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DERGİ HAKKINDA

Journal of Life Economics

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Dergi; KIŞ (Ocak), BAHAR (Nisan), YAZ (Temmuz) ve GÜZ (Ekim) dönemleri olmak üzere yılda 4 sayı olarak yayımlanmaktadır.

Journal of Life Economics, açık erişimli elektronik bir dergidir. Dergide yayımlanan tüm makalelere DOI numarası atanmaktadır. Dergi, başta Index Copernicus, CEEOL, EBSCOHost, Google Scholar, Ulrichsweb, DOAJ olmak üzere çeşitli uluslararası indeks tarafından taranmakta olup birçok indeks tarafından da değerlendirmeye alınmıştır.

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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Asymmetric behavior of oil price shocks and output performance in Africa

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Abstract

A comprehensive cross-country dataset is employed in this reseach to examine the impact of oil price shocks and its asymmetry on output in African oil exporting countries (AOECs). Using a panel-VAR model, the study accounted for impulse-response between output and oil price shocks. In addition, through the PVAR model, variance decomposition is performed to assess the importance of those effects and guidelines are offered for policy formation. The study revaled that oil price shocks create heterogeneously asymmetric effect on output. The study revealed the prevalence of Dutch Disease among the AOECs as apparent in the impact of negative oil price shocks on exchange rates and output. The study recommends that policies should be formulated to minimize the effect of oil price shocks on output, especially negative oil price shocks revealed to adversely affect oil revenue (policies aimed at strengthening economic activities through diversification, so as to enhance the export mix). This will reduce the AOECs' on-going reliance on large revenues from oil, arising from positive oil price shocks which the literature has argued to have a negative and hindering impact on economy, mainly because it impacts the non-oil sector.

Keywords: Asymmetric behavior, oil price shocks, Panel VAR, Africa's, Oil Exporting Countries

JEL codes: P28, P48, Q35, L72.

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1. INTRODUCTION

Several empirical works on the connection amid oil prices and output of the oil-exporting economies have assumed a homogeneous response (see Gachara, 2015). The study also assumes a linear association between macroeconomic variables and oil price shocks. Unfortunately, the study offers no insight into the dynamics of different categories of shocks (see Moshiri, 2015). Consequently, policy makers and scholars have argued that positive and negative oil price shocks impact the macroeconomy differently, and this may vary both in magnitude and signs across regions, hence causing economic imbalances (see Apergis *et al*., 2015; Narayan and Gupta, 2015). The few studies carried out on oil-exporting countries have used linear estimating techniques, focusing on positive oil price shocks, disregarding the likely consequences of negative oil price shocks (see Damechi, 2012; Gachara, 2015). According to Damechi (2012) and Gachara (2015), this may lead to faulty policy decision making which may be counterproductive and misleading. Furthermore, it may result to government's incapability to tackle prolonged effects of oil price shocks on output. Some of the linear techniques such as ordinary least square (OLS) and Fully Modified (FM)-OLS employed in the literature have been critiqued as unsuitable to evaluate the link between oil price behavior and output performance (see Gachara, 2015; Damechi, 2012). In addition, Damechi (2012) and Gachara (2015) argue that the SVARs estimating technique which has frequently been used in the literature to estimate the link between oil price behavior and ouput performance is inadequate and could only be suitable for positive oil price shocks and country specific studies. An asymmetric relationship occurring between output performance and oil price shocks may have vital consequences for policy responses and guidelines in the macroeconomic environment of oil-exporting countries (see Damechi, 2012; Gachara, 2015). Hence, the need for this study.

Considering the possible threat of the current decrease in oil prices and the vital role that variations in crude oil prices play in the behavior of monetary and fiscal policies in AOECs, it is crucial to investigate the asymmetric impacts of negative oil price shocks. This is a critical issue for policymakers in oil-dependent countries, as it will assist them in making decisions that may have serious implications for output growth and the behavior of other macroeconomic variables. While there is evidence on how industrialized countries, mainly developed net oil-importing nations react to positive oil price shocks, which are believed to hamper their economic growth (Hamilton, 2013; Aastveit, Bjornland and Thorsrud, 2015), we are not aware of such a study having been carried out to establish how negative oil price shocks impact the AOECs, where such shocks are similarly believed to hamper output growth. Therefore, this study explicitly estimates a measure of oil price shocks to determine the response of output performance within the context of the AOECs. In addition, while it is expected that oil prices would have various impacts on the output growth of the oil importing and exporting nations, there is a paucity of research on the asymmetric response of AOECs that captures the recent decline in oil prices compared with the differential effects of oil price shocks on exporting oil countries (see Wang, Zhu and Wu, 2017).

While the study deepens the understanding of how oil price shocks impact oil-exporting countries' output, it contributes to knowledge, empirically investigating the non-linear impacts of oil price shocks on the macroeconomy of AOECs, using PVAR.

The remainder of this paper is chronologically organized as beneath: section two discusses the literature review, materials & methods are discussed in section three, analysis of results are presented secion four. Section five and show the interpretation and discussions, and in section six, summary, conclusions and recommendations are presented.

2. LITERATURE REVIEW

A considerable body of empirical and theoretical evidences has been documented on oil price shocks and the reaction of the economy nexus around the world. However, the specific literature on the AOEC bloc appears inadequate. The belief of a nexus amid oil price shocks and output aligns with a few studies that assert that a proportional variation in oil price shocks is analogous to the proportion of variation in output (see Catik and Onder, 2013). However, some scholars have claimend that the proportion of oil price shocks may not necessarily account for the same proportional change in output. Although it is clear that oil price movement affects output, the asymmetric response of economic output to oil price shocks remains unclear (see Catik and Onder, 2013). While many studies on this issue have been carried out in developed oil-importing countries, the experience in oil-exporting economies remains equivocal, calling for an empirical study like the current one.

2.1. Empirical Review

There are various researches on the asymmetric impact of oil price shocks on the output of the importing oil countries (see Herrera, Hamilton, 2009; Lagalo and Wada, 2011). Their studies have generally revealed that upsurges in price of oil have adverse impacts, but the impacts of drops in oil prices on the economic activities of US and some developed oil-importing countries (e.g. the OECD) are not significant. Also, some studies have investigated the oil price shocks transmission mechanisms, seeking to identify the causes of non-linearity (Bernanke, Gertler, Watson, Sims and Friedman, 1997). The transmission mechanisms and the nature of the asymmetric impacts of oil price shocks in the oil-exporting nations may vary from the oil-importing nations. Oil price shocks accounts for demand-side impacts in the oil-exporting nations. A possible explanation for the non-linearity in demand-impacts in the oil-exporting nations may be the size of government and its extreme role in their economies.

The non-linear association amid oil prices and output performance is explained in various ways. For example, Davis (1987) and Loungani's (1986) studies, which are the leading works on this nexus, argue that oil price shocks could cause sectoral swings and expensive reallocation of resources. Mork (1989) reveals that, in separately estimating the coefficients on rises and falls in oil prices, the coefficients on falls are not statistically different from zero. Lee *et al.* (1995) show that a better prediction of GDP can be attained by fine-tuning the oil price rise using standard deviation of price instability. Taking this investigation further, Hamilton (2003) examines the non-linear relationship using an elastic parametric model and finds support for Lee *et al.*'s (1995) results. Various studies offer support for non-linear association between oil prices and output performance for OECD countries (see Mork, 1989; Cunado, Jo, & De Gracia, 2016).

A new strand of studies has come up with an alternative explanation to the identification of oil price shocks used by Lee *et al.* (1995) and Hamilton (2003). These include Kilian and Vigfusson (2011), and Kilian (2010), who point to potential endogeneity in the estimation of the impacts of oil price shocks on US economy and employ a measure of oil price shocks based on a structural near-VAR model of actual crude oil prices. In Kilian (2010), the methodology used to identify structural shocks to real prices of oil relies on delay restrictions that, according to Kilian (2010), are economically reasonable only at the monthly frequency. He develops a technique that permits the separation of innovations on oil prices to three fragments ("*specific oil supply, aggregate demand and oil demand shocks*"). Separating the source of oil price shocks in these three fragments, he concludes that, most of the shocks in the prices of oil are accountable for oil-specific demand shocks and aggregate demand shocks.

The asymmetric relationship amid oil prices and output performance in Nigeria has been investigated. For example, Aliyu (2009) employs a multivariate-VAR model to empirically examine ("non-linear and linear specifications") the impacts of oil price shocks on actual macroeconomic behavior in this country. Among other things, his findings supports the claim that oil price shocks have linear and non-linear effects on real-GDP. In the non-linear models, asymmetric oil price upsurges are revealed to positively impact real GDP growth of greater amount than asymmetric oil price declines' adverse effect on real GDP. Estimations from the non-linear shows significant improvement that is more than the linear estimation that Aliyu (2009) reported.

Asab (2017) examines the impacts of oil price shocks on the economic activities of Jordan, proxied with industrial production growth. The study accommodates non-linearity by using various measures for oil price shocks. His results show that positive oil shocks negatively and significantly impact growth, while a decrease in oil prices do not impact growth. These findings suggest that decreases in oil prices do not certainly trigger industrial growth of oil-importing economies. Consequently, the symmetric specifications of growth and oil price shocks are negatively correlated. Furthermore, he asserts that oil prices have direct relationship with production process and it may therefore significantly impact output, employment, and inflation in oil-importing nations. Variations in oil prices might affect an economy's interest rates and price level (see Cologni and Manera, 2008); exchange rates (see Chen and Chen, 2007); unemployment and stock prices (see Huang *et al.*, 2005; Asab, 2017). Another strand of the literature, consisting Lee *et al*. (1995), and Rafiq, Sgro, and Apergis (2016) examines the impact of uncertainties evolving from oil price shocks. They conclude that oil price shocks significantly affects aggregate macroeconomic indicators like unemployment, interest rates, exchange rates, GDP, investment and inflation. However, they find an asymmetric connection amid oil price variations and the economy, implying that negative impact of oil prices increases varies from positive effects of oil price drops. These studies were conducted in the situation of developed oil-importing nations in Europe and North America. A few academic endeavors have been undertaken to analyze the effect of oil price shocks on external balances (see Bodenstein, Guerrieri and Gust, 2013).

While prior studies have used time series estimating techniques, it is essential to categorize the linkage within a panel framework. This is needed to realize the oil exporting group dynamics evolving from the impact channels. More importantly, regional economic performance is attracting scholarly interest in order to advance appropriate policy guidelines for oil resources. This is the focus of this study. In addition, it adds to extant oil prices and output performance nexus literature. This is achieved by adopting a non-linear estimating technique that ascertains the asymmetric effect of oil price shocks in a panel of countries within the context of the AOECs.

2.2. Theoretical review

Several developing oil-exporters largely rely on proceeds from oil exports, causing their economic activities to oscillate with variations in oil prices (Aastveit, Bjornland, and Thorsrud, 2015). The literature reveals that most developing oil-exporting nations are lagging behind in their non-resource based contemporaries (see Subramanian and Sala-i-Martin, 2003). This is premised within the context of poor economic growth among the exporting economies, and by the contrary impacts of oil windfalls on government policies, institutions, and investment in human capital. It is contended that, comparatively, oil-endowed economies accrue less human capital compared with their oil-poor counterparts due to capital-intensive enclave characterizing it (Hjort, 2006). The oil-poor economy government has little encouragement to invest in skilled workers, and the returns on and quality of education are little (Birdsall, Pinckney and Sabot, 2001). This suggests that oil prices might asymmetrically impacting on the economies of developing oil-exporting nations. This suggests that the economies might not have suffered the conquence of low oil prices due to declining proceed from oil, but might also have been able to fully benefit from increases in upsurge in oil prices, that accounts for massive inflows in foreign reserves, as well as critical for economic growth.

According to Rafiq *et al.* (2016), asymmetric impacts of oil price variations on trade in the oil exporting economies may be classified into positive and negative effects. The impacts of positive oil price shocks have been relatively well accounted for in literature, specifically in relation to oil-importing countries (see Huang, Hwang and Peng, 2005). The studies argue in favour of oil price increase to positively impact the economy of net oil-exporting nations. This direct impact is referred to "*revenue effect*", asserting that oil prices rise may perhaps improve "*terms of trade*" in the net oil-exporting nations, which in turn, may enhance trade balance, cause revenue to increase, and a rise in both investment and consumption (see Korhonen and Ledyaeva, 2010). Such direct positive shocks could be refuted using diverse indirect effects (Lee and Chang, 2013). For instance, increases in oil prices might result to inflationary pressure in international markets, which may ultimately increase the prices of imports in the oil-exporting and oil-importing ceconomies. Therefore, for any country to curb inflationary pressure, the monetary authorities in the trading partners might react by increasing interest rates, which could lead to declining investment and consumption. Thus, reducing growth rate among the partner nations. In addition, this could lead to fall in demand for oil and ultimately leading to a decline in oil exports, affecting trade balance in oil-exporting countries. Conversely, a rise in oil prices might create negative supply shocks to the production processes of the importing countries, which in turn, may result in an economic go-slow in these countries, causing their imports to drop on the one hand and on the other, wielding a negative impact on the trade balances of oil-exporting economies. Overall, the gain from a rise in oil prices for an oil-exporting nation is entirely dependent on the degrees of three effects (supply , revenue and demand effects). In addition, even if the general impact is positive, Lee and Chang (2013) point out that, there are other worries, like the existence of volatility, Dutch Disease and the exhaustibility of the positive effect and dependence on trade partners.

3. METHODOLOGY

3.1. Panel-VAR (PVAR) Technique

Following several studies on natural resources, this study employed the PVAR estimating technique (see Canova and Ciccarelli, 2004; Cunado, Jo, & De Gracia, 2016; Andarov, 2019). The PSVAR generates impulse-response functions (IRFs) to analyze how oil price shocks impacts output of the AOECs. According to Canova and Ciccarelli (2012), the PVAR is built on the VAR framework. Apart from the fact that the PVAR is considered as an appropriate technique, focusing on the multivariate correlation among variables, it supports the creation of several lags because the impacts of oil price shocks might not be instantaneous. Nikolas *et al.* (2001) identify several benefits of using a panel VAR methodology compared with the methods (the OLS model) used previously to investigate the oil price shocks and macroeconomy nexus. Firstly, contrary to cross country methods, panel data techniques permit the control of unapparent time-invariant country features, and minimize concerns relating to omitted variable bias. Secondly, to explain any universal macroeconomic shocks which may impact all nations in similar manner, time fixed effects could be added. Thirdly, the addition of lags to the variables in a PVAR model assists to analyse the dynamic association between the various variables. The IRFs built on PVARs could explain the delayed impacts on the variables employed. This determines whether or not the impacts between the variables are short-lived. Fourthly, treating every variable as endogenous, PVARs overtly address the problem of endogeneity, which is common with empirical studies on oil prices. Fifthly, PVARs can be employed effectively with relatively short-time series as a result of the gained efficiency from cross-sectional measurement. Sixthly, PVAR pools data over time and across the section. This helps the study to overcome the problem of shortage of degrees of freedom which analysis with limited data using a country-specific or single VAR may compromise (see Andarov, 2019). In addition, Andarov (2019) and Gravier-Rymaszewska (2012) assert that, unlike the SVAR model, the PVAR model does not need imposition of a structural relationship. Though theory is considered in selecting the suitable normalisation, to interpret results. Furthermore, PVAR requires only a negligible set of assumptions in order to infer the effects of shocks on the variables of the PVAR system (Gravier-Rymaszewska, 2012).

3.2. Oil Price Change Derivation: *Decomposition*

To critically investigate the asymmetric effect, this study follows Mork (1989), Lee *et al*. (1999) and Hamilton (2003) to decompose the oil price. This procedure helps us to examine output responses within a short-run horizon. Furthermore, it allows us to expound the policy response and obtain policy direction on variations in global oil prices (increases and decreases) over time. An unprecedented variation in oil prices may have serious implications for economies that are reliant on oil, such as the AOECs. These asymmetric estimation techniques have been found suitable to measure movements in oil prices (see Kose and Baimaganbetov, 2015). As a result, this study employs three key non-linear transformations accounting for asymmetry of oil prices to examine the presence of an asymmetric relationship. These transformations have been widely used in related studies and are thus relevant to this study (see Herrera *et al*., 2011; Kose and Baimaganbetov, 2015). The specifications are the asymmetric specification, net specification and scaled specification (see Mork, 1989; Hamilton, 2003; Lee *et al.*, 1995).

Asymmetric specification propounded by Mork (1989) decomposes quarterly oil prices into and differentiates between a positive rate of variation (OP_t^{+}) and negative rate of variation (OP_t^{-}), which are expressed as:

$$OP_t^{+} = \{OP_t if\ OP_t > 0, 0\ otherwise$$

$$OP_t^{-} = \{OP_t if\ OP_t < 0, 0\ otherwise$$

where OP_t represents the rate of change in oil prices. However, OP_t^{+} quotes the net increase in oil prices and OP_t^{-} quotes the net fall in oil prices in a directly opposite way.

Mork (1989) proposes the censoring of the oil price series after the 1985-86 drop in the prices of oil.

Lee *et al*. (1995) propose the second of these transformation measures, PVAR:

$$OP_t^{+} = 0\ if\ \frac{OP_t}{\sqrt{\delta_t}} > 0$$

$$OP_t^{-} = 0\ if\ \frac{OP_t}{\sqrt{\delta_t}} < 0$$

where, OP_t is a measure of changes (increase/decrease) in oil prices.

Hamilton (2003) proposes the third transformation procedure to evaluate the effect of oil price shocks. In addition, the transformation proposes the benchmark model given by:

$$Q_{i,t} = \delta_{\mathrm{i,t}} + \sum_{i=1}^{n} \beta_{t-i}\, Q_{t-i} + \sum_{i=1}^{n} \partial_{t-i}\, OP_{t-1}^{shocks} + \varepsilon_{\mathrm{i,t}}$$

where OP_{t-1}^{shocks} denotes an alternative measure of shocks (positive/negative); Q_t is output.

According to Hamilton (2003), considering the various available metrics of oil price shocks, the following test can help to determine the appropriate measure of such shocks. He further argues that although the measures of shocks could be non-linear functions of oil prices, they are linear functions of the parameter estimates of $Q_{i,t}$ above. Therefore, the benchmark model can be expressly reduced as follows:

$$Q_{i,t} = \delta_{\mathrm{i,t-j}} + \partial' \rho_{i,t-j} + \varepsilon_{\mathrm{i,t-j}}$$

Where $\rho_{i,t}$, is defined as $[Q_{t-1}, Q_{t-2}; OP_{t-1}^{shocks}, OP_{t-2}^{shocks}]$.

3.3. Model Specification and PVAR set up

This study employs data from five AOECs for the period 1980-2018. It uses the Hatemi-J (2012) PVAR methodological technique, which is similar to Hamilton (1989). The technique extends the traditional VAR model developed by Sims (1980), assuming that all variables, within the model, are endogenous. Therefore, the PVAR model, in the general form, is expressed as follows:

$$Q_{\mathrm{i,t}} = \delta_{\mathrm{i,t}} + \psi_{\mathrm{n,i,}} OP_{i,t-j}^{shocks} + \varepsilon_{\mathrm{i,t-j}} \quad (1.0)$$

where, Q is the output growth and OP is the oil prices expressed in USD; $i = 1, 2, \ldots, 5$ denoting the oil-exporting countries; $t = 1980, 1981, \ldots,$ 2018; $n = 1\ and\ 2$,showing movement in oil price or the cumulative amount of movement in the oil price, which could either be positive or negative and is the lag element.

Following Hatemi-J (2012), the study decomposes the prices of oil into their cumulative sums of (+) and (−) shocks. This is in response to Hooker (1996) who argues that the linear connection of oil price and output growth developed by Hamilton (1983) which was built on the oil price rise alone, is not dependable, especially given observed output growth performance realities. In addition, the decomposition of oil prices into negative and positive shocks in this study is a departure from what is common in the literature which considers only positive oil price shocks rather than the fluctuating movement in oil prices (see Huang, Hwang and Peng, 2005; Asab, 2017).

$$OP_{\mathrm{i,t}} = \psi_{\mathrm{i,t}} OP_{i,t}^{+} + \vartheta_{\mathrm{i,t}} OP_{i,t}^{-} \quad (1)$$

Deviating from previous studies that employed Western Texas Intermediate, Brent Sweet Light Crude, Forties Crude and Oseberg Crude (see OPEC, 2016), this study investigates the effects of Brent Crude oil price shocks on AOECs, based on the asymmetric specification framework in equation (1) which is substituted into equation (1) to derive equation (2):

$$Q_{\mathrm{i,t}} = \delta_{\mathrm{i,t}} + \psi_{\mathrm{i,t}} OP^{+}_{i,t-j} + \vartheta_{\mathrm{i,t}} OP^{-}_{i,t-j} + \varepsilon_{\mathrm{i,t}} \quad (2)$$

As shown in equation (1), our benchmark specification is bivariate PVAR, containing output growth and oil prices. Nevertheless, the study extends the model to a quad-variate PVAR with the addition of two policy control variables, namely, inflation and exchange rates. Exchange rates (EXCH) measure the currency of each country which is expressed in the currency of another country. The study uses the USD exchange rate as a benchmark because it is widely acceptable and beign the most traded currency in foreign exchange market (see Rafiq *et al.,* 2016). Its inclusion follows Rafiq *et al*. (2016) to investigate how changes in the worth of the USD affect the variables selected in the AOECs. This also assesses the degree of interaction amid business cycles and the way that it stimulates output growth. Exchange rates assist in examining how changes in the worth of the USD affect oil prices and consequently output (Rafiq *et al.*, 2016). Furthermore, the inclusion of the inflation rate helps in assessing how the general price level may affect output growth when oil prices vary.

$$Q_{\mathrm{i,t}} = \delta_{\mathrm{i,t}} + \psi_{\mathrm{i,t}} OP^{+}_{i,t} + \vartheta_{\mathrm{i,t}} OP^{-}_{i,t} + \mu_{\mathrm{i,t}}\xi_{\mathrm{i,t}} + \omega_{\mathrm{i,t}}\zeta_{\mathrm{i,t}} + \varepsilon_{\mathrm{i,t}} \quad (3)$$

where Q is output growth; OP^{+} means positive oil price shocks; OP^{-}means negative oil price shocks; ξ is exchange rates. $\delta_{\mathrm{i,t}}, \psi_{\mathrm{i,t}}, \vartheta_{\mathrm{i,t}}, \mu_{\mathrm{i,t}}$ and $\omega_{\mathrm{i,t}}$ are parameters for intercept, positive oil price shocks, negative oil price shocks, exchange rates and inflation rate, respectively, $\varepsilon_{\mathrm{it}}$ is error term.

The oil price shocks decomposition procedure used in this study is a clear departure from previous studies that considered the oil price trend over time rather than oil price behavior (shocks). Ojo and Alege (2012) consider this approach a vital variable to determine output in oil-exporting countries. The exchange and inflation rate variables are considered here as policy variables to offer direction to policy makers.

Assumably, $OP_{\mathrm{t}}(\text{oil price at time } t)$ follows a random walk process given by:

$$OP_{\mathrm{t}} = OP_{\mathrm{t-1}} + \varepsilon_{\mathrm{i,t-1}} \quad (4)$$

Such that, the positive shocks from the white noise can be expressed as $\varepsilon^{+}_{1it} = m\,ax(\varepsilon_{1\mathrm{it}}, 0)$ and negative shocks as $\varepsilon^{-}_{1it} = min(\varepsilon_{1\mathrm{it}}, 0)$.. Hence, it is defined as $\varepsilon_{\mathrm{it}} = \sum_{t=1}^{1} \varepsilon^{+}_{it} + \sum_{t=1}^{1} \varepsilon^{-}_{it}$, such that,

$$OP_{\mathrm{t}} = OP_{0} + \sum_{t=1}^{1} \varepsilon^{+}_{it} + \sum_{t=1}^{1} \varepsilon^{-}_{it} \quad (5)$$

where OP_0 is the early value of oil prices and $\varepsilon_{\mathrm{it}}$ is a white noise disturbance term.

Thus, this study uses a non-linear panel to establish the relationship amid oil price shocks and output performance. To carry out this estimation, it utilizes the current non-linear panel estimation technique of Kapetanios *et al*. (2014), allowing for cross-sectional dependence, and is appropriate for panel heterogeneity (see Rafiq *et al.*, 2016; Gravier-Rymaszewska, 2012).

The standard PVAR technique that captures the variables, output (Q_{t}), positive oil price shocks (OP^{+}_{t}), negative oil price shocks (OP^{-}_{t}), exchange rates (ζ_{t})), and inflation (ζ_{t})) employed in this study is made up of five system-equation given as equations (6) to (10).

$$Q_{i,t} = \delta_{1,t} + \sum_{i=1}^{n} \eta_i Q_{i,t-1} + \sum_{i=1}^{n} \psi_i OP^{0+}_{i,t-1} + \sum_{i=1}^{n} \vartheta_i OP^{-}_{i,t-1} + \sum_{i=1}^{n} \mu_{1,i}\xi_{i,t-1} + \sum_{i=1}^{n} \omega_i \zeta_{i,t-1} + \varepsilon_{1,t} \quad (6)$$

$$OP^{+}_{i,t} = \delta_{2,t} + \sum_{i=1}^{n} \eta_i Q_{i,t-1} + \sum_{i=1}^{n} \psi_i OP^{+}_{i,t-1} + \sum_{i=1}^{n} \vartheta_i OP^{-}_{i,t-1} + \sum_{i=1}^{n} \mu_i \xi_{i,t-1} + \sum_{i=1}^{n} \omega_i \zeta_{i,t-1} + \varepsilon_{2,t} \quad (7)$$

$$OP^{-}_{i,t} = \delta_{3,t} + \sum_{i=1}^{n} \eta_i Q_{i,t-1} + \sum_{i=1}^{n} \psi_i OP^{+}_{i,t-1} + \sum_{i=1}^{n} \vartheta_i OP^{-}_{i,t-1} + \sum_{i=1}^{n} \mu_i \xi_{i,t-1} + \sum_{i=1}^{n} \omega_t \zeta_{i,t-1} + \varepsilon_{3,t} \quad (8)$$

$$\xi_{i,t} = \delta_{4,t} + \sum_{i=1}^{n} \eta_i Q_{i,t-1} + \sum_{i=1}^{n} \psi_i OP^{+}_{i,t-1} + \sum_{i=1}^{n} \vartheta_i OP^{-}_{i,t-1} + \sum_{i=1}^{n} \mu_i \xi_{i,t-1} + \sum_{i=1}^{n} \omega_4 \zeta_{i,t-1} + \varepsilon_{4,t} \quad (9)$$

$$\zeta_{i,t} = \delta_{5,t} + \sum_{i=1}^{n} \eta_i Q_{i,t-1} + \sum_{i=1}^{n} \psi_i OP^{+}_{i,t-1} + \sum_{i=1}^{n} \vartheta_i OP^{-}_{i,t-1} + \sum_{i=1}^{n} \mu_i \xi_{i,t-1} + \sum_{i=1}^{n} \omega_5 \zeta_{i,t-1} + \varepsilon_{5,t} \quad (10)$$

The standard PVAR model made up of equations 6 to 10 can be concisely put in matrix notation. Therefore, the reduced form of a relationship between the endogenous variables (output, positive oil price shocks, negative oil price shocks, exchange and inflation rates) is given as:

$$Q_{i,t} = A_0\beta_{i,t} + \alpha_1\phi_{i,t-1} + \ldots + \alpha_n\phi_{i,t-n} + \nu_{i,t} \quad (11)$$

where $Q_{i,t}$ denotes a 5x1 vector of k system-variables (output, positive oil prices, negative oil prices, exchange rates, and inflation); A_0 is the associated parameter matrix; $\beta_{i,t}$ is vector of deterministic terms (trend and a constant); di is a cross-sectional identifier such that, $i = 1, \ldots, l$; $\alpha_{1,2,\ldots,n}$; represents a matrix of slope/coefficient estimates attached to those lagged variables $\phi_{i,t}$; ν ; represents a 5x1 vector of system innovations or the stochastic error terms often called impulse innovations or shocks; and the optimal lag length (VAR order) is denoted by n for each variable selected in accordance with the SIC and AIC. The study adopts lag length two, which is found superior to others in terms of performance (see Table 6).

The reduced form PVAR in equation (11), permits implementation of dynamic simulations, one we estimate the unidentified parameters. The result takes the procedure of IRFs, their coefficient analysis, and "*forecast error variance decompositions*" which enable one to evaluate how oil price shocks impact other variables in the PVAR system.

The error process $\nu_t = \gamma_i + u_t + e_{i,t}$ (12)

where γ_i is the country's definite effect, u_t captures the annual effect, and $e_{i,t}$ is the white noice. Zero mean is assumed for the error term ν_t , i.e., $E(\nu_t) = 0$. The ν_ts and time invariant covariance matrix are independent.

Following Canova and Ciccarelli (2004), this study imposes two restrictions on the specifications in equation (11) and (12). Firstly, common slope coefficients is assumed, and it does't permit interdependences across units. With this restriction, the estimated (matrices) are construed as average dynamics. The interpretation is in reaction to shocks. Secondly, given the standard VAR model, the study assumes that variables rely on past behaviour of variables in the PVAR system, with the key variance being the presence of every nation's specific term, γ_i.

3.4. Data

Quarterly data spanning 1980Q1 to 2018Q4 is employed in this study. The commencement date captures the period of major oil price shocks that are assumed to cause an imbalance in the global economy and the exchange rates of oil-exporting nations. Data paucity dictates the cut-off date. It should be noted that the cut-off date accounts for the period of continuous decline in oil prices. The study sourced data from the OPEC and Federal Reserve Economic Database (FRED), over the period 1980:1 to 2018:4 on three variables. These variables are oil price (OP), output (Q) and exchange rates (EXR). The choice of Brent Blend follows the literature that notes that Brent Blend is the principal oil export in the AOECs among many major classifications (OPEC, 2016). The cutoff date is also informed by the belief that the period coincides with a time of continuous variations in global crude oil prices, with these prices lately showing a more sustained drop than in any other period.

Following Rafiq *et al*. (2016), Le and Youngho (2013), and Korhonen and Ledyaeva (2010), this study considers the terms of trade as a measure of output growth performance. It should be noted that the terms of trade reflect these countries' openness which is predominantly influenced by oil; and that oil accounts significantly for their foreign exchange earnings. In 2018, for instance, oil accounted for about 87 percent of earnings from foreign exchange in Nigeria and approximately 95 percent in Libya. It made up around 80 percent of earnings from foreign exchange in Gabon from 2010 to 2016 (WDI, 2021). Similarly, the terms of trade capture economic activity that may perhaps be affected directly by oil prices and uncertainty about such prices (see Rafiq *et al*., 2016). Theory and empirical works dictate the choice of these variables (see Rafiq *et al*., 2016) that are modeled into a PVAR estimating technique. Due to the requirement for using the panel VAR estimating technique, the variables employed here are subject to the stationarity test before proceeding to estimate the panel VAR model.

3.5. Brief Description of Variables

3.5.1. Output (Q)

The term of trade *(TOT)* proxy for output and it expresses the relationship between import prices and export prices. The TOT ranges from 0-100 percent. The higher the magnitude, the better the economy. Following Rafiq *et al*. (2016), this study uses the TOT to analyse the asymmetric link amid oil price shocks behavior and output performance in AOECs. TOT has been selected due to the understanding that the crude oil exports of these countries account significantly for their revenue and more importantly that, variations in the prices of crude exports affect their exchange rates.

3.5.2. Oil prices (OP)

The oil price means the sum that oil is sold daily on the world market (see Rafiq *et al.*, 2016; Hamilton, 2013; Rotimi and Ngalawa, 2017). It is usually invoiced in dollars. This study uses the prices of Brent Blend being the key oil exported in the AOECs among several key groupings of oil consisting of Brent Sweet Light Crude, Brent Crude, Forties Crude and Oseberg Crude (OPEC, 2016).

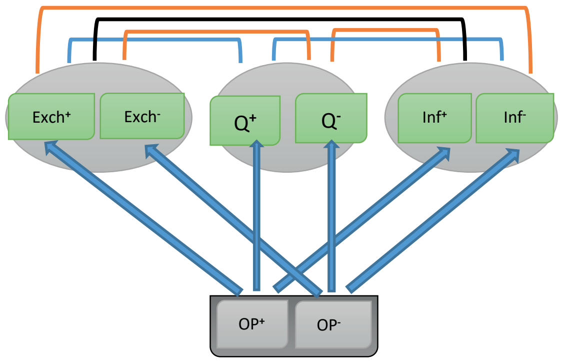
3.5.3. Exchange rates (EXCH)

Exchange rates express each nation's currency in another nation's currency. In this study, USD exchange rates are selected as a benchmark due to their wide acceptability and the most traded currency at the foreign exchange market (Kia, 2013). The choice of nominal exchange rates in this study is premised on various studies like Korhonen and Ledyaeva (2010), and Rafiq *et al.* (2016).

3.5.4. Inflation rate (INF)

Inflation measures the general rise in prices and a fall in purchasing power of money over time. It is measured using a quarter by quarter national composite consumer price index with 2010 as base year. Inflation is a fundamental monetary policy variable and it reacts when oil price shocks occur (see Hamilton, 2013). Therefore, it is introduced into the PVAR model as a monetary policy variable to serve as a control variable with a link to monetary policy decisions, especially exchange rates.

Figure 1. Macroeconomic-Oil Price Shocks Behaviour Model



Source: Authors' compilation (2022).

Figure 1 presents a model showing the relationship among the various macroeconomic variables considered in this study. More specifically, the model shows how the decomposed oil price shocks interact with output, inflation, and exchange rates. For the AOECs, positive oil price shocks lead to exchange rates to appreciate as a result of higher demand for their currencies. However, positive oil price shocks may cause an increase in inflation because the AOECs rely on importation of refined oil and other refined petroleum products due to their low refinery capacity. Inversely, production factors' prices may fall following negative oil price shocks. Output, which is the focus of this study, may respond negatively to oil price shocks and this may lead to a fall in revenue. Furthermore, a fall in oil prices may hamper economic growth and consequently lead to an unfavourable trade balance.

3.6. Estimating technique

3.6.1. Panel unit root tests

Various studies have emphasized the concept of unit root tests (see Moon, Perron, and Phillips, 2007, Im *et al.*, 2003). According to these studies, unit root is necessary to ascertain the because if the variables are non-stationary as well as non-cointegrated so as to avoid wrong specification of the model and hence, spurious results (see Shabri, 2017). Therefore, this study implements tests of Levin *et al*. (2002) and Im *et al*. (2003) to examine whether the variables follow a stationarity procedure, using both the Akaike and Schwarz Information criteria. The choice of the various criteria is informed by the need to confirm the validity and reliability of our results as well as their consistency (see Moon and Perron, 2004; Frimpong and Oteng-Abayie, 2006).

To test whether a series, say , is integrated or equivalent to testing for the significance of a series, the study employs the regression equation. This procedure follows the Augmented Dickey-Fuller technique which suggests that the Dickey-Fuller test creates an autocorrelation problem. An Augmented Dickey-Fuller test is suggested to tackle this problem (see Frimpong and Oteng-Abayie 2006).

$$\Delta\psi_t = \phi_0 + \beta\psi_{1t-1} + \alpha_{1i} + \varepsilon_{1t} \qquad (13)$$

$$\Delta\psi 2_t = \phi_0 + \phi_{1t} + \beta\psi_{2t-1} + \alpha_{2i} + \varepsilon_{2t} \quad (14)$$

Regression equations and , respectively represent ADF with intercept only and ADF with trend and intercept. The hypotheses are specified below:

Null Hypothesis

$(\mathrm{H}_0: Variables\ are\ not\ stationary\ or\ have\ unit\ roots)$

Alternative Hypothesis

$(\mathrm{H}_1: Variables\ are\ stationary\ or\ have\ no\ unit\ roots)$

3.6.2. Panel lag length

Lag length shows the number of times between which output action responds to oil price shock. It refers to number of times back down the Autoregressive (AR) process one examines for serial correlation. According to Lutkepohl (2006), the information criteria for ideal lag length is contingent on the number of observations. Since the series for this study are quarterly, it tests for several orders of lag selection conditions that allows for modifications in the model, and consequently the attainment of good residuals.

3.7. Interpretation of Empirical Results

3.7.1. Panel unit root results

Table 1. Levin *et al.* Im *et al***.** and Fisher-ADF unit root tests: Individual Intercept

Var	Levin *et al.* (Individual Intercept)			Im *et al.* (Individual Intercept)			ADF- Fisher-Chi Square (Individual Intercept)		
	Integ Order	t-stat (t*)	Prob Value	Integ Order	t-stat (t*)	Prob Value	Integ Order	t-stat (t*)	Prob Value
Q	I(1)	-3.43894	0.0001***	I(1)	-3.3199	0.0000***	I(1)	8.19228	0.0001***
OP(-)	I(1)	-11.9081	0.0000***	I(1)	-12.9788	0.0000***	I(1)	11.2142	0.0000***
OP(+)	I(1)	-13.2155	0.0040***	I(1)	-10.6106	0.0000***	I(1)	14.2063	0.0020***
EXCH	I(1)	-9.12571	0.0023***	I(1)	-5.18969	0.0000***	I(1)	71.1402	0.0000***
INF	I(1)	-5.32421	0.0011***	I(1)	-5.24554	0.0000***	I(1)	25.1480	0.0100***

"***", "**" and "*" respectively represent statistical significance at 1%, 5% and 10%.

Source: Authors' computation (2022).

Table 2. Levin *et al.* Im *et al***.** and Fisher-ADF unit root tests: Individual Intercept and trend

Variable	Levin *et al.* (Individual Intercept and trend)			I'm *et al.* (Individual Intercept and trend)			Fisher-ADF (Individual Intercept and trend)		
	Integ Order	t-stat (t*)	Prob Value	Integ Order	t-stat (t*)	Prob Value	Integ Order	t-stat (t*)	Prob Value
Q	I(1)	-2.31527	0.0054***	I(1)	-2.11106	0.0410***	I(1)	22.2875	0.0009***
OP(-)	I(1)	-9.41454	0.0000***	I(1)	-11.3011	0.0010***	I(1)	120.147	0.0000***
OP(+)	I(1)	-16.6126	0.0000***	I(1)	-14.1268	0.0000***	I(1)	172.767	0.0000***
EXCH	I(1)	-13.0597	0.0000***	I(1)	-8.14352	0.0050***	I(1)	69.7551	0.0000***
INF	I(1)	-6.24174	0.0104***	I(1)	-4.24306	0.0000***	I(1)	39.7626	0.0000***

"***", "**" and "*" respectively represent statistical significance at 1%, 5% and 10%.

Source: Authors' computation (2022).

This study first diagonised the chataeristics of the series. The results presented in Tables 1and 2 reveal that output and negative oil price shocks under all the criteria considered are stationary in their first difference and no variable is found to be stationary following the second differences I(2).

3.8. Summary Statistics of variables

Table 3. Summary statistic of variables

	Q	OP^-	OP^+	EXCH	INF
Mean	141.182	-2.09665	2.27453	1.65118	1.16620
Median	134.270	0.00000	0.41500	1.83875	0.94750
Maximum	357.580	1.87726	25.5946	2.41000	2.87000
Minimum	43.8800	-59.8256	0.00000	-0.36000	-0.55000
Std. Dev.	56.8541	5.94569	3.91672	0.54988	1.13503
Skewness	0.94326	-6.68888	2.69320	-1.67347	0.01060
Kurtosis	4.22001	59.8756	12.2250	5.56951	1.49701
Jarque-Bera	164.040	110948	3708.74	578.646	73.4307
Prob	0.00000	0.00000	0.000000	0.00000	0.00000
Sum	110122.2	-1635.39	1774.139	1287.92	909.636
Sum Sq. Dev.	2518037.	27538.6	11950.40	235.549	1003.59
Obs	780	780	780	780	780

Sources: Authors' computation (2022).

Table 3 shows the statistics for the series employed in this study for the period under consideration, namely, output, positive and negative oil price shocks, exchange rates and inflation rates. The study focuses on decomposed oil prices and output because they are variables of interest, as the aim is to establish if oil prices have an asymmetric relationship with output. The maximum and minimum values of output are 357.58 and 43.88, respectively. The mean value of output is 141.18, suggesting that the mean falls at the lower side of the distribution. The range of the series and its mean distribution are relatively close to the minimum output, suggesting that oil prices might not have been significantly impactful on output but rather are considered low. This further suggests that the various positive oil price shocks experienced during the period under review may not have significantly impacted output, or the negative shocks could have retarded the economies of the oil-exporting nations. -2.09 and 2.27 are respectively the means of the negative and positive values of oil price shocks. The minimum negative oil price shocks and maximum positive oil price shocks are -59.8 and 25.59, respectively. The standard deviation for output stands at 56.85.

3.9. Panel Correlation Matrix

Table 4. Panel Correlation Matrix

Variables	Q	OP^-	OP^+	EXCH	INF
Q	1.00000	-0.07660	0.20413	0.25328	0.21776
OP^-	-0.07660	1.00000	0.20441	-0.06246	-0.12042
OP^+	0.20413	0.20441	1.00000	0.13902	0.23533
EXCH	0.25328	-0.06246	0.13902	1.00000	0.40015
INF	0.21776	-0.12042	0.23533	0.40015	1.00000

Sources: Authors' computation (2022).

To ascertain that the multi-collinearity problem is averted in the estimation of this study, this section presents the extent of the relationship among the series under consideration. These include output, oil price (positive and negative), exchange rates and inflation rates. Table 5.4 presents the association of these series.

A close look at the correlation matrix shows that the sign of connecting coefficients is consistent. For instance, the connecting coefficient of Q and OP^- is negative while that of Q and OP^+ is positive, indicating an improvement in output and fall in output. Nonetheless, the positive shocks coefficient (0.02) does not suggest an asymmetric relationship with negative shocks (-0.07). Similarly, negative oil price shocks reveal a weak association between oil prices and output, and positive oil price shocks reveal a relatively strong link amid oil prices and output. These findings validate the *"oil revenue effect"* on the oil-exporting economies. The association between negative oil price shocks and output presents an inverse relationship, while positive oil price shocks show otherwise. This validates our earlier results that positive oil price shocks are good news for oil-exporting nations (see Rafiq *et al.*, 2016; Catik and Onder, 2013; Hamilton, 2009).

This study also considers the association between monetary variables and the many oil price shocks. In particular, it considers the association between inflation and oil price shock. The positive sign between inflation and negative oil price reveals that a decline in oil prices reduces inflation but a rise in oil prices has the tendency to heighten inflation.

Apart from output and exchange rates that record a slightly weak coefficient with oil price shocks, other variables record strong correlations with such shocks. Nevertheless, the overall correlation among the various paired variables presents a negative and positive mix.

3.10. Panel Cointegration

Table 5a. Panel Cointegration- Individual Intercept

Criteria	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-1.448872	0.9263	-1.540788	0.9383
Panel rho-Statistic	1.531916	0.9372	1.613725	0.9467
Panel PP-Statistic	1.336873	0.9094	1.424279	0.9228
Panel ADF-Statistic	1.914493	0.9722	2.086855	0.9815

Sources: Authors' computation (2022).

Table 5b. Panel Cointegration- Individual Intercept and Trend

Criteria	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	-2.199932	0.9861	-2.163561	0.9848
Panel rho-Statistic	2.775702	0.9972	2.748835	0.9970
Panel PP-Statistic	3.219331	0.9994	3.215085	0.9993
Panel ADF-Statistic	3.238242	0.9994	3.269647	0.9995

Sources: Authors' computation (2022).

After the variables have been tested and found stationary, a panel cointegration test is conducted using the Pedroni-Engle-Granger based procedure (1999). This is conducted to establish if there is a cointegrations relationship among the variables. Tables 5a and 5b show that there is no cointegrations relationship. The presence of a cointegrations relationship among variables may call for SVAR analysis of long-run effects (see Baltagi and Kao, 2001).

3.11. Panel Optimal Lag Selection

Table 6. The Panel ARDL Optimum Lag Selection Criteria

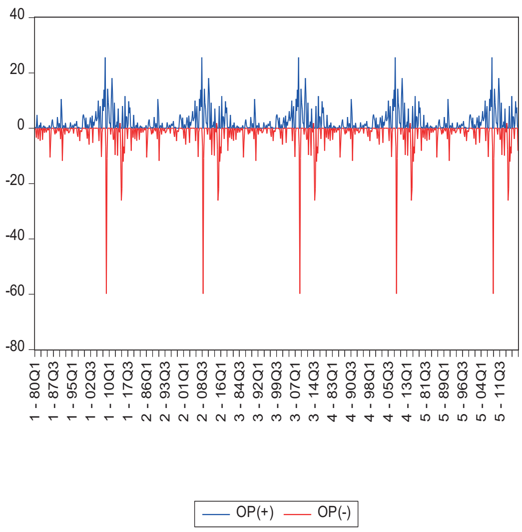
Lag	LogL	LR	FPE	AIC	SC	HQ
0	-649.9163	290.9888	6.06e-06	2.175449	3.140356	2.547482*
1	-626.0697	78.65847	6.08e-06	2.178567	3.299103	2.610604
2	-584.4336	45.37297*	5.81e-06*	2.133604*	3.109771*	2.625647
3	-564.5175	101.9111	6.16e-05	2.223020	3.321037	3.015037
4	-450.1018	99.3375	9.09e-06	2.281356	3.235003	2.833378
5	-401.7723	93.26296	8.54e-06	2.218303	3.327580	2.830330

Source: Authors' Computation (2022).

The lag length result is presented in Table 6. It reveals that lag length 2 is the optimal lag length.

3.12. Panel VAR Estimation Results

Figure 2. Oil Price Shocks (Positive and Negative)



Sources: Authors' computation (2022).

The panel data procedure employed in this study follows Holtz-Eakin *et al.*'s (1988) claim that PVAR addresses unobserved heterogeneity in a model. To explain the cause-effect association amidst the explained and explanatory variables, two perspectives of oil prices are considered, via the OP_t^+ and OP_t^- to investigate the impact of oil price behavior on the output of the AOECs. These perspectives are showed in figure 2, showing the graphical demonstration of various oil price shocks' behavior. In this distinction, positive oil price shocks are referred to as a rise in oil prices as shown above line zero (0) in Figure 2 and negative oil prices are referred to as a fall in oil prices as shown below line zero (0).

The following section shows the findings of the PVAR model. The study focuses on the link amid output and various oil price shocks. Therefore, it tracks the dynamic paths of oil prices and how they impact on output over time. The study relies on the IRFs obtained from the VAR technique, since it endogenously treats the variables. Sims (1980) introduced impulse response function analysis in the VAR estimating technique. The technique highlights futre economic system state, if variation occurs in any of its components. This procedure provides an answer to the question of the way the economic system would be affected by variation in one of its variables. The impulse response technique helps to trace the time pathway reaction of the contemporary and future values of every variable to a one-unit rise in the present value of one of the innovations of VAR (see Stock and Watson, 2001). Bernanke and Mihov (1998) confirm that the IRF provides quantifiable measure of the response of every variable to shocks in the differential equations of the system. In addition, the impulse response generates the anticipated future path of variables subsequent to particular shocks. It is also exciting to establish how vital are particular shocks to explain instabilities of variables employed into the PVAR system, that is realized using VD. Following this background, this study relied on an atheoretical PVAR model, instead of a regression reliant panel data procedure that was perhaps more based in theory but will come at the cost of its failure to track the dynamics of output over time, following oil price shocks. We distinguish between negative and positive oil price shocks that are respectively captured by the negative and positive values of oil price variations.

To order the variables used in our model, the study follows Demary (2010). A study that addresses the wealth effect in time-series built VAR models for specific nations. According to the study, the VAR model is principally an atheoretical one, and accordingly, proper identification of the structural shocks is a field of on-going study in time-series econometrics. Therefore, the probable shocks in the system are recognized based on slow "(ordered before)" and fast-moving "(ordered after)" variables in relation to specific shocks.

3.13. Impulse Response Functions Analyses

Sims (1980) pioneered the application of the impulse response function technique (IRFT) in VAR modeling, to demonstrate the future position of an economic system when a variation occurs in a component of the system. The IRFT answers the question: How is the future of a system affected by a change in one of its variables? It thus shows the extent to which variables of the VAR system react to one another at a time.

Given that the impulse response function accounts for the extent to which the endogenous (dependent) variables react to one another as variations occur over time, the study constructs impulse responses for all the variables considered in the model. This allows us to recognize the economic reaction to various oil price shocks. For suitable analysis to be achieved, the IRFs analyses are divided into a thirty-period horizon, as presented on the horizontal axis (see figures 3 and 4). This is done to highlight the economy's reaction to various oil price shocks. Since stability of the VAR framework has been achieved, this study examines the economic system of the AOECs' impulse reaction to various oil price shocks (i.e., negative and positive oil price shocks) via exchange rates, output, and inflation rate. In the impulse responses depicted in figures 3 and 4, the x-axis represents the periods that the analysis covers. Generally, the unit root results of these macroeconomic variables reveal that the variables are stationary (see Tables 2a and 2b for details).

3.13.1. Impulse responses of output and other selected macroeconomic variables to negative oil price shocks

The vital focus of this study is to analyze how various oil price shocks impact output, with the aim of establishing whether or not there is an asymmetric relationship. The reaction of each variable to negative oil price shocks is analyzed. Figure 3a to 3c respectively depict the impulse responses of output, exchange rates, and inflation to a one percent standard deviation in negative oil price shocks, as dictated by the international oil market, covering thirty periods. Output is negative and significantly explain the impact of negative oil price shocks. One standard deviation in negative oil price shocks leads to a negative response in output. Following the negative oil price shocks' behavior, it is evident that output continuously declines from the beginning through period five to nine and bottoms at period ten. As it proceeds into future periods, it begins to rise until period thirty. This suggests recovery or improved output among the AOECs and also implies that negative oil price shocks may not necessarily dictate a continuous fall in output over time.

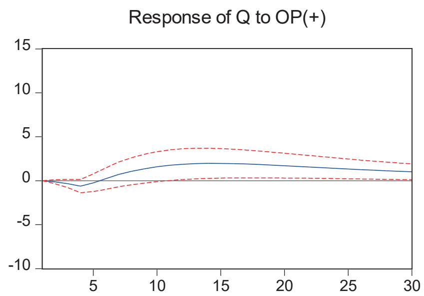
The attendant impact of a one percent variation in negative oil price shocks is also shown in a positive and significant reaction in exchange rates from periods fifteen to thirty. Prior to this, the exchange rates trend is positive but not significant, suggesting that the effect of negative oil price shocks is not felt instantaneously in exchange rates variations. Furthermore, the response shows that unanticipated negative oil price shocks from the external environment reduce the value of the domestic currency, as more units of domestic currency exchange for fewer units of dollars and this situation may relatively persist in the future period. This finding is in line with Kose and Baimaganbetov (2015) and Rafiq *et al*. (2016), who claim that the influence of oil price shocks on the currency of oil-exporting nations leads to currency appreciation or depreciation if the shocks are respectively positive or negative. Figure 3c shows a slight, significant decline in inflation over a relatively long period, specifically from the eighth to the thirtieth period, consequent to a one percent standard deviation in negative oil price shocks. More precisely, inflation rises sharply within periods one and two, peaks in period three and begins to decline continuously from period four as it moves towards period five, bottoming at period ten. It stabilizes steadily and flattens at period ten and continues up until period thirty with a negligible increase. These findings align with our expectations that, negative oil price shocks reduce output and cause a decline in oil revenue (revenue effects). However, external shocks have a spill-over impact on economic output. For example, negative oil price shocks could lead to a fall in production arising from a rise in the prices of production factor inputs. Following Di Giovanni and Shambaugh (2008) who assert that various economies are affected by external conditions, this is reflected in inflation that initially trends upward within the first three periods and later declines significantly until period thirty.

3.13.2. Impulse responses of output and other selected macroeconomic variables to positive oil price shocks

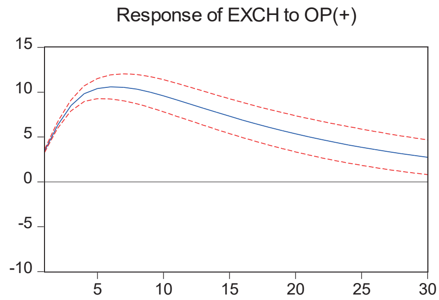
Figure 3a-3c presents the impulse responses of output and other macroeconomic variables to a one percent standard deviation in positive oil price shocks. More specifically, figure 3(a) shows that positive oil price shocks reduce output in periods one and three, bottoming out in period four. Thereafter, they become positive and significant, rising over a relatively long period and peaking at about period fifteen. Output responds positively to one standard deviation in positive oil price shocks. This may result in a rise in oil proceeds accruing to domestic oil-exporting economies and may consequently lead to domestic currency appreciation. This finding is in line with theory and also supports the findings of Rafiq *et al*. (2016) who report a positive nexus between output and one standard deviation in positive oil price shocks. Despite this observed similarity, there is a slight difference in output behavior in reaction to positive oil price shocks. For instance, this study finds a positive and significantly prolonged rise in output among the AOECs.

Figure 3

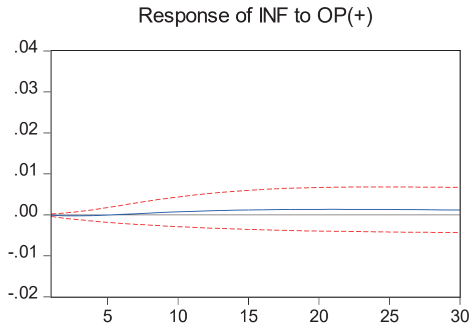
(a)



(b)



(c)



The impulse responses of the exchange rates to a one percent standard deviation in positive oil price shocks are presented in Figure 3(b) that shows that exchange rates rise, peaking in the fourth period and begin to decline significantly and continuously as it moves to period thirty. This suggests appreciation in the domestic currency of the AOECs, as less of their domestic currency will be required in exchange for foreign currencies. This is in line with the literature and the standard theory of exchange rate determination, suggesting that, positive oil price shocks lead to currency appreciation in an oil-exporting country and vice versa. Demand for its currency leads to a rise in the foreign exchange market, and this causes the value of domestic currency to appreciates. In contrast to negative oil price shocks, the inflation rate depicted in figure 3(c) does not significantly respond to one standard deviation in positive oil price shocks. This suggests that positive oil price shocks may not necessarily trigger inflation in the AOECs.

3.14. Variance Decomposition (VD)

VD shows the proportion of shocks to a exact variable that relates to either self innovations or innovation from other endogenous variables over a specified or forecasted time frame in a given model (see Rotimi and Ngalawa, 2017). Furthermore, variance decomposition accounts for the information on the percentage of movements in an order of a given variable due to self shocks or shocks arising from other variables (see Adarov, 2019). It analyses the relative significance of shocks in explaining changes among the variables in a given model. In this study, VD is employed to evaluate the relative fraction of shocks to variables in our model; basically, to assess how various oil price shocks impact output of the AOEC.

In order to determine the comparative significance of each structural innovation in explaining variabilities and shocks of the variables in our model, Tables 7-9 present variance decompositions for the variables output, exchange rates, and inflation for period thirty. The analyses thus cover a six-year forecast horizon.

Table 7. Variance Decomposition of Output

Period	S.E.	Q	OP^{-}	OP^{+}	EXCH	INF
1	3.47149	100.000	0.00000	0.00000	0.00000	0.00000
6	21.7749	93.1920	6.64621	0.13117	0.01787	0.01273
12	34.0327	87.2754	11.3884	1.14459	0.18155	0.01002
18	39.6121	84.0331	13.2026	2.26750	0.42680	0.06981
24	42.1613	82.3279	13.9000	2.86442	0.67838	0.22927
30	43.3597	81.3124	14.1614	3.14582	0.91651	0.46375

Source: Authors' Computation (2022).

Table 7 shows that the difference in the number of variations in output specifically ascribed to positive and negative oil price is relatively pronounced compared to inflation and exchange rates. Negative oil price shocks account for more than five times the proportion of the fluctuations in output that positive oil price shocks account for during the periods under examination. The degree of fluctuations associated with negative oil price shocks rose consistently over the period. It is zero percent within the first period, jumps to 6.6 percent, rises steadily through period twenty and peaks at 14.1 percent in period thirty. Similarly, positive oil price shocks gently appreciate within these periods. For example, it starts at 0.31 percent in the sixth period, jumps to 2.2 percent, more than quadruples in period eighteen and peaks at 3.1 percent in period thirty.

Table 7 reveals that exchange rates are relatively more influential in accounting for fluctuations in output than inflation.

Comparatively, the study reveals that negative oil price shocks and exchange rates, respectively account for more fluctuations in output than positive oil prices shocks and inflation rates. On the whole, the fluctuations in output ascribed to positive oil price shocks are more than those arising from either exchange rates or inflation rates. Similarly, the fluctuations in output that are ascribed to negative oil price shocks exceed those arising from positive oil price shocks, exchange rates and inflation rates. The result reveals that negative oil price shocks, that measure a net fall in oil prices is most influential on output behavior. The inference is that, of the two decomposed oil price shocks used to measure the attendant impacts of shocks on output, OP^{-} is higher than OP^{+}. Similarly, the outcome shows that negative and negative oil price shocks are disproportionate, suggesting the existence of asymmetry.

In addition, the finding reveals that negative oil price shocks explain the largest share of the fluctuations in output from the beginning to the end of the period. This clearly suggests that caution should be exercised, and appropriate policy measures should be applied to cushion the impact of negative oil price shocks.

Table 8. Variance Decomposition of Exchange Rates

Period	S.E.	Q	OP^{-}	OP^{+}	EXCH	INF
1	0.01415	0.87393	0.02748	0.00883	99.0897	0.00000
6	0.09032	2.30454	0.35920	0.06099	97.1222	0.15301
12	0.16700	3.53055	0.82375	0.02506	94.9738	0.64674
18	0.22648	4.69953	1.24902	0.02669	92.6775	1.34717
24	0.27530	5.72800	1.62358	0.05477	90.4438	2.14976
30	0.31731	6.57603	1.94015	0.09340	88.3885	3.00182

Source: Authors' Computation (2022).

Table 8 presents the variance decomposition of exchange rates, showing the different contributions of each innovation to exchange rates fluctuations. Exchange rates have been noticed to have large effect on output. As Table 8 shows, inflation rate has a marginal impact on exchange rates.

This account for less than 0.1 percent of fluctuations in exchange rates in period six, increasing to 1.3 percent in period eighteen and peaking at 3 percent in period thirty. Negative oil price shock has a somewhat larger effect on exchange rates fluctuations than positive oil price shocks. Furthermore, the result shows that negative oil price shock accounts for 0.02 percent of the instabilities in exchange rates in the first period. It jumps to 0.82 percent, and rises to 1.24 percent, 1.62 percent, and 1.94 percent by the end of the third, fourth, fifth and sixth periods, respectively. Consequently, the effect of negative oil price shocks is more pronounced than positive oil price shocks that stand at 0.0600 percent, 0.0200 percent, 0.0500 percent, and 0.0900 percent at the end of periods six, eighteen and thirty, respectively.

The results show that, during the period under examination, output increasingly accounts for fluctuations in exchange rates. This aligns with the exchange rates theory that posits that increases in output cause exchange rates to appreciate. It suggests that governments should focus on output enhancing policy to stabilize exchange rates. Table 8 also shows that output has significant impact on exchange rates fluctuations compared with negative and positive oil price shocks, and inflation rates. Furthermore, positive oil price shocks, is directly proportionate to output. Therefore, output increases during positive oil price shocks and vice versa.

Table 9. Variance Decomposition of Inflation Rates

Period	S.E.	Q	OP^{-}	OP^{+}	EXCH	INF
1	0.00428	0.00125	0.00714	0.07021	0.23065	99.6907
6	0.03210	0.01316	0.07021	0.01771	0.39965	99.4992
12	0.06670	0.11635	0.12135	0.06554	0.58570	99.1110
18	0.09603	0.29767	0.11851	0.12558	0.73311	98.7251
24	0.11965	0.52049	0.09905	0.15475	0.85010	98.3756
30	0.13846	0.75802	0.07971	0.16350	0.94773	98.0510

Source: Authors’ Computation (2022).

Table 9 shows the VD, indicating that positive oil price shock accounts for marginal impact of 0.07 percent on the inflation rate. It rises progressively to 0.06 percent by the end of the twelfth period and at the end of periods eighteen, twenty-four and thirty, positive oil price shocks account for 0.1200 percent, 0.1500 percent and 0.1600 percent of the instabilities in inflation, respectively.

Contrarily, negative oil price shocks’ affect inflation rate changes in the first ten periods, peaks at the end of period twelve and continuously declines to 0.07 percent at period thirty. The implication is that negative oil price shocks might result in an unstable inflation rate in AOECs. Shocks to exchange rates largely account for fluctuations in inflation from period one through to period thirty. For example, exchange rates account for 0.23 percent of the fluctuations in inflation in the first period. They account for 0.03 percent of fluctuations in inflation after six periods and 0.58 percent after twelve periods, peaking at 0.94 percent in period thirteen. Output shocks account for a negligible 0.01 percent of the fluctuations in inflation after the sixth period, 0.11 percent after twelve periods and progressively rise to 0.75 percent after period thirty.

4. DISCUSSIONS AND INFERENCES

This study primarily established the existence of asymmetry in oil price shocks in the various AOECs. Its findings may lead to vital conclusions in the debate concerning oil price asymmetry.

Firstly, the study finds evidence to support Rafiq *et al.*’s (2016) conclusion that the relationship amid oil price shocks and output is asymmetric, implying that output performance is different when positive oil price shocks are used, compared with when negative oil price shocks are employed. This is also evident from the impulse response analyses results (see Figures 3a and 4a). As indicated, positive oil price shocks clearly present a disproportionate pattern from negative oil price shocks. Consequently, output performance reacts to various oil price shocks in a disproportionate way. In addition, the study presents evidence that increased uncertainty with regard to variations in oil prices is connected with lower output. The generalized impulse response function shows an asymmetric effects of negative and positive oil price shocks on output. The IRFs reveal that the impact of positive oil price shocks on output over time differs in size and persistence from that of negative oil price shocks (bad news). This further assists to explain the asymmetric reaction of output to oil price.

Secondly, findings from the study offer a contrary opinion to the earlier claim that positive oil price shocks might trigger inflation (see figure 3b). This submits that positive oil price shocks might not account for inflation, but changes in other factors may lead to inflation.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This study employs a comprehensive cross-country dataset to examine the impact of oil price shocks and its asymmetry on output performance in AOECs. Previous researches on oil price shocks and the macroeconomy nexus focused on how oil price uncertainty affected output in developed oil-importing countries but neglected the asymmetric relationship amid oil price shocks and economic activities, which may offer better policy options. This study specifically examines this relationship using output and decomposed oil price in the AOECs. It relies on a panel VAR model to study this relationship which allows us to account for impulse-response analysis to examine the impacts of oil price on output. In addition, through the panel VAR model, variance decomposition is performed to assess the importance of those effects and guidelines are offered for policy formation. The study, argue that negative and positive oil price shocks create asymmetric and heterogeneous impacts on output in the AOECs.

Furthermore, the study finds that, on average, positive oil price shocks positively impact output and this effect remains significant for more than fifteen periods. The reverse is observed with regard to negative oil price shock. Negative oil price shocks result in a fall in output. This implies that revenue from output will also fall. In terms of magnitude, the study finds that negative oil price shocks impact output greater than positive oil price shocks. For instance, fourteen percent of the fluctuations in output are associated with a change in negative oil price shocks, while only a three percent change in output is explained by a change in positive oil price shocks. The finding validates the claim that oil price shocks and output nexus is asymmetric. In addition, the results offer additional support for the institutional view of output performance that, with lower negative oil price shocks, output could be enhanced. Similar to output, fluctuations in exchange rates arising from negative oil price shocks are higher than those ascribed to positive oil price shocks. This suggests that negative oil price shocks affect AOECs more than positive oil price shocks. The net effect of positive and negative oil price shocks on output in the AOECs may therefore be unfavorable. Since this study established that the AOECs rely on proceeds from oil, and that, many of these countries rely on importation of refined oil due to their weak refinery capacity to meet local consumption, they need to mitigate against negative oil price shocks which may have serious consequences for their economies, and cause a decrease in oil revenue. The findings reveal the prevalence of Dutch Disease among the AOECs that is apparent in the impacts of negative oil price shocks on both exchange rates and output. The attendant effect of this phenomenon on the AOECs' tradable sectors is that it impacts domestic factors' prices. It squeezes out the tradable sector which my consequently portend further negative impacts for their macroeconomic behaviour. Previous studies concur that increase oil prices brings in extensive capital which may result in greater investment into human and physical capital in oil-exporting economies. In another way, a windfall from oil could cause exchange rates appreciation and deindustrialization that are detrimental to economic growth.

There is policy need to minimize the effect of oil price shocks on output, especially negative oil price shocks which have been found to adversely affect oil revenue (e.g., policies aimed at strengthening economic activities through diversification, so as to enhance the export mix). This will reduce the AOECs' on-going reliance on large revenues from oil arising from positive oil price shocks which the literature argues has had a negative and retarding impact on the economy, mainly because it affects the non-oil sector. Therefore, it is recommended that governments should provide public goods to support diversification.

It would also be beneficial for the AOECs to adopt economic stabilization policies that could reduce the level of risk attached to oil price shocks. This could include a more flexible exchange rates policy, which, to a reasonable degree, would raise the degree that the economy could make essential modifications without impeding output growth in the long run. In addition, a counter-cyclical fiscal policy is recommended. This aims to lessen spending and raise taxes during boom, and raise expenditure and lessen taxes during recession, to improve output and exchange rates. It could also mitigate oil price shocks effects on the AOECs' economies, through active and prudent management of the government estimate over the business cycles. This approach will demand that funds are reserved and a mechanism instituted through which assets may accumulate during oil booms and drawn during busts. This serves as a cushion fund that government can rely on without having to secure external borrowing to finance domestic investment. While it is noted that developed oil-importing and oil-exporting nations have some type of oil reserve fund and other internal mechanisms to stabilize their economies during unfavorable oil price shocks or in case of any uncertainties, reverse is the case in most developing oil-exporting countries. This scenario is still somewhat new to them, and they confront challenges like corruption, accountability, governance, transparency, insecurity, inequality, and high mortality rates.

It is also recommended that oil proceeds, windfalls and excess crude oil revenue are transformed into physical amenities and capital instead of being redistributed to municipal and regional governments that may not use it prudently to finance productive ventures. Funding business support projects will go a long way in encouraging production of additional tradable goods for export, and will empower the industrial base of the economy, and increase output. In addition, since oil resources are characterized as a generational resource, it is recommended that tax policy is introduced to transform today's oil revenue into social infrastructure and physical capital that will benefit future generations.

In conclusion and for the purpose of further research, the optimal size and management of oil proceeds within the oil-exporting regions are vital and this may be an motivating area for future research. On the whole, governance of the AOECs should always be proactive and provide public goods without having to rely on revenue from oil.

While our data sample for the countries under consideration is assumed adequate, a larger sample size, and more high-frequency variables, especially for the estimation of the panel VAR model, would be more appropriate. This is due to the fact that the assumption underlying the VAR model identification, where the data is on a quarterly or annual basis, could be too strong, because variables don't contemporaneously respond (within one year) to variations in other variables. Hence, data on monthly or daily frequency might offer more reliable results. Unfortunately, monthly and weekly data on national income accounts are unavailable for the nations included in our sample. The Mixed Data Sampling (MIDAS) estimating technique is recommended to handle this problem in further research.

Finally, it is recommended that future studies focus on oil revenue shocks instead of oil price shocks which could confuse demand and supply shocks. This will offer opportunities to discern the nature of oil price shocks which could be an interesting subject for investigation.

End Nots

[1] Demand effect.

[2] Supply effect.

[3] Dutch Disease is a situation where a rise in oil revenue does not result in increased domestic growth.

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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Principal component and regression analysis of the natural resource curse doctrine in the Azerbaijani economy

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Abstract

The Azerbaijani economy has long been discussed in academic literature with reference to the theories of the natural resource curse (NRC) and Dutch disease. This is due to Azerbaijan's heavy dependence on the oil and gas industry for its economic growth and development since 1995. While revenues from mineral resources helped overcome extreme poverty and increased GDP and GDP per capita, macroeconomic stability was shaken by the sharp decline in commodity prices in 2014 and 2015. This reality prompted scholars to look into the significance of NRC and Dutch disease in Azerbaijan. This paper therefore aims to contribute to the literature by analyzing NRC using principal component and regression techniques (dynamic and ordinary least squares) in a way that has not been studied before. The results of this study show that the oil industry had a negative impact on institutional quality in Azerbaijan between 1996 and 2019, which may translate into further negative impacts. For this reason, the human capital channel of NRC was tested for possible negative impacts of NRC and several negative associations were found. These results indicate that policymakers need to take the NRC doctrine more seriously. Although the first oil boom (2005–2014) is over, the Azerbaijani economy is facing a second oil boom starting in 2020, and the lowered quality of institutions could significantly reduce the benefits of mineral revenues if left unmanaged.

Keywords: Azerbaijan economy, Dutch disease, natural resource curse, principal component analysis, regression

JEL codes: E02, C38, O13, O15, O17

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1. INTRODUCTION

According to the World Bank (2020), Azerbaijan is more dependent on its natural resources than any other post-Soviet state. Czech (2018) claimed that Azerbaijan enters into the group of 15 most oil-dependent countries in the world based on the ratio of oil revenues to GDP. Azerbaijan's oil revenues, which started at 22.5% of GDP in 2001, rose steeply, reaching a record 39.6% in 2006. Although the country has many natural resources, the non-oil sector has been de-industrialized (Sadik-Zada et al., 2021), and most of the government's money comes from crude oil and petroleum exports.

The mining industry contributed significantly to national economic growth, while manufacturing and agriculture gradually contracted. Government spending, fueled by commodity gains, encouraged growth in the tertiary sector. As a result, most major infrastructure and transportation projects were geared toward the needs of the extractive sector, particularly the development of new oil and gas deposits. This structural shift in favor of the oil and gas industry is believed to have led to problems such as the Dutch disease, in which a country is unable to foster growth in other areas of the economy and repeatedly suffers from political and institutional deficiencies as well as deficiencies in governance and thus human capital.

Amineh (2006) claimed that resource-rich post-Soviet countries, such as Azerbaijan, Turkmenistan, and Kazakhstan, would not be able to successfully industrialize due to issues arising from the NRC. Similarly, Esanov et al. (2005) argued that political reforms in resource-rich transition countries do not favor a deterministic model of policy formation. In fact, according to Kronenberg (2004), substantial differences exist between resource-rich and resource-poor transitional countries. He argued that, while resource-poor Central and Eastern European (CEE) countries performed well in catching up with developed economies, resource-rich countries seemed to lag. This was mainly due to corruption inherited from the Soviet era, which entailed a high level of state capture. Franke et al. (2009) argued in favor of the existence of the NRC in Azerbaijan because of the lack of an alternative political elite as well as a substandard democracy; moreover, they argued that a lopsided economic structure was established after high mineral revenue flowed into the country.

NRC and its economic explanation, Dutch disease, are a major economic challenge to a country if not addressed because they deprive the country of the long-term benefits of available natural resources (Krugman, 1987; Matsuyama, 1992; Lucas, 1988; Hausmann et al., 2007). This is due to the lack of preparation of the political system, governance traditions, and institutional responsiveness. Therefore, the main objective of this paper is to analyze the presence of NRC in the Azerbaijani economy using empirical models that are country-specific and theoretically grounded. To this end, the research design was based on a general descriptive assessment of the main institutional and oil-related variables, PCA, dynamic least squares (DOLS) and ordinary least squares (OLS) regressions. The study adopted a deductive approach based on the following research question: what was the impact of the oil industry on institutional quality and human capital (as measured by the variables of health care, education, and human rights) between 1995 and 2019? The paper fills the persistent research and conceptual gaps in the NRC field by analyzing the Azerbaijani economy. The use of PCA and regression techniques such as OLS and DOLS also overcomes the methodological gaps that usually exist among scholars to properly conceptualize the NRC doctrine.

The results of this study demonstrate the presence of NRC in the Azerbaijani economy due to the negative impact of the oil industry on institutional quality. Moreover, numerous negative and statistically significant coefficients identified in the regression equations for health care, education, and human rights point to the specific channel of NRC, namely the change in human capital, which is quite actual for Azerbaijan. It is an absolute necessity to transform revenues from mineral resources into long-term and sustainable economic development. While these findings are worrisome, they also challenge policymakers to think twice in times of high oil prices.

The structure of this article is as follows: The next section contains a two-level literature review, NRC at a Glance, which informs the reader of the theoretical basis of the doctrine. Azerbaijan-specific NRC literature examples are then briefly discussed. Section 3 provides all the information about the data and methodology of the study, while Section 4 presents the results of the descriptive and empirical research. The final section concludes.

2. LITERATURE REVIEW

This section is a literature review that includes a brief discussion of the theoretical underpinnings of the NRC doctrine and its relevance to the Azerbaijani economy since the collapse of the Soviet Union.

2.1. NRC at a Glance

The term NRC is used to describe the disparity in economic growth rates between resource-rich and resource-poor nations. (Auty and Warhurst, 1993). Numerous studies have provided a solid foundation for resource curse-related studies, enabling an enhanced understanding of the economic reasons of the disparity in economic growth rates between resource-rich and resource-poor nations.

NRC theory has been discussed since 1970; pioneering papers were by Sachs and Warner (1997; 1999; 2001), who discovered a negative correlation between natural resource availability and resource dependency and GDP performance in cross-national research. They also highlighted the fact that mineral-rich countries tend to be expensive countries, which hinders export-led industrialization in the long term. Furthermore, According to Auty (2001), between 1960 and 1990, resource-poor nations saw greater increases in their per capita income than did resource-rich ones. In fact, among the largest mineral exporters, the annual GDP per capita growth rate decreased from 1980 to 1993 following the boom period of 1970 to 1980 (Mikesell, 1997). Mikesell (1997) also noted that the average annual GDP growth rates of mineral exporters declined after commodity prices collapsed from 1980 to 1993. In a more recent study, Using data from a panel of 111 countries from 1996–2015, Sharma and Pal (2020) found support for the resource curse phenomenon in both the short and long term. They observed a negative impact of resource dependence on economic growth.

If a downward trend occurs in main commodity prices in the long term, then the NRC may pose a serious threat to mineral-rich countries (Arezki et al., 2014). This could lead to trade deterioration or simply the contraction of mineral revenue. A growing body of literature related to the NRC and Dutch disease has cited other risks too. For instance, through the effects of Dutch disease, REER appreciation significantly reduces the productive capacity of non-resource tradeable sectors (Krugman, 1987), encourages corruption, and decreases bureaucratic quality (Busse and Gröning, 2013). The resource curse also hinders knowledge accumulation and capital formation (Welsch, 2008), which harms education levels as the need to invest in education to provide specialized human capital to crowded-out manufacturing sectors is reduced (Wadho, 2014). Moreover, a study found that "knowledge accumulation and capital formation are inversely related to the natural-resource intensity" (Welch, 2008: 62).

Based on the example of successful countries such as Norway, Botswana, Indonesia (Gurbanov and Merkel, 2009), Chile (Havro and Santiso, 2017), and Iceland (Gylfason and Zoega, 2006), natural resources can be said to increase wealth if the negative impacts of resource abundance are minimized through institutional regulations. Thus, general claims of the existence of the NRC in a country or region should be handled very carefully. If institutions function well and the state distributes income equally and efficiently, it is possible that the abundance of natural resources may prove to be a boon instead of a bane, contributing to accelerated economic development (Acemoglu et al., 2005). However, if a country becomes dependent solely on the sale of one primary product during its developmental stages and has weak institutions, macroeconomic destabilization may be inevitable due to volatile commodity prices and political challenges (Venables, 2016).

2.2. NRC in the Azerbaijani Economy

The literature examples dealing with the NRC doctrine in the case of Azerbaijan are sparse. In general, authors claim that Azerbaijan has a high propensity for NRC and its economic explanation (Dutch disease) due to political problems, corruption, institutional mismanagement, and rent-seeking behavior (Laurila and Singh, 2001; Mahnovski, 2003; Kaser, 2003). There is a lack of solid empirical models to capture the NRC phenomenon, specifically in the Azerbaijani economy. Nevertheless, some studies that have analyzed NRC to some extent are worth mentioning.

Tsalik (2003) suggested that Azerbaijan's new agreements with multinational companies in the extractive industries in the mid-1990s could ease the burden on government officials to further reform the economy. Tsalik (2003) emphasized that Azerbaijan's domestic absorption capacity was too small to benefit from such a large influx of FDI within a short time frame. Similarly, Esanov (2001) and Hoffman (1999) argued that the domestic tax collection apparatus, financial administration, and domestic energy sector presented challenges to transparent and efficient management of oil revenues. In early articles on NRC in Azerbaijan, government decisions and new spending habits raised serious concerns. Some authors claimed that oil revenues were spent in a non-transparent manner that did not promote development outside the oil sector that could ensure long-term sustainable development; in addition, the distribution of profits at the national level was problematic (Gulbrandsen and Moe, 2007). All of this created initial evidence for NRC in Azerbaijan.

Khanna's (2011) descriptions of Azerbaijan's oil boom period highlighted the government's low willingness to redistribute oil revenue, market-distorting interventions by the state, and the influential position of oligarchs. Achieving independence from the Soviet Union did not appear to inspire Azerbaijan to manage its oil revenue in a desirable way. Consequently, if the management of oil revenue fails, the reasons behind the fiasco point to the relevance of the NRC.

Observations and analyses of political and institutional variables in Azerbaijan have supported the relevance of NRC syndrome. Bhatty (2002) considered corruption, weak state capacity, and impediments to trade the main signals of the political and institutional channel for the NRC. Bayulgen (2005) argued that oil rents encouraged an authoritarian regime, resulting in the accumulation of power in the hands of the president. Later, O'Lear (2007) provided evidence of the NRC based on survey data from Azerbaijani citizens. According to his findings, an oil-dominated economy, high accumulation of fortune by the nation's elite, political legitimacy problems, and centralized political control were clear signs of the NRC. Other indications of the NRC's political and institutional channel include internal and external patronage networks, clientelism (Bayulgen, 2005; Guliyev, 2009), autocracy (Schubert, 2006; Pomfret, 2011; Kendall and Taylor, 2012; Radnitz, 2012), problems with political freedom and democracy (Altstadt, 2017), transparency and accountability issues in revenue spending (Wakeman-Linn et al., 2003; Franke et al., 2009), and intense pushback to private sector expansion (Kalyuzhnova and Kaser, 2005). A further indication is neopatrimonialism, which refers to informal personalized rule combined with pyramidal power structures (Franke and Gawrich, 2010; Heinrich, 2010).

More recent studies continue to emphasize NRC's possiblity in Azerbaijan. For example, Biresselioglu et al. (2019) classified Azerbaijan as a country highly vulnerable to the NRC, ranking it among the top 10 countries labeled "high," as measured by the Resource Curse Vulnerability Index (RCVI). This indicated a lack of economic diversification, economic planning, and industrial development policies.

The literature reviewed in this section shows that since the mid/late 1990s, a growing number of studies have sounded the alarm about the presence of NRC in the Azerbaijani economy. The changes in the Azerbaijani economy call for further study of NRC and Dutch disease theories, because to date there are no clear conclusions about the above economic phenomena.

3. DATA AND METHODOLOGY

This section contains detailed information on quantitative data and analytical methods in separate subsections.

3.1. Data

The political and institutional channel of the resource curse in Azerbaijan was traced through the following variables: political stability and absence of violence/terrorism (POL_ST; hereinafter "the political stability index" or "political stability"), the rule of law (RULE_O_LAW), the voice and accountability index (VO_AND_ACC), and latent human rights protection scores (H_RIGHTS; hereinafter "human rights scores"). The first four variables were obtained from the Worldwide Governance Indicators (WGI) provided by the World Bank, while the last variable was taken from the data set of Schnakenberg and Fariss (2014), referred to by Fariss (2019) as "Latent Human Rights Protection Scores."

Furthermore, POL_ST has quantified people's expectations about the frequency of political violence and terrorism. The extent to which public authority is exercised for private gain, whether through petty or grand corruption, and the "capture" of the state by elites and corporate interests was quantified by controlling for corruption. RULE_O_LAW reflected agents' views on the reliability of social institutions, including the police and courts, the protection of private property and the quality of contract enforcement, and the incidence of violence and crime. A measure of freedom of speech, association, and the press, as well as the extent of public participation in the election of government, was captured by VO_AND_ACC. Lastly, H_RIGHTS looked at the human rights situation in a country as a whole.

All of the variables related to the political and institutional channel, excluding human rights scores, ranged between −2.5 and +2.5 (the higher the better). Human rights scores ranged from −3.8 (minimum) to 5.4 (maximum). The examined period was from 1996 to 2019.

In the DOLS analysis, both dependent and independent variables come from the previously estiamted principal components.

Of the independent variables, only the extractives dependency index (EDI) was calculated according to Hailu and Kipgen's (2017) methodology. The calculation formula is presented below:

$$EDI_t = \sqrt{[EIX_t \times (1 - HTM_t)] \times [Rev_t \times (1 - NIPC_t)] \times \times [EVA_t \times (1 - MVA_t)]} \quad (1)$$

where **EDI** is the extractives dependence index for a country at time *t*; **EIX** is the revenue from the extractive industry, expressed as a share of total export revenue; **HTM** is the export revenue from high-skill and technology-intensive manufacturing as a share of global HTM exported in year *t*; **Rev** is the share of revenue from the extractive industry in total fiscal revenue; **NIPC** is non-resource income, including tax revenue, profits, and capital gains as a percentage of GDP; **EVA** is the share of the extractives industries' value-added in GDP; and **MVA** is the countrywide non-resource manufacturing potential, as measured by per capita manufacturing value-added.

Other factors may also play a role in explaining this phenomenon. The ratio of oil exports to GDP (OIL_ EXP /GDP) indicates the importance of exports to the Azerbaijani economy as a whole, while oil rents (OIL RENTS) variable reflects the difference between the value of crude oil production at international prices and total production costs. FDI in the oil industry (OIL_FDI) was another potential channel for booming sectors to influence the variables of interest. SOFAZ's share of the state budget (SOFAZ's_SH) measured the state budget's performance in relation to the oil revenue transfers from SOFAZ. Last but not least, both the global financial crisis of 2008–2009 and the dramatic commodity price declines of 2014–2015 are reflected in the dummy variable ECON_SHOCK, which measures economic shocks.

The source for OIL_RENTS is the World Bank. The ratio of oil exports to GDP was calculated using official statistics from SSCRA. OIL_FDI is from SSRA, SOFAZ's_SH from SOFAZ annual reports. All the data are secondary and come from reliable sources. Descriptive statistics, normality tests, outliers, and missing values for variables of interest can be found in tables A1 and A2 in the Appendix. Missing values were filled by the linear interpolation method, and outlier values were cleaned by the Winsorization technique.

3.2. Methodology for PCA

Considering the wide range of the collected data set, the main empirical stage started with PCA. PCA is beneficial when the data set is large and several variables need to be examined (Bro & Smilde, 2014). Jolliffe's (1990) early study on PCA stressed that if the correlation between variables is strong, it may be decreased to discover "a true dimension" of the data set that would deliver the same information with the least information loss. This reduction yields "components," which help one to identify patterns across various data series (Ringnér, 2008). Ringnér (2008) also emphasized the independence of components rather than them being uncorrelated. If the original variable quantity *a* can be reduced to *b* using newly constructed index variables or components, a large amount of information can be analyzed using a relatively simple technique. PCA is often used as a pre-analysis of variables of interest and also as an analytical bridge for further investigation.

Here, PCA provided the main components for analyzing institutional quality and its relation to the oil sector. Varimax rotation was used in the PCA to maximize the variance of the factor loadings (Dien 2010). The main components were then saved as individual time series and regressed against each other using the dynamic ordinary least squares (DOLS) method.

3.3. Methodology for Regression Analysis

The regression analysis began with the inclusion of the principal components obtained from the PCA, which grouped the variation in the data into the factors related to oil and institution. In the literature, change in institutional quality is usually evident only over time. For this reason, DOLS was the most appropriate method to account for the dynamic nature of the newly created principal components-based time series. Thus, the model specification is as follows:

$$Institutional\_quality_t = \beta_0 + \beta_1 Oil\_factor_t + + \sum_{i=-m}^{i=m} \Delta\beta_1 Oil\_factor_t + \epsilon_t \quad (2)$$

where institutional_quality is the first component of PCA at time t; Oil_factor is the second component of PCA at time t; and ϵ is the error terms. Furthermore, Oil_factor was added along with lags, allowing to find the best way to build the model and to test how stable the results were.

This study also used the ordinary least squares (OLS) technique to test the effect of individual oil-related variables on the selected human capital variables. Three models related to this are presented as follows:

$$OP\_Expenses_t = \beta_0 + \beta_1 Oil\ Rents_t + \beta_2 EDI_t + \beta_3 Oil\ Exports_t + \beta_4 Economic\ Shocks_t + \epsilon_t \quad (3)$$

$$TGEE_t = \beta_0 + \beta_1 Oil\ Rents_t + \beta_2 EDI_t + \beta_3 Oil\ Exports_t + \beta_4 Economic\ Shocks_t + \epsilon_t \quad (4)$$

$$Human\ Rights_t = \beta_0 + \beta_1 EDI_t + +\beta_2 Mining\ industry_t + \beta_3 SOFAZ'share_t + \epsilon_t \quad (5)$$

In the above-listed models, *OP_Expenses* denotes the out-of-pocket expenses on health care; *TGEE* is the total government expenditure on education; *Human Rights* is the human rights scores at time t; and β_0 is the intercept in all models. Then, *Oil rents*, *EDI*, *Oil Exports*, *Economic Shocks*, *Mining Industry*, and *SOFAZ's share* are the explanatory variables at time t. Lastly, ϵ_t is the error terms at time t.

All variables used in the regression analysis were transformed to their first difference due to the unit root in the time series (see Table A3 and A4 in the Appendix section). PCA was used in SPSS version 23, and regression and related analyses were carried out in Eviews version 11.

4. RESULTS

4.1. Figure Analysis

Figure 1 indicates that indices such as control of corruption, government effectiveness, and rule of law experienced either a downward trend or a slowdown as soon as the oil boom started in 2005. However, political stability dramatically improved starting from 2006 but fell between 2011 and 2013. Interestingly, political stability values during the post-boom period were lower than in the first half of the oil boom period. Next, regulatory quality started to decline in 2009 but recovered after 2012. Among the selected institutional variables, voice and accountability display a strong negative trend starting in 2000. Lastly, it seems that there were positive developments in the rule of law index in 2006 and a recovery after 2012. These data showed that the negative consequences of the oil boom on Azerbaijan's economy were real. This led this study to systematically investigate oil-related variables in connection with institutional quality.

The year-over-year growth rates illustrated in Figure 2 indicate that of the six institutional variables, four were associated with lower development during the oil boom period. Specifically, the rule of law, control of corruption, regulatory quality, and the voice and accountability indices displayed a lower average growth rate compared with the catch-up period of Azerbaijan's economy. During the post-boom period, only one indicator—the political stability index—had a severe deterioration.

4.2. PCA Results

Through the use of PCA, researchers are able to compress massive data sets to a smaller collection of factors that explain most of the variance. Before the PCA, the relevance of the data set for PCA had to be analyzed, for which the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were applied. To produce optimal principal components, the data set was analyzed in its original form, and then irrelevant variables were dropped (see Jaba et al., 2009 for similar PCA adjustments). If KMO values are higher than 0.300, then PCA is recommended (Kaiser, 1974). As presented in Table 1, the KMO value was 0.772 in the first analysis phase; moreover, Bartlett's test of sphericity revealed high significance, suggesting that at least one correlation was significant among the variables. In the second phase of the analysis, the KMO value dropped to 0.624, but it was still higher than the expected threshold values and still highly significant according to Bartlett's test of sphericity.

Table 1. Kaiser–Meyer–Olkin (KMO) values and Bartlett's test results.

1st phase		
KMO measure of sampling adequacy		0.772
Bartlett's test of sphericity	Approx. chi-square	303.784
	df	55
	Sig.	0.000
2nd phase		
KMO measure of sampling adequacy		0.624
Bartlett's test of sphericity	Approx. chi-square	142.479
	df	21
	Sig.	0.000

Table 2. Communalities of the variables related to institutional quality and the oil sector in Azerbaijan's economy.

Communalities	**Initial**	**Extraction**
COC	1	0.920
ROL	1	0.944
GOVEFF	1	0.927
GOVINT	1	0.634
OIL_RENTS	1	0.764
EDI	1	0.660
OIL_BOOM	1	0.766

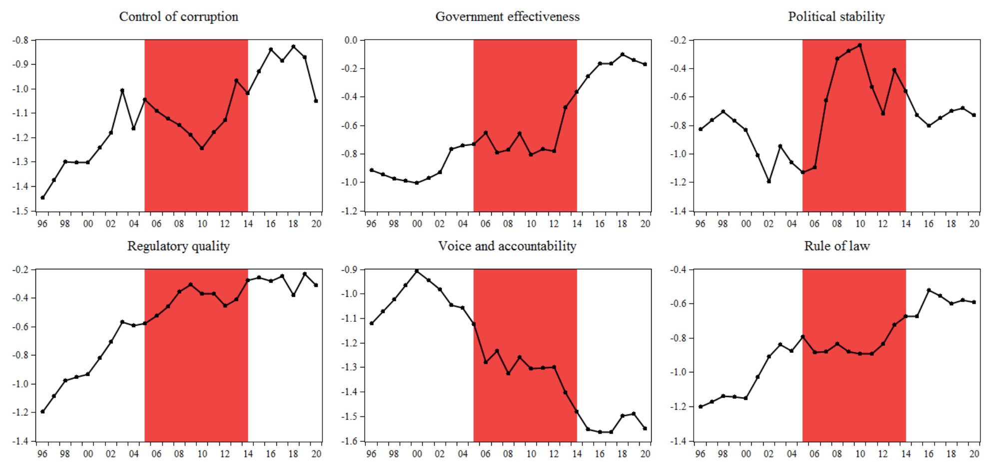
Note: Extraction method = principal component analysis.

The applicability of PCA is heavily dependent on communalities (i.e., common features). In PCA, a variable's communality value reveals how much of the variation is explained by the extracted component. A value greater than 0.35 is appropriate for PCA analysis to achieve a statistical significance of 0.05 and a power level of 80% (Tsiouni et al., 2021). The greater the communality value, the more it explains the variance of the original variable of interest. The extraction was high in variables such as control of corruption, rule of law, and government effectiveness indices (see Table 2). Oil rents and the oil boom had values of 0.764 and 0.766, respectively. EDI and the government integrity index had the lowest extraction values, but they still exceeded the level of 0.600.

The first component accounted for 47.7% of the variation based on rotation sums of squared loadings. The second component individually accounted for 32.6% but cumulatively 80.2% of the variation in the data set (see Table 3). Although the main variables were reduced to two principal components, the fact that these numbers are high indicates that enough information was stored.

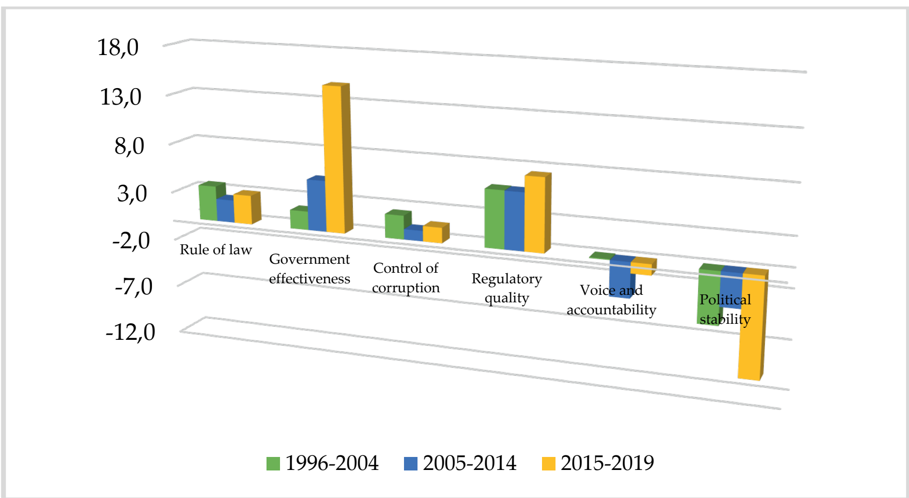
Next, the scree plot in Figure 3 indicates that the optimal number of components out of the original variables is 2 because the eigenvalues drop below 1 if the number of the components is higher than 2.

Figure 1. Worldwide governance indicators for Azerbaijan, 1996–2020.



Source: World Bank, Worldwide Governance Indicators.
Notes: Red denotes the oil boom period between 2005 and 2014.

Figure 2. Distribution of year-over-year average growth rates for institutional quality, based on the development phases of Azerbaijan's economy (index values).



Source: World Bank, Worldwide Governance Indicators.

Table 4 reports the main PCA results, including the component matrix and rotated component matrix. From both matrices, it became clear that the first component covers the variation among variables such as control of corruption, rule of law, government effectiveness, and government integrity, as they loaded high and positively on it. Similarly, the second component was the most optimal subset of the oil-related variables, such as oil rents, EDI, and oil boom. Therefore, the first component should be called "institutional quality" and the second component should be called "oil factor." Visual representations of the loadings are depicted in Figure 4.

4.3. Regression Results

The DOLS model of the principal components with one lead and one lag identified a statistically significant and negative impact of the oil factor on institutional quality in Azerbaijan (see Table 5). The sign of the coefficient related to the oil factor was always negative in the DOLS model and the intercept was positive and statistically

Figure 3. Scree plot of the variables related to institutional quality and the oil sector in Azerbaijan's economy.

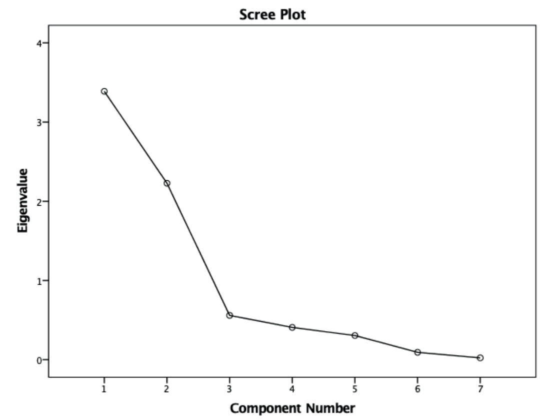


Figure 4. Component plot in rotated space of institutional quality and the oil sector in Azerbaijan's economy.

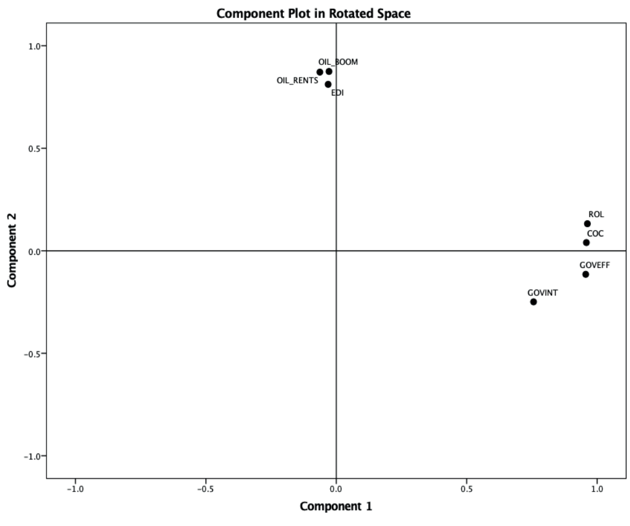


Table 3. Total variance explained of the variables related to institutional quality and the oil sector in Azerbaijan's economy.

Total Variance Explained									
Comp.	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Var.	Cum. %	Total	% of Var.	Cum. %	Total	% of Var.	Cum. %
1	3.388	48.401	48.401	3.388	48.401	48.401	3.337	47.672	47.672
2	2.228	31.824	80.225	2.228	31.824	80.225	2.279	32.553	80.225

Notes: Comp. = components; Var. = variance; Cum. = cumulative.

significant. Before DOLS mode, the principal components were checked for a unit root (see Table A3 in appendix section).

The next part of the regression analysis included some individual indicators that were definitely related to the NRC doctrine (see Table 6). They were out-of-pocket expenditures on healthcare (OP_EXP_HC), total government expenditure on education (TGEE), and human rights (HUM_RIGHTS). These variables were regressed against the following oil-related variables: oil rents, share of oil exports in GDP, EDI, economic shocks, oil FDI, mining industry's share of overall industrial production, and proportion of SOFAZ allocated to state spending or budget.

The human rights scores provided unambiguous results regarding the NRC as EDI, oil FDI, mining industry's share of overall industrial production, and share of SOFAZ in the state budget exhibited negative and statistically significant coefficients. Next, oil rents and EDI negatively and statistically significantly influenced TGEE. However, the share of oil exports in GDP and economic shocks positively impacted TGEE. Lastly, out-of-pocket expenses on health care tended to rise when EDI rose and economic shocks occurred, but oil rents and oil exports as a share of GDP negatively affected out-of-pocket expenses on health care.

All of the models were statistically significant according to significant F statistics, moderate R-squared values, and no multicollinearity issues as the variance inflation factors (VIFs) were less than 10.0. Moreover, CUSUM and CUSUMSQ tests indicated that the models were stable. Furthermore, the models were functionally correct, without any serial correlation and heteroscedasticity problems. Lastly, the Wald test indicated that all coefficients differed from

Table 4. Component matrices of the principal component analysis (PCA) related to institutional quality and the oil sector in Azerbaijan's economy.

Component Matrix[a]			Rotated Component Matrix[b]		
Component			Component		
	1	2		1	2
COC	0.929	0.24	COC	0.959	0.04
ROL	0.913	0.331	ROL	0.963	0.132
GOVEFF	0.959	0.088	GOVEFF	0.956	−0.115
GOVINT	0.792	−0.085	GOVINT	0.756	−0.249
OIL_RENTS	−0.245	0.839	OIL_RENTS	−0.063	0.872
EDI	−0.201	0.787	EDI	−0.031	0.812
OIL_BOOM	−0.211	0.849	OIL_BOOM	−0.028	0.875
Extraction method: PCA a – two components extracted.			Extraction method: PCA. Rotation method: Varimax with Kaiser normalization. b – rotation converged in three iterations.		

Table 5. Dynamic ordinary least squares (DOLS) results of the oil factor and institutional quality in Azerbaijan's economy.

	(1)	(2)	(3)	(4)	(5)
C	0.13**	0.11**	0.15**	0.15**	0.15**
	(2.18)	(1.75)	(2.86)	(2.62)	(2.35)
Oil factor	−0.23	−0.30	−0.42**	−0.28	−0.30
	(−1.68)	(−1.68)	(−2.48)	(−1.30)	(−1.51)
R-squared	0.11	0.14	0.24	0.30	0.30
S.E. of regression	0.32	0.31	0.26	0.27	0.29
Long-run variance	0.08	0.08	0.05	0.06	0.08
Jarque–Bera	1.04	0.55	0.34	0.51	0.55
	[0.595]	[0.759]	[0.843]	[0.777]	[0.757]
Wald test – F-stat.	3.55**	2.63*	6.35***	4.01**	3.30*

Notes: Model 1: without lags and leads; model 2: one lag, zero leads; model 3: one lag, one lead; model 4: two lags, one lead; model 5: two lags, two leads.

zero in a statistically significant manner.

5. CONCLUDING REMARKS

In this paper, the typical signs of NRC syndrome in Azerbaijan's economy were examined through figure analysis, PCA, DOLS, and OLS regressions. The main objective of this study was to determine the negative impact of the oil industry on the institutional quality of the Azerbaijani economy, using NRC theory as a theoretical framework. The use of quantitative methods enabled an analysis of the underlying institutional dynamics of the NRC to relate it to economic concepts such as Dutch disease. To this end, data related to institutions, governance, and human capital in Azerbaijan were collected, mainly covering the period 1996–2019. The data analysis provided reason to believe that there is an NRC in the Azerbaijani economy, as institutional quality, as measured by various World Bank indicators, declined during the oil boom (2005–2014) compared to other periods. Moreover, PCA and variable-specific modeling enabled this study to capture the typical NRC signs to estimate them for the hypothesis testing.

Moreover, a figure analysis of selected institutional variables related to Azerbaijan's economy revealed negative trends and slowdowns in institutional quality, as measured by variables such as control of corruption, government effectiveness, voice and accountability, and the rule of law as soon as the oil boom period started. In addition, year-over-year and periodic averages of the growth rates revealed a systematic decline in institutional quality during the oil boom years. For example, the period 2005–2014 had lower year-over-year growth rates for the rule of law, control of corruption, regulatory quality, and voice and accountability indices compared with the recovery phase.

Table 6. OLS results of individual NRC-related indicators against oil-related variables.

Dep. Var.	OP_EXP_HC	TGEE	HUM_RIGHTS
C	13.34** (2.88)	−0.17*** (−3.25)	0.01 (0.15)
Oil Rents	−2.84*** (−3.02)	−0.01 (−0.74)	
Oil Exp/GDP	−108.24** (−1.89)	1.15* (1.77)	
EDI	5.11* (1.84)	−0.19** (−2.78)	−0.01** (2.24)
Econ. Shocks	33.38** (2.82)	0.43*** (3.21)	
Oil FDI			−3.44*** (−3.84)
Mining Industry			−0.01** (−2.76)
SOFAZ's Share			−0.01* (−1.94)
R-squared	0.76	0.64	0.58
Adj. R-squared	0.71	0.54	0.46
F-stat.	12.10	6.23	4.76
F-stat. prob.	0.00	0.00	0.01
Variance inflation factors	All <10.00	All <10.00	All <10.00
CUSUM	Within 5% sig.	Within 5% sig.	Within 5% sig.
CUSUMSQ	Within 5% sig.	Within 5% sig.	Within 5% sig.
Ramsey reset test	Functional spec. is true	Functional spec. is true	Functional spec. is true
Wald test (F-stat.)	16.04***	7.40***	6.60***
Wald test ($\chi 2$)	80.22***	37.92***	33.02***
JBN test	0.48	0.11	1.80
JBN test Prob. value	0.79	0.94	0.41
Serial corr. (F-stat.)	0.17	1.77	0.76
Serial corr. (Obs*R2)	0.53	4.33	2.13
Heteros. (F-stat.)	1.82	2.02	1.76
Heteros. (Obs*R2)	6.48	6.96	6.37

Notes: (1) Dep. var = dependent variable; (2) OP_EXP_HC = out-of-pocket expenditure on health care; (3) TGEE = total government expenditure on education; (4) HUM_RIGHTS = human rights; (5) *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively; (6) the figures were rounded to two decimal places for compactness; (7) values inside parentheses indicate standard errors and those inside brackets are t-statistics.

Therefore, the PCA indicated that institutional quality and oil-related variables can be explained by a few key variables, principal components, and a DOLS analysis. The latter demonstrated that the oil sector negatively affected the institutional quality in Azerbaijan between 1996 and 2019. Variables such as out-of-pocket expenses on health care and total government expenditures on education and human rights exhibited statistically significant and negative associations with oil-related variables, and they captured the negative nexus between human capital channels of the NRC and the oil sector.

An adequate analysis of NRC in the Azerbaijani economy is scarce in the economic literature. Topics such as NRC and Dutch disease usually require country-specific approaches and modeling when a quantitative methodology is used. In the case of Azerbaijan, this work has contributed to the study by using PCA and DOLS for the first time in addressing NRC in Azerbaijan, although OLS is a common technique for analyzing various economic indicators. Further studies should focus on more comprehensive data collections provided by different data centers (e.g., the Quality of Governance dataset from the University of Gothenburg). The NRC study is an absolute necessity for Azerbaijan. The Azerbaijani economy goes through boom and bust phases that are caused by commodity super-cycles. These phases need to be studied from institutional, governance, and political points of view.

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APPENDIX

Table A1. Descriptive statistics of the variables of interest used in regression.

Variable	N	Min	Max	Mean	St.Dev.
OP_EXP_PC	20	73.441	507.431	253.153	165.389
H_RIGHTS	20	-0.518	-0.021	-0.326	0.133
TGEE	20	2.068	3.854	2.821	0.470
OIL_RENTS	20	12.037	39.558	25.998	7.674
EDI	20	0.000	4.911	1.936	1.440
OIL_ EXP/GDP	20	0.296	1.964	0.603	0.356
OIL_FDI	20	546.100	7,448.300	4,240.899	1,958.284
SH_SOFAZ	20	7.300	62.430	35.426	20.730

Table A2. Normality test, outlier and missing values of the variables of interest used in regression.

Variable	Shapiro-Wilk Test		Outliers years	Missing value (years)
	Stat.	Sig.		
OP_EXP_PC	0.851	0.005		2019
H_RIGHTS	0.904	0.049	2001	2018; 2019
TGEE	0.949	0.351		2019
OIL_RENTS	0.971	0.769		2019
EDI	0.910	0.063		2019
OIL_ EXP/GDP	0.650	0.000	2008	
OIL_FDI	0.964	0.627		2018; 2019
SH_SOFAZ	0.833	0.003		
MINING_SHARE	0.927	0.134		

Table A3. Unit root test results for principal components (augmented Dickey–Fuller).

Null Hypothesis: The variable has a unit root			
	At Level		
		OIL_FACTOR	INSTITUTIONS
With Constant	t-Statistic	−1.7234	−1.3903
	Prob.	0.4074	0.5699
		n0	n0
With Constant & Trend	t-Statistic	−1.5259	−2.7407
	Prob.	0.7916	0.2319
		n0	n0
Without Constant & Trend	t-Statistic	−1.7570	−1.4118
	Prob.	0.0750	0.1432
		*	n0
	At First Difference		
		d(OIL_FACTOR)	d(INSTITUTIONS)
With Constant	t-Statistic	−5.4093	−4.3425
	Prob.	0.0002	0.0026
		***	***
With Constant & Trend	t-Statistic	−5.5958	−4.2568
	Prob.	0.0008	0.0140
		***	**
Without Constant & Trend	t-Statistic	−5.5223	−3.8707
	Prob.	0.0000	0.0005
		***	***

Notes: (1) (*) Significant at the 10% level; (**) significant at the 5% level; (***) significant at the 1% level and (no) nonsignificant; (2) lag length based on the Akaike information criterion; (3) probability based on MacKinnon's (1996) one-sided p values.

Table A4. Unit root test results for regression analysis (augmented Dickey–Fuller).

Null Hypothesis: The variable has a unit root										
	At Level									
		H_RIGHTS	TGEE	OP_EXP_PC	EDI	OIL_EXP_GDP	OIL_RENTS	MINING_INDUSTRY	SH_SOFAZ	OIL_FDI
With Constant	t-Statistic	-1.35	-4.04	0.32	-2.66	-2.10	-1.63	-1.92	-0.89	-1.49
	Prob.	0.58	0.01	0.97	0.10	0.25	0.45	0.32	0.77	0.51
		n0	***	n0	n0	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	-2.59	-2.56	-2.38	-3.07	-2.33	-2.45	-1.70	-3.01	-4.29
	Prob.	0.29	0.30	0.37	0.15	0.40	0.35	0.71	0.16	0.02
		n0	n0	n0	n0	n0	n0	n0	n0	**
Without Constant & Trend	t-Statistic	1.53	-1.41	2.60	-1.03	-0.87	-0.86	-0.02	0.78	0.82
	Prob.	0.96	0.14	0.99	0.26	0.32	0.33	0.66	0.87	0.88
		n0	n0	n0	n0	n0	n0	n0	n0	n0
	At First Difference									
		H_RIGHTS	TGEE	OP_EXP_PC	EDI	OIL_EXP_GDP	OIL_RENTS	MINING_SHARE	SH_SOFAZ	OIL_FDI
With Constant	t-Statistic	-5.85	-4.09	-3.14	-7.80	-6.68	-3.91	-2.65	-3.70	-4.26
	Prob.	0.02	0.01	0.04	0.01	0.01	0.01	0.10	0.01	0.01
		***	***	**	***	***	***	n0	**	***
With Constant & Trend	t-Statistic	-5.78	-4.37	-4.11	-7.53	-6.50	-3.79	-3.45	-3.56	-4.21
	Prob.	0.01	0.02	0.03	0.01	0.03	0.04	0.08	0.06	0.02
		***	**	**	***	***	**	*	*	**
Without Constant & Trend	t-Statistic	-4.88	-4.06	-2.27	-7.98	-6.79	-4.03	-2.77	-3.380	-3.88
	Prob.	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01
		***	***	**	***	***	***	***	***	***

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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Türkiye'de sektörel seragazı salımının ekonomik büyümeye etkisi

The impact of sectoral greenhouse gas emissions on economic growth in Turkey

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Öz

Bu çalışma Türkiye'deki sektörel toplam seragazı salımı ile ekonomik büyüme arasındaki ilişkiyi araştırmaktadır. Çalışma ile 1990-2020 yılları arasındaki enerji, endüstriyel işlemler ve ürün kullanımı, tarım ve atık üretimine ait sektörel toplam seragazı emisyonlarının, Türkiye'nin ekonomik büyümesi ile olan ilişkileri incelenmiştir. Her bir sektöre ait seragazı salımının uzun ve kısa dönemde ekonomik büyüme ile olan ilişkilerini gözlemlemek için ARDL modelinden faydalanılmıştır. Bununla birlikte ekonomik büyümeye etki eden nedensel faktörlerin değerlendirilmesinde ise Granger nedensellik testi kullanılmıştır. Uzun dönemde tarım sektörü seragazı salımının, kısa dönemde ve nedensellik testinde ise atık sektöründen kaynaklı seragazı salımının ekonomik büyüme ile olan bağımlılığı tespit edilmiştir. Ekonomik büyümeyi seragazı salımı ile olan bağımlı yapısından çıkarmak için tarım ve atık sektörüne yönelik politikaların önceliklendirilmesi gerekmektedir. Türkiye'de ekonomik büyümenin seragazı salımı bağımlılığı ile ilgili literatürde pek çok çalışma yer almaktadır. Bu çalışma ile ilgili bağımlılığın sektörel yapısı ekonometrik analiz yöntemi ile incelenmiştir. Çalışma, sektörel belirleyicilikte literatüre katkı sağlayacaktır.

Anahtar kelimeler: Sektörel seragazı salımı, ekonomik büyüme, ARDL sınır testi, Granger nedensellik

JEL kodları: C22, O44, Q5.

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Abstract

This study investigates the relationship between total sectoral greenhouse gas emissions and economic growth in Turkey. The study examines the relationship between sectoral total greenhouse gas emissions of energy, industrial processes and product use, agriculture and waste production between 1990-2020 with Turkey's economic growth. The ARDL model is used to observe the relationship between the greenhouse gas emissions of each sector and economic growth in the long and short term. The Granger causality test evaluates the causal factors affecting economic growth. The study shows a dependence between economic growth and greenhouse gas emissions caused by the agricultural sector in the long term. In contrast, the greenhouse gas emissions caused by the waste sector show a dependence in the short term and in the causality test. Policies addressing the agricultural and the waste sector should be prioritized to ensure that economic growth does not depend on greenhouse gas emissions. There are many studies in the literature on the dependence of economic growth on greenhouse gas emissions in Turkey. This study uses the econometric analysis method to examine the sectoral structure of dependency and will contribute to the literature regarding sectoral determination.

Keywords: Sectoral Ghg emissions, economic growth, ARDL boundary test, granger causality.

JEL codes: C22, O44, Q5.

1. GİRİŞ

Seragazı emisyonlarının, küresel ısınmanın ve iklim değişikliklerinin temel nedeni olduğu kabul edilmektedir. Küresel ekonominin artan emisyonlara bağımlılığının incelenmesi özellikle dünyanın her yerinde felaket düzeylerine varan iklim değişikliklerinden kaçınılabilmesi için büyük önem taşımaktadır. Ulaşılan noktada ekonomik başarının ölçütünün sadece ekonomik büyüme üzerinden sorgulanmasının yetersizliği ortadadır. Refah ve servetin adil olarak dağıtılmadığı ve emisyon oranlarının kesilemediği ya da azaltılamadığı büyüyen bir GSYİH değeri ekonomik başarı olarak nitelendirilmemelidir.

Dünyadaki ekonomik gelişmelerin seyri bir bakıma ekonomilerin emisyonlara olan bağımlılıklarının ilerlemesi durumudur. 1700 'lü yılların sonlarından itibaren kömür kullanımının İngiltere'de sanayi devriminde yarattığı etki ve ertesinde zenginleşen ülkelerdeki fosil yakıt kullanımının yaygınlığı örneklerinde olduğu gibi, ekonomik faaliyetlerin artması da emisyonları arttırıyordu. Tabii bunun tersi yönde emisyon miktarlarında azalmalar meydana geliyorsa bu da döneme ilişkin ekonomik aktivitelerin aslında azaldığını göstermektedir.

Ekonomik büyümenin emisyonlara olan bağımlılıklarının sürdürülemez oluşu, emisyon ve ekonomik büyüme değerlerinin ayrıştırılmasının sağlanması ya da emisyonlar azalırken de istikrarlı bir ekonomik büyümenin oluşturulabilmesi için ülke bazında farklı politikalar gözlemlenebilmektedir. Özellikle enerji kullanımında verimliliğin önceliklendirilmesi, düşük ve sıfır karbonlu enerji kaynakları kullanımına maliyet avantajlarının kazandırılması ve de işletmelerin daha temiz enerji kaynaklarına ve teknolojilerine erişim sağlayabilmeleri için karbon fiyatlama sistemi oluşturulması benzeri politikalarla karşılaşılmaktadır.

Özellikle küresel karbon emisyonları salımında sorumluluğu yüksek olan gelişmiş ülkelerin bir çoğunda ortaya konan emisyonların belli bir oranın altına kademeli olarak çekilerek sonrasında net sıfır emisyonun ya da karbon nötrlüğünün hedeflenmesi ulaşılan durumun ciddiyetinin kavranılmasına yardımcı olacaktır. Tabii ki bu çerçeve beraberinde bu ülkelerde iklim politikalarının üretilmesine ve de karbon yoğun ekonomik sektörlerden, ekonomik büyüme artışının sağlanabileceği hizmet ekonomisi benzeri farklı sektörlere yönelimleri de beraberinde getirmektedir.

Bu çalışmada Türkiye'nin sektörel seragazı üretimi/salımı ile ekonomik büyümesi arasındaki ilişki araştırılmaktadır. Her yıl TÜİK tarafından yayınlanan enerji, endüstriyel işlemler ve ürün kullanımı, tarım ve atık üretimine ait sektörel toplam seragazı emisyonlarının Türkiye'nin ekonomik büyümesi ile olan ilişkisi ayrı ayrı incelenerek ilgili sektörlerdeki seragazı artışı/düşüşü ile ekonomik büyümedeki artışın/düşüşün nedenselliği ortaya konulacaktır.

Literatürde yer alan benzeri çalışmalar incelendiğinde ekonomik büyüme ekonometrik modellerde bağımsız değişken olarak kullanılmaktadır. Ekonomik büyümedeki değişimin seragazı salımını hangi ölçüde etkilediği ya da nasıl bir nedensellik oluşturduğu üzerine çalışmalar geliştirilmiştir. Bu çalışmada ise ekonomik büyüme bağımlı, farklı sektörlerden salımı gerçekleşen toplam seragazı emisyonları bağımsız değişken olarak alınmıştır. Böylelikle farklı sektörlerde değişen seragazı salımının ekonomik büyüme üzerindeki etkilerinin araştırılması hedeflenmektedir. Çünkü seragazı salınımı yüksek olan sektörlere yönelik farklı politikaların gelişiminin sağlanması ve hatta ekonomik büyümenin de korunarak farklı sektörlere geçiş oluşturulması benzeri politikaların gündeme taşınmasını gerektirmektedir.

Çalışmanın ilk bölümünde literatürde yer alan çevresel bozulma, ekonomik büyüme, enerji tüketimi ve seragazı salımı arasındaki ilişkileri inceleyen çalışmalar kategorilendirilerek incelenecektir. Takip eden bölümde çalışmaya ilişkin data ve metodoloji hakkında içerik oluşturulmuştur. Oluşturulan metodolojiye ilişkin analiz çalışmaları bir sonraki bölümde yer almaktadır. Son bölüm ise araştırmaya yönelik sonuç kısmını kapsayacaktır.

2. LİTERATÜR

Literatürde çevresel faktörlerin göz önünde bulundurulduğu, ekonomik büyüme ve sürdürülebilirlik perspektifinin gelişimine katkı sağlayacak olan pek çok farklı çalışmaya rastlamak mümkündür. Bu çalışmalar kronolojik yapıdan uzak farklı şekillerde kategorize edilebilmektedir.

Öncelikli olarak Kuznets Eğrisi Yaklaşımının, çevre sorunlarına da adapte edilerek Çevresel Kuznets Eğrisi (ÇKE) perspektifi ile gerçekleştirilen pek çok çalışmaya rastlanılmaktadır. Bu yaklaşımda çevresel bozulmaya yönelik oluşturulan faktörler ile gelir artışı arasındaki ilişkinin ters-U formatında ilerlediği kabul edilmektedir. Ekonomik büyümenin başlarında kişi başına gelir artışı ile birlikte çevresel bozulmanın da arttığı kabul edilmektedir.Ancak belli bir eşik düzeyine ulaşılması ile birlikte, kişi başına gelir seviyesindeki artışın çevresel bozulmada azalış yaratacağı ileri sürülmektedir (Çetintaş ve Sarıkaya, 2015).

Tabii burada belirtilmesi gerekli olan farklı çalışmalardaki data kaynağı, ilişkisi araştırılan çevre kirliliği faktörleri, kullanılan zaman aralığı ve örneklenen ülke ile birlikte araştırma sonuçları da farklılaşmaktadır. Bu farklılıkta öne çıkan bir diğer durum ise ters-U şeklinde ilişki yapısı ile birlikte N şeklindeki yapının da oluştuğudur. Bu yapı ise ikinci bir eşik değeri daha ortaya çıkarmaktadır. Gelir seviyesindeki artış ile birlikte çevresel bozulmanın da tekrardan artmaya başlaması olarak nitelendirilmektedir (Işık, Engeloğlu ve Kılınç, 2015). Bu durum kullanılan fonksiyonel yapının kübik formda olmasından da kaynaklanmaktadır (Beşer ve Beşer, 2017).

Çevresel Kuznet Eğrisi Hipotezinin testi üzerinden oluşturulan ilk çalışma Grossman ve Kreuger (1991)' e aittir. Çalışmada hava kalitesi ile ekonomik büyüme arasındaki ilişki 42 ülke üzerinden ve de hava kirletici maddelerin karşılaştırılabilir ölçümleri üzerinden gerçekleştirilmiştir. Çalışma sonucunda iki hava kirletici madde konsantrasyonunun kişi başı gelir seviyelerinin düşük olduğu ülkelerde arttığı buna karşın yüksek gelir seviyelerinde GSYİH büyümesi ile bu iki kirletici madde konsantrasyonunun azaldığını ortaya koymaktadırlar. Böylece çevre ve gelir arasındaki ters-U hipotezine yönelik ilişkisel yapı ortaya konmaktadır (Grossman and Kreuger, 1991).

Bu çalışma ile birlikte Grossman ve Kreuger (1995)'ın bir diğer çalışması daha öne çıkmaktadır. Burada da ilk çalışmadakine benzer şekilde hava kirliliği ile birlikte nehir havzalarının kirliliği üzerinden oluşturulan göstergelerin kişi başı milli gelir ile olan ilişkileri araştırılmıştır. Çalışma sonucunda ekonomik büyüme ile birlikte çevresel kalitenin istikrarlı bir şekilde arttığına dair sonuç bulunamamıştır. Ayrıca çoğu gösterge için ekonomik büyüme başlangıçta bir bozulma aşamasını ardından ise bir iyileşme sürecinin ortaya çıktığını belirlemişlerdir. Ters–U şeklindeki ilişkisel yapı ile birlikte N şeklindeki yapı da bu çalışmada elde edilmektedir.

ÇKE hipotez testi perspektifinde oluşturulan çalışmalar yoğunluklu olarak ÇKE'ye (ters-U ya da N şeklindeki) uygunluk / uygun olmadıkları üzerinden sonuçlandırılan çalışmalardır. Benzer nitelikte Panayotou (1993) 'nun çevresel bozulma ile ekonomik kalkınma arasındaki 1982-1994 yıllarını kapsayacak şekilde 30 ülke üzerinde gerçekleştirmiş olduğu ters-U hipotezine uygunluk ile sonuçlandırılan çalışma ile Torras ve Boyce (1998) 'un 42 ülke üzerinden 1977-1991 dönemini test ettikleri ve N tipli ÇKE ile uyumlandırdıkları çalışmadan bahsetmek mümkündür.

Pao ve Tsai (2011), 1980-2007 dönemi için Brezilya üzerinde gerçekleştirdikleri çalışmalarında hem emisyon ile gelir hem de enerji tüketimi ile gelir arasında ters U-biçimli ilişki yapısının uygunluğu üzerinde durmaktadırlar. Elde edilen bulgulara göre çevresel bozulmanın ve enerji tüketiminin öncelikle gelirle birlikte arttığını, sonra sabitlendiğini ve en sonunda da azaldığını belirtmektedirler.

Bu sonuçlarla birlikte Carson, Jeon ve McCubbin (1997)'nin ABD'deki 50 eyalet üzerinde yapmış oldukları 1988-1994 dönemini kapsayan çalışmada emisyonlardaki değişimin gelirdeki değişimin büyüklüğü ile ilgisi olmadığı sonucuna ulaştıkları çalışmada yer almaktadır.

Emisyon salınımı ile gelir arasındaki ilişki de ÇKE hipotezi yaklaşımı ile ters-U ilişkisine uyumluluğun olduğunu gösteren çalışmalar Türkiye'de de gerçekleştirilmiştir. Atıcı ve Kurt, (2007)'un 1968-2000 tarih aralığı için gerçekleştirmiş oldukları çalışma ÇKE 'yi doğrular niteliktedir ve çalışma CO_2 emisyonu, gelir ve de dış ticaret değişkenleri arasındaki ilişki üzerine gerçekleştirilmiştir.

Benzer şekilde Lebe (2016) çalışmasında 1960-2010 dönemi için Türkiye'de ÇKE'nin testini gerçekleştirmiştir ve Türkiye için geçerliliği sonucuna ulaşmıştır. Lebe çalışmasında özellikle enerji tüketimi, finansal gelişme ve dışa açıklığın CO_2 emisyonunu arttırdığını belirtmektedir.

Akbostancı, Türüt-Aşık ve Tunç (2009), Türkiye üzerinde 1968-2003 tarih aralığında kişi başı gelir ve emisyon değerleri üzerinden gerçekleştirmiş oldukları çalışmalarında N-tipli bir ilişki yapısı üzerinde durmaktadırlar. Buna karşın Başar ve Temurlenk (2010) ise gelirin ve kişi başı CO_2 miktarı ile katı yakıt tüketimi sonrası oluşan emisyon değerleri arasında ters-N şeklinde ilişki elde etmişlerdir. Bundan dolayı da ÇKE'nin çalışmanın tarih aralığı olan 1950-2000 yılları arasında Türkiye için geçerli sayılabilecek bir bulgu sağlamadığını belirtmektedirler.

Yukarıda bahsi geçen çalışmalar literatürde ÇKE hipotezinin testine yönelik gerçekleştirilen çalışma kapsamındadırlar. ÇKE 'nin testi dışında karbon emisyonu ile enerji tüketimi arasındaki nedensellik ilişkisini araştıran çalışmalar, başka bir kategori olarak da karbon emisyonu ile ekonomik büyüme arasındaki ilişkiyi araştıran çalışmalar literatürde göze çarpmaktadır. Bu iki kategori ile birlikte de karbon emisyonu, enerji tüketimi ve ekonomik büyümenin birbirleri ile olan ilişkilerini araştıran ve bu çalışmalara ekonomik açıklık, yabancı sermaye, istihdam oranı ve finansal gelişmişlik benzeri değişkenlerin de eklendiği ve değişkenler arasında nedensel ilişkilerin araştırıldığı daha geniş değişkenler bütününün yer aldığı çalışmalar literatürde yer almaktadır. İlgili kategorilerde yapılan örnek çalışmalar şu şekilde özetlenebilir:

Soytaş, Sarı ve Ewing (2006) , ABD'de enerji tüketimi ve çıktısının karbon emisyonları üzerindeki Granger nedensellik ilişkilerini araştırdıkları çalışmayı gerçekleştirmişlerdir. Çalışma ile ABD'de uzun vadede gelirin, karbon emisyonunun Granger nedeni olmadığı ancak enerji tüketiminin Granger nedeni olduğu sonucuna ulaşmaktadırlar. Gelir artışının tek başına çevre sorunlarının çözümü olamayacağı şeklinde çıkarım sağlamaktadırlar.

Abid (2015), 1980-2009 döneminde Tunus için kayıt dışı ekonominin varlığında ekonomik büyüme ve CO_2 emisyonları arasındaki nedensel ilişkiyi araştırmıştır. Elde edilen sonuçlara göre hem kısa hem de uzun vadede CO_2emisyonları ile toplam GSYIH (kayıtiçi ve kayıtdışı) arasında çift yönlü nedensellik ortaya konulurken, kayıtiçi (resmi) ekonomik büyümeden CO_2 emisyonlarına tek yönlü nedensellik ilişkisi tespit etmiştir.

Lotfalipour, Falahi ve Ashena (2010), 1967-2007 dönemi için İran üzerinde yapmış oldukları çalışmalarında ekonomik büyüme ve iki çeşit enerji tüketiminden (petrol ve doğalgaz tüketimi) karbon emisyonlarına uzanan tek yönlü bir Granger nedenselliği üzerinde durmaktadırlar. Bununla birlikte uzun vadede fosil yakıt tüketiminden karbon emisyonlarına yönelik Granger nedensellik yakalamamışlardır. Bu sonuçla karbon emisyonlarının, petrol ve fosil yakıt tüketiminin ekonomik büyümeye yol açmadığı sonucuna ulaşmaktadırlar.

Kasperowicz (2015) çalışmasında 1995-2012 dönemi için 18 Avrupa Birliği üyesi ülkede CO_2 emisyonu ile ekonomik büyüme arasındaki ilişkiyi araştırmıştır. Kısa vadede ekonomik büyüme ile CO_2 emisyonları arasında pozitif, uzun vadede ise negatif ilişki olduğu sonucuna ulaşmıştır.

Çetintaş ve Sarıkaya (2015) ekonomik büyüme, enerji tüketimi ve emisyonlar arasındaki ilişkiyi, çok değişkenin dahil edildiği (dış ticaret, şehirleşme, nükleer enerji üretimi) model çevreçevesinde nedensellik çalışması şeklinde gerçekleştirmişlerdir. Çalışma 1960-2004 tarih aralığını kapsamakta olup İngiltere ve ABD' de gerçekleştirilmiştir. Çalışmada CO_2'den ekonomik büyümeye doğru nedensellik ilişkisi İngiltere' de tespit edilmiştir. Bununla birlikte ABD' de ise nedensellik ilişkisi enerji tüketiminden CO_2'a doğru tek yönlü olarak gerçekleşmiştir.

Öztürk ve Acaravcı (2010) , 1968-2005 dönemi için Türkiye üzerinde gerçekleştirmiş oldukları çalışmalarında ekonomik büyüme, karbon emisyonları, enerji tüketimi ve istihdam oranı arasındaki nedensel ilişkiyi araştırmışlardır. Kişi başına karbon emisyonu ve enerji tüketiminin, kişi başı reel GSYİH için nedensellik oluşturmadığı ancak istihdam oranından kişi başı reel GSYIH' ya neden olan kısa vadeli ilişki üzerinde durmaktadırlar.

Wang, Zhou, Zhou ve Wang (2011), Çin üzerinde yapmış oldukları çalışmada CO_2 emisyonu, enerji tüketimi ve ekonomik büyüme arasındaki nedensellik ilişkisini araştırmışlardır. CO_2 emisyonu, enerji tüketimi ve ekonomik büyümenin eşbütünleşik olduğu sonucuna ulaşmışlardır. Ekonomik büyüme ile enerji tüketimi arasında ayrıca enerji tüketimi ile CO_2 emisyonu arasında çift yönlü nedenselliği vurgulamaktadırlar. Uzun vadede enerji tüketimi ile ekonomik büyüme, CO_2 emisyonunun nedenidirler. Diğer taraftanda CO_2 emisyonu ile ekonomik büyüme uzun vadede enerji tüketiminin nedenidirler.

3.VERİ VE METODOLOJİ

Bu çalışmada 1990-2020 yılları arası Türkiye için ölçülen gayri safi yurt içi hasıla (GDP) (toplam hasıla-üretim değeri $) ile enerji (ESG), endüstriyel işlemler ve ürün kullanımı (EKSG), tarım (TSG) ve atık (ASG) sektörlerinden üretilen toplam sera gazı emisyonları (CO2 eşdeğeri, milyon ton) arasındaki uzun ve kısa dönem ilişkiler ve nedensel ilişkiler zaman serisi analizi yöntemleriyle araştırılmıştır. Bu amaç doğrultusunda GDP bağımlı ve ESG, EKSG, TSG ve ASG bağımsız değişken olarak ele alınmıştır. Analizlerde logaritması alınmış olan değişkenler LGDP ve LASG olarak gösterilmiştir. Sektörlere ait emisyon değerleri için TÜİK Sera Gazı Emisyon İstatistikleri'nden faydalanılmıştır. Gayri Safi Yurt İçi Hasıla değerleri Dünya Bankası veritabanından temin edilmiştir.

İlk aşamada LGDP, ESG, EKSG, TSG ve LASG değişkenlerine ait zaman serisi grafikleri ve tanımlayıcı istatistikler sunulmuştur. Tanımlayıcı istatistiklerden, ortalama (Ort), standart sapma (SS), medyan, minimum (Min), maksimum (Maks), çarpıklık (Çarp) ve basıklık (Bas) değerleri birlikte verilmiştir.

İkinci aşamada araştırma kapsamında ele alınan değişkenlerin durağanlık düzeyleri incelenmiştir. Değişkenlerin durağanlık düzeyleri Augmented Dickey Fuller (ADF) testi, Philips-Perron birim kök testi ve Zivot-Andrews yapısal kırılmalı birim kök testi ile değerlendirilmiştir. Durağanlık aşamasında kendi seviyesinde durağan olmayan değişkenlerin birinci dereceden farkları alınmıştır. Farkı alınan değişkenler D(LGDP, 1), D(ESG, 1), D(EKSG, 1) ve D(TSG, 1) şeklinde gösterilmiştir.

Üçüncü aşamada değişkenlerin durağanlık düzeyleri incelenmiş ve değişkenler arasındaki eşbütünleşme ilişkisinin olup olmadığı Bounds (Sınır) Testi ile değerlendirilmiştir. Değişkenler arasında uzun ve kısa dönem ilişkileri gözlemlemek için ARDL modeli kullanılmıştır. Gecikme uzunluğunun seçiminde Akaike bilgi kriteri (AIC) kullanılmıştır, ARDL modeli ile elde edilen hata terimleri üzerinden varsayım testleri gerçekleştirilmiştir. Hata terimleri arasında otokorelasyon probleminin olup olmadığı Breusch-Godfrey otokorelasyon testi, değişen varyans probleminin olup olmadığı Breusch-Pagan değişen varyans testi ve normal dağılıma uygun olup olmadığı ise Jargue-Bera normallik testi ile incelenmiştir. Ayrıca ARDL modeli sonucunda bulunan kısa ve uzun dönem katsayılarının uygun olup olmadığı CUSUM testi ve CUSUM χ^2 testi ile incelenmiştir.

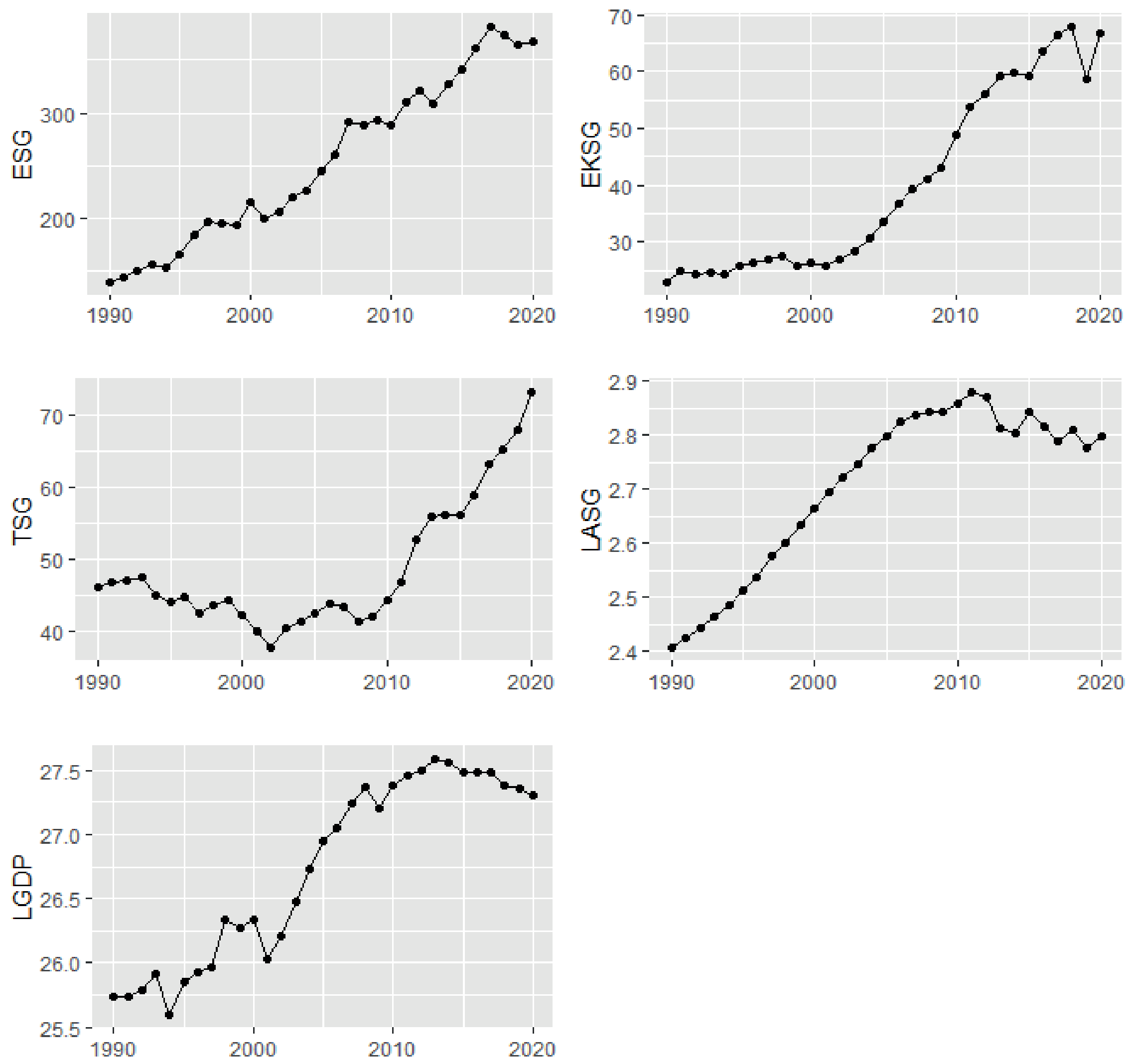
Son aşamada ise D(LGDP, 1) değişkenine etki eden faktörlerin değerlendirilmesinde Granger nedensellik testi kullanılmıştır.

4.ANALİZ

Öncelikle ekonometrik analiz bulgularının değerlendirilmesinde, test istatistikleri parantez içerisinde anlamlılık değerleri ile bir arada verilmiştir. Model katsayılarının test istatistiği ve anlamlılık değerleri ayrı gösterilmiştir. Zivot-Andrews testi sonuçları ise test istatistiği ve kritik değerleri ayrı sunulmuştur. Test sonuçları için hata payı %1, %5 ve %10 olarak değerlendirilmiştir.

Şekil 1. ESG, EKSG, TSG, LASG ve LGDP değişkenlerine ait zaman serisi grafikleri

[Zaman serisi grafikleri ve Granger testi R-Project programı (R Core Team, 2022) ve ggplot2 Wickham ve diğ. (2016) ve lmtest Zeileis ve Hothorn (2002) paketleri kullanılarak gerçekleştirilmiştir. Diğer analiz bulguları Eviews 10 programı kullanılarak elde edilmiştir.]



Tablo 1' de 1990-2020 yılları arasında ölçülen LGDP, EKSG, ESG, TSG ve LASG değişkenlerine ait tanımlayıcı istatistikler gösterilmektedir. Tanımlayıcı istatistik bulguları incelendiğinde, LGDP ortalaması 26.730, EKSG ortalaması 40.210, ESG ortalaması 253.970, TSG ortalaması 48.620 ve LASG ortalaması ise 2.706 olarak bulunmuştur.

Tablo 2'de 1990-2020 yılları arasında ölçülen LGDP, EKSG, ESG, TSG ve LASG değişkenlerinin kendi düzeylerinde ve birinci dereceden farkları alındığında durağan olup olmadıkları ADF birim kök testi ile araştırılmıştır. Düzey seviyesinde değişkenlerin durağan olup olmadığı incelendiğinde; LGDP, EKSG, ESG ve TSG değişkenlerinin sabit ve hem sabit hem de trend içeren model için durağan olmadığı belirlenmiştir ($p>0.10$). Ayrıca LASG değişkeni düzey seviyesinde sabit ve hem sabit hem de trend içeren modelde durağan olduğu saptanmıştır ($p<0.10$). Bu bulgular ışığında, LASG değişkeninin düzeyde durağan olduğu görülürken, LGDP, EKSG, ESG ve TSG değişkenlerinin düzeyde durağan olmadığı belirlenmiştir. Değişkenlerin birinci farkı alındıktan sonra durağan olup olmadığı incelendiğinde; LGDP, EKSG, ESG ve TSG değişkenlerinin sabit ve hem sabit hem de trend içeren model için durağan olduğu saptanmıştır ($p<0.10$). LASG değişkenin birinci farkı alındığında sabit içeren modelde durağan olmadığı ($p>0.10$), ancak hem sabit hem de trend içeren modelde durağan olduğu görülmüştür ($p<0.10$). Düzey ve birinci fark durumunda durağanlık bulguları incelendiğinde; LGDP, EKSG, ESG ve TSG değişkenlerinin birinci farkı alındığında durağan olduğu ve LASG değişkeni ise düzey seviyesinde durağan olduğu sonucuna varılmıştır.

Tablo 3'de 1990-2020 yılları arasında ölçülen LGDP, EKSG, ESG, TSG ve LASG değişkenlerinin kendi düzeylerinde ve birinci dereceden farkları alındığında durağan olup olmadıkları Philips-Perron birim kök testi ile araştırılmıştır. Düzey seviyesinde değişkenlerin durağan olup olmadığı incelendiğinde; LGDP, EKSG, ESG ve TSG değişkenlerinin sabit ve hem sabit hem de trend içeren model için durağan olmadığı görülmüştür ($p>0.10$). Ancak LASG değişkeni düzey seviyesinde sabit içeren modelde durağan olduğu ($p<0.10$), hem sabit hem de trend içeren modele göre durağan olmadığı saptanmıştır ($p>0.10$). Bu bulgular ışığında, LASG değişkeninin düzeyde durağan olduğu belirlenirken, LGDP, EKSG,

Tablo 1. Tanımlayıcı İstatistik Bulguları.

Değişken	Ort	SS	Medyan	Min	Max	Çarp	Bas
LGDP	26.730	0.710	26.950	25.600	27.590	-0.220	-1.690
EKSG	40.210	16.070	33.700	22.980	67.970	0.480	-1.490
ESG	253.970	78.320	244.450	139.600	382.390	0.130	-1.430
TSG	48.620	9.060	44.760	37.610	73.160	1.180	0.290
LASG	2.706	0.152	2.777	2.405	2.878	-0.734	2.067

Ort: Ortalama, SS: Standart sapma, Min: Minimum, Max: Maksimum, Çarp: Çarpıklık, Bas: Basıklık

Tablo 2. ADF Birim Kök Testi Sonuçları.

Değişken	Genişletilmiş Dickey-Fuller (ADF)			
	Düzey		Birinci Fark	
	Sabit	Sabit+Trend	Sabit	Sabit+Trend
LGDP	-1.173 (0.673)	-1.061 (0.919)	-5.631*** (0.000)	-5.738*** (0.000)
EKSG	0.357 (0.978)	-1.882 (0.639)	-5.524*** (0.000)	-5.636*** (0.000)
ESG	-0.426 (0.892)	-2.881 (0.182)	-5.547*** (0.000)	-5.441*** (0.001)
TSG	2.731 (1.000)	0.528 (0.999)	-2.668* (0.092)	-4.315** (0.010)
LASG	-2.997** (0.047)	-4.383** (0.010)	-1.653 (0.441)	-4.447*** (0.007)

*p<0.10, **p<0.05, ***p<0.01

ESG ve TSG değişkenlerinin düzeyde durağan olmadığı görülmüştür. Değişkenlerin birinci farkı alındıktan sonra durağan olup olmadığı incelendiğinde; LGDP, EKSG, ESG, TSG ve LASG değişkenlerinin sabit ve hem sabit hem de trend içeren model için durağan olduğu saptanmıştır (p<0.10). Düzey ve birinci fark durumunda durağanlık bulguları incelendiğinde; LGDP, EKSG, ESG ve TSG değişkenlerinin birinci farkı alındığında durağan olduğu ve LASG değişkeni ise düzey seviyesinde durağan olduğu sonucuna ulaşılmıştır.

Tablo 3. Philips-Perron Birim Kök Testi Sonuçları.

Değişken	Philips-Perron Testi			
	Düzey		BirinciFark	
	Sabit	Sabit+Trend	Sabit	Sabit+Trend
LGDP	-1.173 (0.673)	-1.162 (0.900)	-5.630*** (0.000)	-5.738*** (0.000)
EKSG	0.506 (0.984)	-1.819 (0.670)	-5.537*** (0.000)	-5.636*** (0.000)
ESG	-0.299 (0.914)	-2.669 (0.255)	-6.685*** (0.000)	-6.440*** (0.000)
TSG	2.219 (0.999)	2.045 (1.000)	-2.704* (0.086)	-4.550*** (0.006)
LASG	-2.686* (0.082)	0.053 (0.995)	-3.761*** (0.008)	-5.107*** (0.002)

*p<0.10, **p<0.05, ***p<0.01

Tablo 4. Yapısal Kırılmalı Birim Kök Testi Sonuçları

Seviye	Değişken	Model	Test ist	Kritik değerler		
				%1	%5	%10
I(0)	LGDP	Sabit	-2.692	-5.340	-4.930	-4.580
		Sabit+Trend	-3.054	-5.570	-5.080	-4.820
	EKSG	Sabit	-3.352	-5.340	-4.930	-4.580
		Sabit+Trend	-3.058	-5.570	-5.080	-4.820
	ESG	Sabit	-3.699	-5.340	-4.930	-4.580
		Sabit+Trend	-3.506	-5.570	-5.080	-4.820
	TSG	Sabit	-1.035	-5.340	-4.930	-4.580
		Sabit+Trend	-3.135	-5.570	-5.080	-4.820
	LASG	Sabit	-2.238	-5.340	-4.930	-4.580
		Sabit+Trend	-4.142	-5.570	-5.080	-4.820
I(1)	LGDP	Sabit	-7.310	-5.340	-4.930	-4.580
		Sabit+Trend	-7.520	-5.570	-5.080	-4.820
	EKSG	Sabit	-6.664	-5.340	-4.930	-4.580
		Sabit+Trend	-7.352	-5.570	-5.080	-4.820
	ESG	Sabit	-5.861	-5.340	-4.930	-4.580
		Sabit+Trend	-5.762	-5.570	-5.080	-4.820
	TSG	Sabit	-4.747	-5.340	-4.930	-4.580
		Sabit+Trend	-4.821	-5.570	-5.080	-4.820
	LASG	Sabit	-5.688	-5.340	-4.930	-4.580
		Sabit+Trend	-6.335	-5.570	-5.080	-4.820

I(0): Düzey seviyesi, I(1): Birinci fark seviyesi

Tablo 4'de 1990-2020 yılları arasında ölçülen LGDP, EKSG, ESG, TSG ve LASG değişkenlerinin kendi düzeylerinde ve birinci dereceden farkları alındığında durağan olup olmadıkları yapısal kırılmayı dikkate alan Zivot-Andrews testi sonuçları gösterilmektedir. Düzey seviyesinde sabitte ve hem sabitte hem de trendde kırılmayı dikkate alan model için bulgular incelendiğinde; LGDP, EKSG, ESG, TSG ve LASG değişkenlerinin yapısal kırılma olmadan birim köklü olduğu saptanmıştır (p<0.10). Diğer taraftan birinci fark seviyesinde sabitte ve hem sabitte hem de trendde kırılmayı dikkate alan model için bulgular incelendiğinde; LGDP, EKSG, ESG, TSG ve LASG değişkenlerinin yapısal kırılma ile birlikte durağan olduğu belirlenmiştir (p<0.10). Bu bulgular ışığında LGDP, EKSG, ESG, TSG ve LASG değişkenlerinin I(1) düzeyinde durağan olduğu görülmüştür.

ADF testi, Philips-Perron testi ve Zivot-Andrews testi bulguları birlikte değerlendirildiğinde, LGDP, EKSG, ESG ve TSG değişkenlerinin durağanlık seviyeleri I(1) ve LASG değişkenin ise durağanlık seviyesi I(0) olduğu saptanmıştır. Değişkenlerin durağanlık seviyelerinin I(0) ve I(1) olduğu belirlendiğinden, bu değişkenler arasında eşbütünleşme ilişkisinin olup olmadığı Bounds (Sınır) testi yaklaşımı ile incelenmelidir.

Tablo 5'de D(LGDP, 1) bağımlı ve D(EKSG, 1),

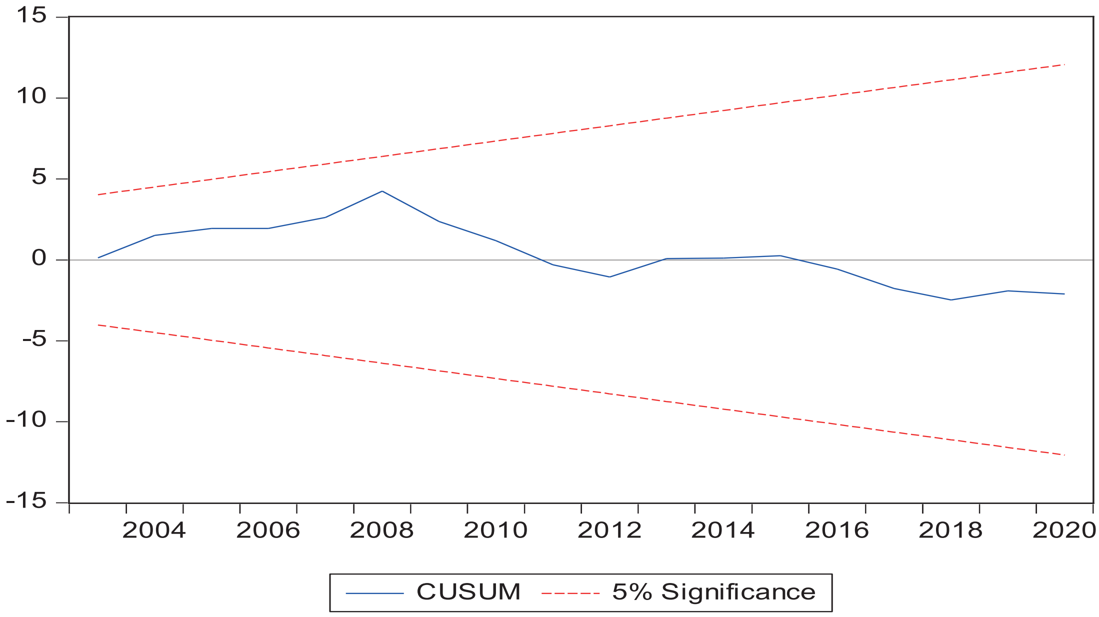
Tablo 5. ARDL(1,0,0,0,4) Modelinin Tahmin Sonuçları

Test istatistiği		**Değer**	
F-istatistiği		10.259	
Anlam düzeyi		**Kritik değer**	
		I(0)	**I(1)**
%1		4.590	6.368
%5		3.276	4.630
%10		2.696	3.898
Değişken	Beta	t	p
D(LGDP, 1) (-1)	-0.304	-1.528	0.145
D(EKSG, 1)	0.007	0.463	0.649
D(ESG, 1)	0.004	1.661	0.115
D(TSG, 1)	0.034	1.859*	**0.080**
LASG	-0.516	-0.261	0.797
LASG (-1)	3.766	1.378	0.186
LASG (-2)	-3.296	-1.038	0.314
LASG (-3)	4.313	1.253	0.227
LASG (-4)	-4.215	-2.192**	**0.043**
Sabit	-0.241	-0.241	0.812
Tanısal Test Sonuçları			
Adj R2		0.210	
Breusch-Godfrey otokorelasyon testi		0.312 (0.737)	
Breusch-Pagan değişen varyans testi		0.935 (0.521)	
Jargue-Bera normallik testi		0.209 (0.901)	

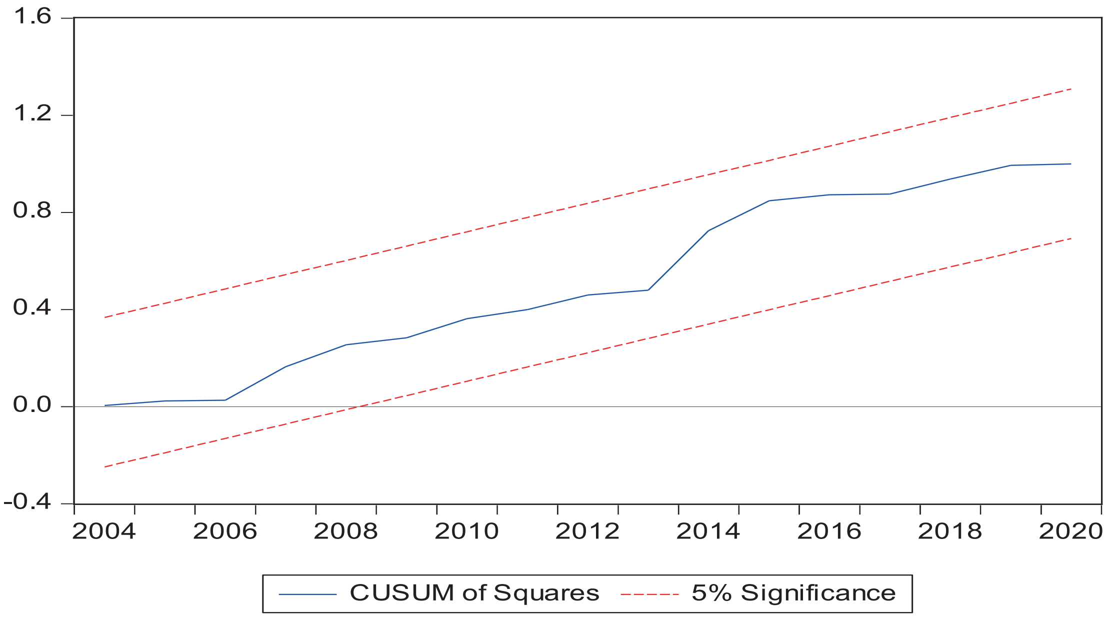
Beta: Katsayı, *p<0.10, **p<0.05, ***p<0.01

D(ESG, 1), D(TSG, 1) ve LASG değişkenlerinin ise bağımsız olarak alındığı ve AIC bilgi kriterine göre maksimum gecikme uzunluğunun belirlendiği ARDL(1, 0, 0, 0, 4) model tahmin sonuçları gösterilmektedir. F-Bounds test bulguları incelendiğinde; değişkenler arasında %10 anlam düzeyinde eşbütünleşme ilişkisi olduğu belirlenmiştir (F-istatistiği: 10.259, Kritik değer: 3.898). Tanısal test bulgularından Breusch-Godfrey otokorelasyon testi sonuçları incelendiğinde, kurulan modelde otokorelasyon probleminin olmadığı görülmektedir (F-istatistiği: 0.312, p>0.10). Breusch-Pagan değişen varyans testi bulguları değerlendirildiğinde, kurulan modelde değişen varyans probleminin olmadığı saptanmıştır (F-istatistiği: 0.935, p>0.10). Ayrıca Jargue-Bera normallik testi sonuçları incelendiğinde, kurulan modelin hata terimlerinin normal dağılıma uygun olduğu görülmüştür (Jargue-Bera istatistiği: 0.209, p>0.10).

Şekil 2. CUSUM Testi



Şekil 3. CUSUM χ2 testi



Şekil 2 ve 3 'de ARDL(1, 0, 0, 0, 4) modeli sonucunda elde edilen kısa ve uzun dönem katsayılarının uygun olup olmadığı CUSUM testi ve CUSUM χ^2 testi ile incelenmiştir. CUSUM testi ve CUSUM χ^2 test istatistikleri kritik sınırların içerisinde (%5 anlamlılık düzeyinde) bulunmaktadır. Bu bulgular ışığında, incelenen dönem içerisinde tahmin edilen kısa ve uzun dönem katsayıların istikrarlı olduğu belirlenmiştir.

Tablo 6'da D(LGDP, 1) bağımlı ve D(EKSG, 1), D(ESG, 1), D(TSG, 1) ve LASG değişkenlerinin bağımsız olarak alındığı ARDL(1, 0, 0, 0, 4) modeli uzun dönem tahmin sonuçları gösterilmektedir. Analiz bulguları incelendiğinde, D(TSG, 1) değişkeninin D(LGDP, 1) değişkeni üzerindeki uzun dönem etkisi istatistiksel olarak anlamlı bulunmaktadır (p<0.10). Uzun dönem katsayısı değerlendirildiğinde, D(TSG, 1) değişkeni ile D(LGDP, 1) değişkeni arasında aynı yönlü bir ilişki olduğu belirlenmiştir (Beta: 0.026>0). Bu bulgu ışığında, D(TSG, 1) değişkeni bir birim arttığında (yani tarımsal üretimde gerçekleşen bir birimlik seragazı artışı), D(LGDP, 1) değişkeni üzerinde (ekonomik büyümede) uzun dönemde yaklaşık %0.026'lık bir artışa sebep olduğu saptanmıştır.

Tablo 7'de D(LGDP, 1) bağımlı ve D(EKSG, 1), D(ESG, 1), D(TSG, 1) ve LASG değişkenlerinin bağımsız olarak alındığı ARDL(1, 0, 0, 0, 4) modeli kısa dönem tahmin sonuçları gösterilmektedir. ARDL(1, 0, 0, 0, 4) modeli kısa dönem tahmin sonuçları değerlendirildiğinde, LASG değişkenin D(LGDP, 1) üzerindeki kısa dönem etkisi istatistiksel olarak anlamlı olduğu belirlenmiştir (p<0.10). Bu bulgular ışığında, LASG değişkeni %1 arttığında 1. ve 3. dönemde D(LGDP, 1) değişkeni üzerinde sırasıyla %3.198 ve %4.215'lik bir artışa sebep olduğu saptanmıştır. Bu bulgu-

Tablo 6. ARDL(1, 0, 0, 0, 4) Modeli Uzun Dönem Tahmin Bulguları.

Değişken	**Beta**	**t**	**p**
D(EKSG, 1)	0.005	0.454	0.656
D(ESG, 1)	0.003	1.647	0.118
D(TSG, 1)	0.026	1.891*	**0.076**
LASG	0.040	0.144	0.887
Sabit	-0.185	-0.243	0.811

*p<0.10, **p<0.05, ***p<0.01

Tablo 7. ARDL(1, 0, 0, 0, 4) Modeli Kısa Dönem Tahmin Bulguları.

Değişken	**Beta**	**t**	**p**
LASG	-0.516	-0.400	0.694
LASG (-1)	3.198	2.665**	**0.016**
LASG (-2)	-0.098	-0.073	0.943
LASG (-3)	4.215	2.815**	**0.012**
HDT (-1)	-0.643	-8.153***	**0.000**

*p<0.10, **p<0.05, ***p<0.01, HDT: Hata düzeltme terimi

Tablo 8. Granger Nedensellik Testi Sonuçları

Nedensellik yönü	**Granger nedensellik testi**
D(EKSG, 1) -> D(LGDP, 1)	1.029 (0.400)
D(ESG, 1)) -> D(LGDP, 1)	0.025 (0.995)
D(TSG, 1)) -> D(LGDP, 1)	1.636 (0.211)
LASG) -> D(LGDP, 1)	3.500** (0.033)

*p<0.10, **p<0.05, ***p<0.01

lara ek olarak hata düzeltme katsayısının negatif ve anlamlı olduğu görülmektedir (p<0.10). Ayrıca hata düzeltme katsayısı 0 ile 1 arasında yer almaktadır. Bu sonuç kısa dönemde meydana gelen sapmaların %64.3'ünün bir sonraki dönemde düzeltilerek uzun dönem dengesine hızlı bir şekilde döneceği sonucuna ulaşılmaktadır (Koçak, 2014).

Tablo 8'de D(LGDP, 1) bağımlı ve D(EKSG, 1), D(ESG, 1), D(TSG, 1) ve LASG değişkenlerinin bağımsız olarak kullanıldığı Granger nedensellik testi sonuçları gösterilmektedir. Nedensellik testi bulguları incelendiğinde, D(EKSG, 1), D(ESG, 1) ve D(TSG, 1) değişkenlerinin D(LGDP, 1) değişkeni üzerinde nedensel bir etkisinin olmadığı görülmüştür (p>0.10). Ancak LASG değişkenin D(LGDP, 1) değişkeni üzerinde nedensel bir etkisinin olduğu belirlenmiştir (p<0.10).Yani atık sektörü seragazı salımı ekonomik büyümenin Granger nedenidir.

5.SONUÇ VE DEĞERLENDİRME

Ekonomik büyümenin seragazı salımına olan bağımlılık yapısının tespiti ve de bu bağımlılık yapısının önlenmesi ya da azaltılması günümüzde oldukça önemlidir. Bu bağlam beraberinde ekonomik büyüme ve kalkınmada sektörel dağılımın doğru belirlenmesini gerektirmektedir. Özellikle sektör bazlı seragazı salınımının iklim değişikliğine ve küresel ısınmaya olan etki düzeylerinin farklılığı, sektörel belirleyiciliği sadece ekonomik bir karar olmasından çok öteye taşımaktadır.

Çalışmada Türkiye'de ekonomik büyümenin uzun dönemde tarımsal üretimden kaynaklı, kısa dönemde ve de nedensel olarak ta atık üretiminden kaynaklı seragazı salınımı ile olan bağımlı yapısı ortaya konmuştur. Her ne kadar Türkiye'nin gelişmekte olan ekonomik yapısı sanayi ve hizmetler sektörüne yönelik yönelimi ağırlıklı olarak ortaya çıkarsa da tarımsal üretimin beslenme, sanayi sektörü için hammade, istihdam yaratma, ihracat vs üzerinden hala ulusal gelir içerisinde önemli yer edinmektedir.

Bu çerçevede ekonomik büyümenin önemli unsuru olarak tarımsal üretimin sürdürülebilirliğinin sağlanmasında seragazı salınımına neden olan unsurların belirlenmesi büyük önem taşımaktadır. Özellikle arazi ve mahsül yönetimi, hayvancılık, gübre yönetimi, çeltik tarlaları gibi yoğunluklu seragazına neden olan tarımsal faaliyetlerde önleyici politikaların geliştirilmesi önceliklendirilmelidir.

Benzer şekilde, atık üretiminden kaynaklı seragazı salımının Türkiye'de ekonomik büyüme ile olan güçlü bağımlılığı ve de ekonomik büyüme üzerindeki nedensel etkisi tespit edilmiştir. Atık sektörü seragazı salımının ekonomik büyümede yaratmış olduğu önemli etkiyi kıracak stratejilerin belirlenmesi oldukça önemlidir. Özellikle bu sürecin atık yönetiminin seragazı oluşumuna neden olan katı atık depolaması, arıtılması, açıkta yakılması, atıksu arıtımı vb gibi her bir alt dalını kapsayıcı şekilde ilerletilmesi gerekmektedir.

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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Kargo lojistik yönetiminde sistem dinamiği modeli

System dynamics model in cargo logistics management

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Öz

Kargomatlar, pratik kullanımları ve müşterilere sağladığı kolaylık sayesinde son zamanlarda oldukça popülerdir. Bu çalışmanın amacı, kargo lojistiğinde son günlerde sıklıkla kullanılan kargomat için sistem dinamiği modelinin geliştirilmesidir. Sistem Dinamiği MIT'den Jay Wright Forrester tarafından geliştirilmiştir. Birçok farklı disiplin için kullanım alanı olmasının yanında, sistem dinamiği stok yönetimi konusunda sıklıkla kullanılan bir yöntemdir. Sistem Dinamiği stok ve akış temeline dayanmaktadır. Bu çalışmada, kargomat stoğunun planlanması için sistem dinamiği (SD) modeli Vensim PLE iLe oluşturulmuştur. Geliştirilen sistem dinamiği modeli ile farklı senaryoların analizini gerçekleştirmek mümkündür. Kargomatın kapasitesinin yeterliliği geliştirilen sistem dinamiği modeli yardımıyla incelenmiştir. SD model sayesinde kargomat stoğunun planlaması yapılabilmektedir.

Anahtar kelimeler: Stok Yönetimi, Kargomat, Kargo Lojistik Yönetimi, Sistem Dinamiği.

JEL kodları: C44, C61, L91.

Abstract

Cargomats are very popular lately, thanks to their practical use and the convenience they provide to customers. The aim of this study is to develop a system dynamics model for Kargomat, which is frequently used in cargo logistics. System Dynamics was developed by Jay Wright Forrester at the MIT. In addition to being a field of use for many different disciplines, system dynamics is a frequently used method in stock management. System Dynamics is based on stock and flow. In this study, system dynamics (SD) model was created with Vensim PLE for the planning of cargomat stock. It is possible to analyze different scenarios with the developed system dynamics model. The adequacy of the cargomat's capacity was examined with the help of the developed system dynamics model. Thanks to the SD model, it is possible to plan the cargo mat stock.

Keywords: Stock Management, Cargomat, Cargo Logistics Management, System Dynamics.

JEL codes: C44, C61, L91.

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1. GİRİŞ

Lojistik kelimesinin kökünü incelediğimizde; Latin dilinden "Logic (mantık)" ve "statics (istatistik)" kelimelerinin birleşmesi ile meydana geldiğini ifade edebiliriz. Lojistik kelimesi sözlük anlamını incelediğimizde ise "mantıklı istatistik (hesap)" tır (Bakkal ve Demir, 2011: 3).

Lojistik kelimesinin 1905 yılında ilk defa askeri bir fonksiyonu tanımlamak amacıyla; "orduya ait malzeme ve personelin taşınma, tedarik, bakım ve yenilenmesi" olarak kullanılmıştır. (Kobu, 1998: 200).

Lojistik kavramının günümüzde kabul görmüş en geçerli tanımı ise "The Counsil of Management (CLM)" kuruluşu tarafından yapılmıştır. Bu tanıma göre;

"Lojistik, müşterilerin ihtiyaçlarını karşılamak üzere her türlü ürün, servis hizmeti ve bilgi akışının başlangıç noktasından (kaynağından), tüketildiği son noktaya (nihai tüketici) kadar olan tedarik zinciri içindeki hareketinin etkili ve verimli bir biçimde planlanması, uygulanması, taşınması, depolanması ve kontrol altında tutulması hizmetidir." Lojistik kavramının tanımının günümüz koşullarına uyarlanmış hali;

"Lojistik, mal ve hizmet tedarikine yönelik planlama, organizasyon, nakliye ve yönetim faaliyetlerinin bütünüdür."(Bakkal ve Demir, 2011: 6).

Lojistik yönetimi, müşterilerin gereksinimlerini karşılamak amacıyla her türlü ürün, hizmet ve bilgi akışının üretim noktasından tüketildiği son noktaya kadar olan tedarik zinciri içerisindeki hareketinin etkili bir biçimde planlama, uygulama, taşıma, depolama ve denetim altında tutulmasını sağlamaktadır(Ballou, 2004; Akbal, 2022: 111).

Lojistiğin kaynak yönetimi, tedarik zinciri yönetimi gibi konularla birlikte kullanılmaya başlaması 20. Yüzyılın sonunda ve 21. Yüzyılın başlarında olmuştur(Dinçel, 2016: 19).

2. LİTERATÜRE KISA BAKIŞ

Erdem ve Akolaş (2020) çalışmalarının amacı, kargo şirketi müşterilerinin satın aldıkları hizmetten duydukları memnuniyetin, gerek demografik ve gerekse diğer değişkenlerden dolayı farklılık gösterip göstermediğinin belirlenmesidir.

Adıgüzel (2022), bu çalışmasının amacı, afet lojistiğinde yapay zekânın kullanım alanlarını ve lojistik sektöründeki yapay zekâ teknolojileri alanının ekonomik katkılarını incelemektir. Bu çalışmada, yapay zekâ teknolojisi ile lojistik desteğin güncellenmesi mal ve can kaybını önlemekte ülkelerin ekonomik kayıplarının önüne geçeceği vurgulanmaktadır.

Çelik ve Yelkikalan (2022), bu çalışmada makine öğrenme platformlarından Azure MLStudio'da işlenmesi ile depo süreçlerinin iyileştirmesi hedeflenmektedir.

Korkmaz (2022), bu çalışmasının amacı, mobil kargo dolapları son mil taşımacılığında kullanan kuruluşlara bir karar destek modeli önermektir. Bu çalışmada, mobil koli dolapları kullanılarak yatay işbirliği altında teslim alma ve teslim etme ile lokasyon yönlendirme problemi için bir karma tamsayılı doğrusal programlama modeli önerilmiştir.

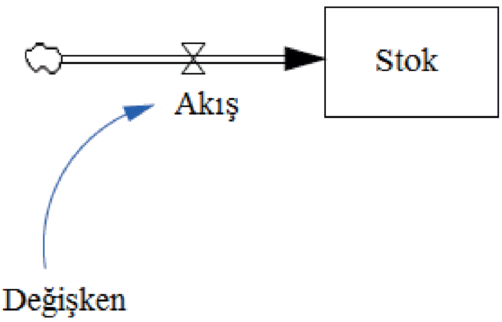
Taşkın v.d. (2022), bu çalışmada optimal RFID teknoloji seçimi problemini PROMETHEE, ANP ve MAUT yöntemlerini ele alarak incelemişlerdir. Firma için mevcut durum incelenerek altı farklı alternatif RFID teknolojisini ele almışlardır.

3. SİSTEM DİNAMİĞİ

Jay W. Forrester, sistem davranışını tanımlamak amacıyla Sistem Dinamiği dilini yaratmıştır. Sistem dinamiği dili dört bileşenden oluşmaktadır. Bu dört bileşen; stoklar, akışlar, karar fonksiyonları ve bilgi akışı olarak ifade edilebilir. Ele alınan sistem istediği kadar karmaşık olsun, bu sistemi tanımlamak için gerekli olan ele alınan bu dört bloğu oluşturmaktır(Yamaguchi, 2013).

Şekil 1'de sistem dinamiği dili, stok ve akış ilişkisi gösterilmektedir.

Şekil 1. Sistem Dinamiği Dili



Stok(stock) ayrıca birikim olarak da tanımlanabilir. Akış(Oran, rate) birikimlerin(stokların) seviyesini değiştiren oran olarak ifade edilebilir. Stoklar(Seviyeler, birikimler) ham maddelerin veya nihai ürünlerin birikimleri (stokları) olarak ifade edilebilir. Stok, sistem içindeki birikimler olarak ifade edilebilir. Bu stoklar (birikimler) işletme hacmi, farklı nitelik ve deneyimlerdeki çalışan sayıları, işgücü vb. kavramlar olabilir. Stoklar(birikimler, seviyeler), içe akış(in flow) ve dışa akış (out flow) arasındaki biriken farktan oluşan değişkenlerin mevcut değerleri olarak ifade edilebilir(Sezen ve Günal, 2009: 306-307; Erkut,1983: 44).

4. KARGOMAT ÖRNEĞİ İÇİN SD MODEL

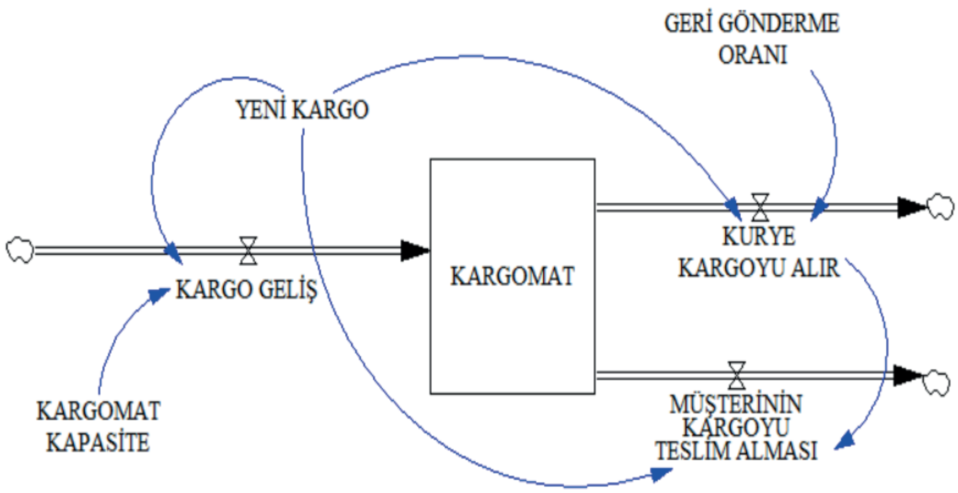
Bu çalışmanın kapsamı; lojistik sistemlerinde son zamanlarda sıklıkla kullanılan kargomat için stok akış ilişkisini modellemektir. Bu kapsamda, bir kargomata ilişkin günlük kargo akışının incelenmesi amacı ile Sistem Dinamiği modeli geliştirilmiştir. Sistem Dinamiği stok ve akış temeline dayanan bir yöntemdir. Kargomat örneği için stok (stock), kargomatta yer alan depo bölümleridir. Akışlar (oranlar, rates) ise; kargomata gelen, teslim alınan veya kurye tarafından geri alınan kargolardır.

Şekil 2'de kargomat örneğine ilişkin oluşturulan Vensim modeli yer almaktadır.

Şekil 2'de görüldüğü gibi kargomat stok (seviye, stock) olarak tasarlanmıştır. Yeni kargo, kargomat kapasite ve geri gönderme oranı değişken (variable) olarak modele elenmiştir. Kargo geliş, Kurye kargoyu alır ve müşterinin kargoyu teslim alması ise akışlardır.

Kargomata gelen ürünler müşteri tarafından teslim alınır. Ancak müşteri gerekli teslim alma süresinde kargomattan ürünü teslim almaması durumunda ürün kurye tarafından alınmaktadır. Bu sebeple gelen ürünün kurye tarafından teslim alınmasını geri gönderme oranı gibi bir değişken ile tanımlanması gerekmektedir.

Şekil 2. Kargomat Örneği Vensim Modeli



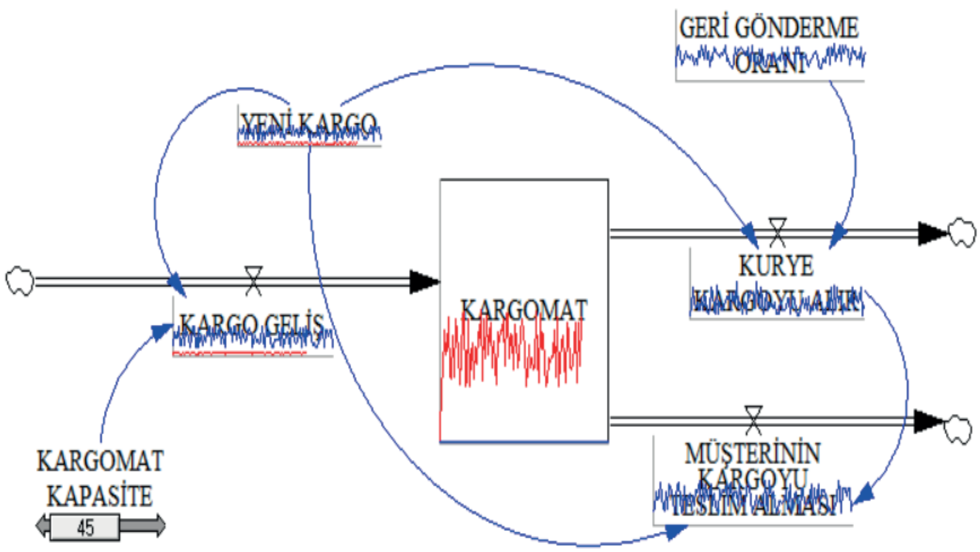
Şekil 3'te görüldüğü gibi kargomat örneğine ilişkin Vensim modeli *SystheSim* ekranı yer almaktadır. Kargomat kapasitesi değişkenine ilişkin *slider* yardımıyla kargomat kapasitesinde bir değişim meydana gelmesinin SD model üzerindeki etkisi pratik olarak incelenebilmektedir.

5. BULGULAR

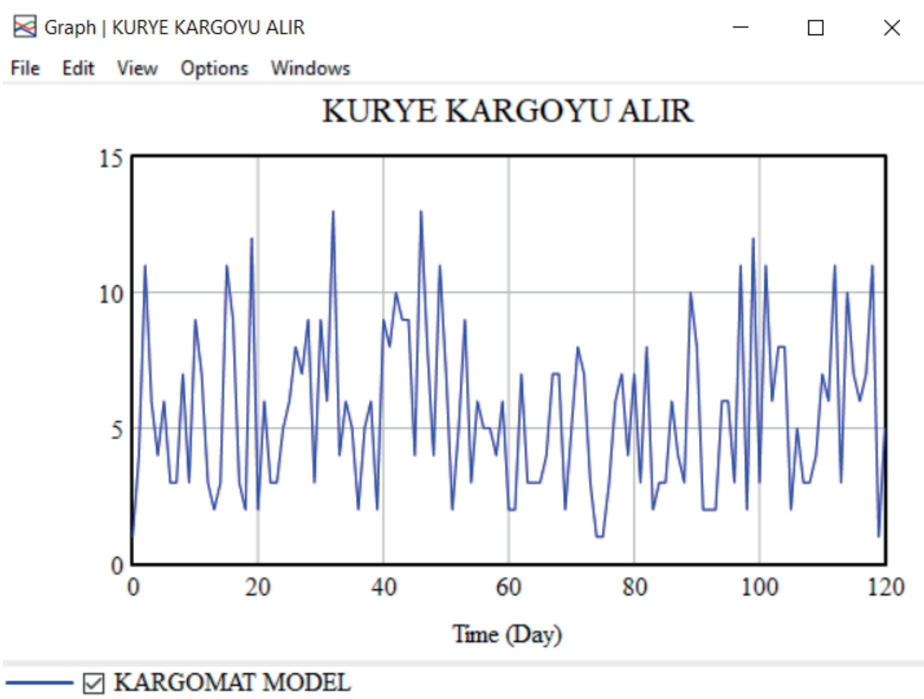
Vensim PLE ile geliştirilen SD modelin çalıştırılmasıyla aşağıdaki bulgular elde edilmektedir.

Şekil 4'te kargomat örneği Vensim modelinde kuryenin kargoyu alma grafiği yer almaktadır.

Şekil 3. Kargomat Örneği Vensim Modeli SystheSim Ekranı



Şekil 4. Kargomat Örneği Vensim Modeli Kuryenin Kargoyu Alma Verileri Grafiği



Şekil 5'te kuryenin kargoyu alma verileri yer almaktadır.

Şekil 5. Kuryenin Kargoyu Alma Verileri

Table Time Down

Time (Day)	"KURYE KARGOYU ALIR" Runs: KARGOMAT MODEL	KURYE KARC
0		1
1		4
2		11
3		6
4		4
5		6
6		3
7		3
8		7
9		3
10		9
11		7
12		3
13		2
14		3
15		11
16		9
17		3
18		2
19		12
20		2
21		6
22		3
23		3
24		5
25		6

Şekil 5 incelendiğinde, 10. Gün kuryenin 9 kargoyu geri aldığı, 18. gün 2 kargoyu geri aldığı söylenebilir.

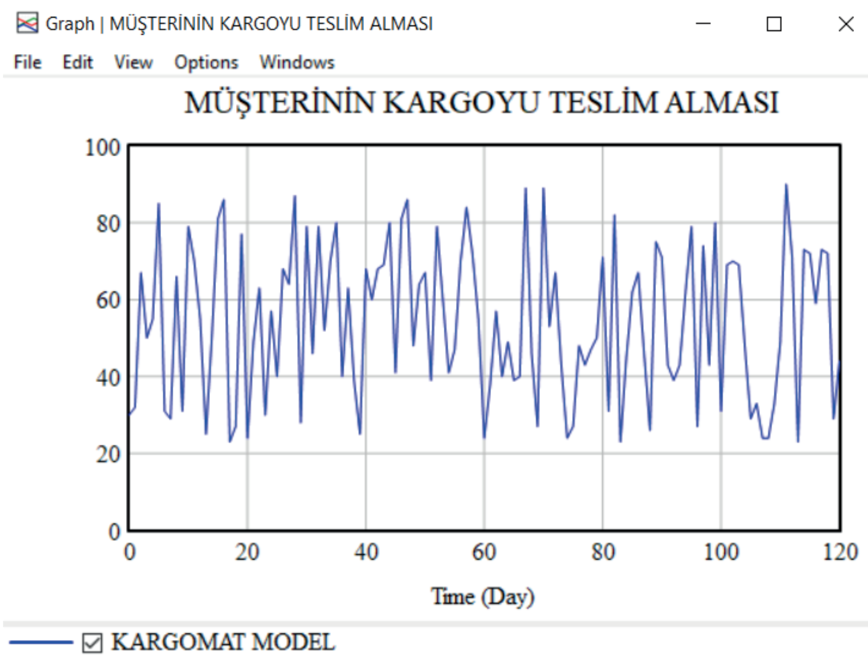
Şekil 6'da müşterinin kargoyu teslim alma verileri grafiği yer almaktadır.

Şekil 7. Müşterinin Kargoyu Teslim Alma Verileri

Table Time Down

Time (Day)	"MÜŞTERİNİN KARGOYU TESLİM ALMASI" Runs: KARGOMAT MODEL	MÜŞTERİNİN
0		30
1		32
2		67
3		50
4		55
5		85
6		31
7		29
8		66
9		31
10		79
11		70
12		55
13		25
14		51
15		81
16		86
17		23
18		27
19		77
20		24
21		49
22		63
23		30
24		57
25		40

Şekil 6. Müşterinin Kargoyu Teslim Alma Verileri Grafiği



Şekil 8'de kargo geliş verileri grafiği yer almaktadır.

Şekil 9'da kargo geliş verileri yer almaktadır.

Şekil 9. Kargo Geliş Verileri

Table Time Down

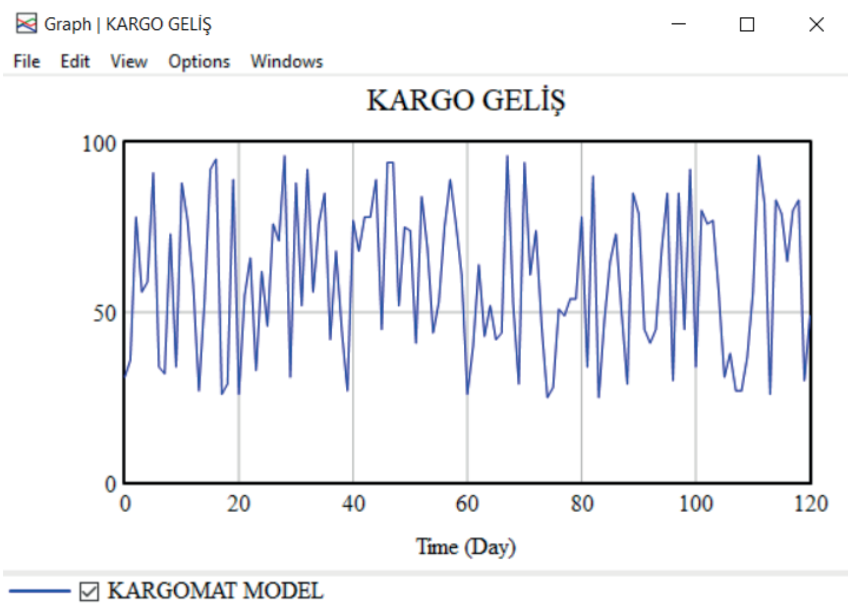
Time (Day)	"KARGO GELİŞ" Runs: KARGOMAT MODEL	KARGO GELİŞ
0		31
1		36
2		78
3		56
4		59
5		91
6		34
7		32
8		73
9		34
10		88
11		77
12		58
13		27
14		54
15		92
16		95
17		26
18		29
19		89
20		26
21		55
22		66
23		33
24		62
25		46

SD modelden elde edilen veriler ile kargomat için kargo akışının durumu incelenerek farklı senaryolar denenebilir. Kargo akışının incelenmesiyle kargomatiğin kapasitesinin yeterliliği analiz edilebilir. Geliştirilen model yardımıyla kargo kapasitesinin arttırılması gerekliliği analiz edilebilir. İhtiyaç olması durumunda kargomat kapasite arttırımı planlanabilecektir.

6. SONUÇ

Günümüzde lojistik kavramı, tüm dünyada ve ülkemizde gelişimine hızlı bir şekilde devam eden sektörlerden bir tanesi olarak ifade edilebilir. Koban ve Keser(2011)'in de vurguladığı gibi; lojistik kavramı en çok gelişmesi beklenen üç sektörden bir tanesi olarak görülmektedir. Pandeminin de etkisiyle, dünyada ve ülkemizde lojistik kavramının ilerleyen günlerde de oldukça önemli bir konu olacağı açıktır. Bu çalışmada, son zamanlarda sıklıkla kullanılmaya başlanan kargomatların stok yönetimine ilişkin bir Sistem Dinamiği modeli geliştirilmiştir. SD model incelendiğinde kargo stok ve akışının incelenmesi sağlanmaktadır. Sistem Dinamiği modelleri, farklı politikaların sistem üzerindeki etkisini incelemek ve etkin politikalar tasarlamak için kullanılan bir yöntemdir. Bu çalışma, kargomat gibi depo yönetimi konusunda ileriki çalışmalara ışık tutacaktır.

Şekil 8. Kargo Geliş Verileri Grafiği



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