LNLPG: | | | | |
|---|---|---|---|---|
| Period | S.E. | LNLPG | LNOIL | LNNG |
| 1 | 0.043766 | 100.0000 | 0.000000 | 0.000000 |
| 2 | 0.070925 | 99.14645 | 0.817645 | 0.035901 |
| 3 | 0.092321 | 98.58132 | 1.397416 | 0.021260 |
| 4 | 0.110479 | 98.44834 | 1.489363 | 0.062300 |
| 5 | 0.126832 | 98.46454 | 1.340308 | 0.195154 |
| 6 | 0.142046 | 98.47276 | 1.138470 | 0.388772 |
| 7 | 0.156388 | 98.43893 | 0.957896 | 0.603174 |
| 8 | 0.169968 | 98.37331 | 0.814181 | 0.812511 |
| 9 | 0.182855 | 98.29175 | 0.703532 | 1.004722 |
| 10 | 0.195107 | 98.20561 | 0.618424 | 1.175964 |
| | | | | |

In the above Table, the share or relative importance of each the effective variables on log of LPG prices can be observed. Based on obtained results, it can be stated that the share of price shocks caused by the OPEC oil and natural gas in LPG price shocks traded on the Iran energy stock exchange is small and insignificant.

## Conclusion

As stated in the introduction, this paper seeks to answer the following questions:

1. Is there a significant and sustainable long run relationship between price of raw energies such as OPEC oil basket and natural gas with price of LPG traded on the Iran's energy stock exchange or not?

2. To what extent price of raw energies such as OPEC oil basket and natural gas are related with price of LPG traded on the Iran's energy stock exchange?

3. Does the change in the price of OPEC basket price and natural gas price changes LPG traded in the Iran's energy stock exchange or vice versa? In other words, which variable is the cause of another variable and how is the causal relationship between these three variables?

4. In the event of a shock on variables OPEC oil basket prices, natural gas and LPG traded in Iran's energy stock exchange, do these variables again return to their long-run path? How is the speed of adjustment?

Results mentioned in the previous part clearly specifies answer of each question. On the first question, answer is yes and a long run relationship between the two variables is confirmed that is acceptable at 95 percent confidence level. Regarding the second question, estimation results show that change in logarithm of OPEC oil basket price as much as 1 percent leads to 17.24 percent change in the opposite direction to the logarithm of the price of LPG. Also change in logarithm of natural gas prices as much as 1 percent leads to 26.52 percent change in the same direction to the logarithm of the price of LPG. Regarding the third question, causality directions in the long-run from logarithm of OPEC basket price to the logarithm of the price of LPG and the logarithm of natural gas price to the logarithm of the price of LPG are concluded. And finally on the fourth question, due to lack of statistical significance in the estimated correction factor, it is inferred that there is no relationship between the studied variables in the short run and in case of shock, there will be no the possibility for correction. Also checking out the dynamics of the specified model based on two criteria impulse response function and variance decomposition indicates the low importance of OPEC oil basket price shocks and natural gas on LPG price shocks traded on the Iran's energy stock market. This reflects the fact, low sensitivity of traders and activists in the area to factors and inputs prices for production of this product and strict attention on previous price trend of the product (LPG). Hence, it is obvious that traders and activists of LPG in Iran's energy stock market can adopt appropriate strategies for their trading in future periods by monitoring and keeping track the price trend of the product previous periods, although it seems that evaluation of OPEC oil basket price and natural gas price, as two inputs used in production of this product, can be a proper solution in analyzes and transactional strategies of LPG.

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