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Investigation of effect of crude oil consumption on economic growth in oil exporting countries: Panel data analysis

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Abstract: This paper examines the effects of oil consumption on the economic growth of oil-exporting countries (Algeria, Angola, Canada, Russian, Iran, Nigeria, Kuwait, and Venezuela). Accordingly, the study was adopted on panel cointegration and panel vector error correction modeling techniques, during the period (1997-2013) through the panel fully modified ordinary least square (FMOLS) approaches and dynamic ordinary least square (DOLS) methods. The results showed the data are unstable at the level and are stable when taking the first difference. Results indicate there are a long-term equilibrium relationship between the oil consumption and the economic growth of the countries concerned. In this context, the results of the study indicate the significance of all the independent variables means that there is a short-term relationship between the variables, and through the negative signal and the significance of the coefficient of error correction coefficient means that there is a long-term relationship between the variables. Consequently, there are a two-way causality relationship between economic growth and oil consumption in the short and long term. Thus, in order to reduce reliance on crude oil from policy makers in countries, more attention should be paid to the issue of energy efficiency programs.
Keywords: Oil Consumption;Economic Growth;Panel Data;FMOLS.

1. Introduction

Oil was first discovered in 1859 as the most important energy source from the day it was discovered to the present day, and after that date the oil has begun to grow rapidly (Smith, 1994: 127). Total oil production was about 10 million tons in 1890, but close to 200 million tons in 1930 (Jenkins, 1990: 119). There are a number of important factors that contribute to this increase. Particularly, the effect of personal consumption of oil has been due to the widespread use of cars. With this effect, the other significant rise of oil was realized with the First World War. Motor vehicles used intensively in the war can be considered as one of the important factors that increase petroleum consumption. A similar effect occurred in the Second World War. Second the post-World War era has emerged as a period in which natural gas has become widespread and has increased its importance.

Long-term economic growth and the representative of the rate of increase in GDP are among the most important priorities that countries seek to achieve. Economic theories differ on the determinants of economic growth between a numbers of macroeconomic variables. Determining the source of growth is necessary to activate economic growth and to sustain it by adopting appropriate economic policies. Economic growth has become the focus of many economic studies. The reality which most societies often live in is the relative increase in prices annually. The rise in commodity prices in general is inversely proportional to monetary value. The higher the price, the lower the monetary value. This in turn leads to higher levels of poverty in countries that do not strive to maintain and balance their prices. Especially in light of the economic fluctuations in the world, the most important of which are the fluctuation in oil price(Usta, 2016) (Karan, 2008).The existence or absence of the relationship between energy consumption and economic growth is an important indicator of the direction of energy policies in countries where the state is active, especially in energy markets. The fact that there is no relationship between energy consumption and growth removes the possibility of adversely affecting the growth of energy conservation policies (energy saving, energy taxes, energy price policies, etc.). On the contrary, when there is a causal relationship between energy consumption and growth, conservation policies that reduce energy consumption can adversely affect growth.

At the outset, we wonder, does the increase in global crude oil consumption have a positive or negative impact on the economic growth of the oil exporting countries under study (Algeria, Angola, Canada, Russian, Iran, Nigeria, Kuwait, and Venezuela)?, for answer this question, we must clarify the determinants of economic growth, and the speed of this growth. The results of previous studies that attempted to explain the impact of increasing crude oil consumption in economic growth have not reached a definite result in this regard, due to several reasons including the different standard models used and the different time period. Therefore, the objective of this study will be to test the relationship between global crude oil consumption and the real GDP in a panel of oil exporting countries over the long term. Specifically, we want to know how the change in global oil consumption affects the economic growth of the countries concerned. This study is based on data covering the

period (1997- 2013) using appropriate standard methods such as unit root tests (for measuring stability of variables) and co-integration. Also, the fluctuations in oil prices have an impact on economic activity, and some studies indicates a positive relationship between fluctuations in world oil prices and the dollar exchange rates in the long and short term(Aimer, 2016a, 2016b and 2017).Crude oil price shocks have a major impact on stock indices during the global crisis in 2008 (Aimer, 2016a, Ulusoy et al., 2012 andUlusoy, 2017).

The remaining chapters are presented as following: Section II presents some of the previous experiences that took place within the context of oil consumption with economic growth. Section III shows data sources. Section IV provides an explanation of the methodology and standard model used in the study. Section V deals with the analysis of the findings. The final chapter of this study give a summary of this study. Some of the leading studies carried out by economic researchers in determining the relationship between GDP and oil consumption in some countries of the world, as in the table 1 below.

2. Literature Review

In the present day, the importance of economic growth in terms of states has increased considerably and has become indispensable in terms of economic policies. Although the relationship between energy consumption and growth has been extensively studied in the literature, there is debate about the direction of causality between these two variables. That is, there is no consensus on whether economic growth will lead to energy consumption, or whether energy consumption is a locomotive for economic growth.

In the light of these developments, the relationship between energy and growth has been tested with different methods,of these methods; production function based work. But the weak point of production function-based work is that it promotes energy use by growing up due to a high correlation between energy and economic growth, indicating that energy uses may not be necessary for growth (Stern, 1993). Another method is causality analysis. The first study in which the method was used is the work of Kraft & Kraft, (1978). This study examined the relationship between energy consumption and Gross Domestic Product (GDP) using the VECM causality test for the US between 1950 and 1970. It has been determined that there is a one-way positive causality from GDP to energy consumption. Akarca & Long, (1980) did not find a relationship between energy consumption and GDP in the study of the United States using VECM causality in the period 1950-1968.

The following empirical studies on the relation between energy consumption and economic growth have been given by following the examples in time order. Table 1 contains 21 studies for many countries that have practically dealt with the relationship between energy consumption and economic growth. In studies, it is seen that the country has differentiated results about energy consumption and economic growth.

Table 1 Studies Testing the Relation Between Energy Consumption and Economic Growth.

Authors	Countries	Method	period	Results
(Asafu-Adjaye, 2000)	India, Indonesia, the Philippines and Thailand	Co-integration and error-correction	India and Indonesia (1973-1995), Thailand and the Philippines (1971-1995)	energy → income
(Aqeel & Butt, 2001)	Pakistan	co-integration and Hsiao's version of Granger causality	(1956-1996)	energy ↮ growth
(Zou & Chau, 2006)	China	panel cointegration	1953-2002	oil consumption ↔ growth
(Mehrara, 2007)	11 oil-exporting developing countries	panel cointegration	1971-2002	GDP → energy
(Huang, Hwang, & Yang, 2008)	82 countries: low income group, lower middle income group, upper middle	GMM-SYS approach, Panel VAR	1972-2002	In the low income group (energy ↮ growth). In the middle income groups (growth → energy).

	income group, and high income group.			In the high income group countries (growth → energy) but negatively.
(Lee & Chang, 2008)	16 Asian countries	Panel date	1971-2002	energy → growth
(Zhang & Cheng, 2009)	China	VAR and ECM	1960–2007	GDP → energy consumption
(Chontanawat, Hunt, & Pierse, 2008)	over 100 countries in the developed OECD countries and the developing non-OECD countries	Granger-causality	(1960-2000) OECD, (1971-2000) non-OECD	Causality from energy to GDP is found to be more prevalent in OECD developed countries than in non-OECD developing countries
(Ighodaro, 2010)	Nigeria	Johansen co-integration	1970-2005	economic growth → domestic crude oil production
(Ighodaro, 2010)	25 OECD countries	Panel date	2007-1981	energy consumption ↔ economic growth
(Al-Mulali, 2011)	MENA countries	Panel date	1980-2009	energy consumption ↔ economic growth
(Shaari, Hussain, & Ismail, 2012)	Malaysia	Johansen co-integration	1980-2010	consumption of oil and coal ↔cause economic growth
(Behmiri & Manso, 2012)	27 OECD countries	Panel cointegration	1976–2009	energy consumption ↔ economic growth
(Behmiri & Manso, 2013)	23 Sub-Saharan African countries	panel Granger causality	1985-2011	(energy ↔ growth) in oil importing region & (energy → growth) in oil exporting region
(Çemrek & Burhan, 2014)	21 European Union and Turkey	Panel cointegration	1990-2010	There is a low positive correlation between GDP and oil consumption.
(Bhattacharya et al., 2016)	38 top renewable energy consuming countries	Panel	1991-2012	Renewable energyconsumption has a significant positive impact on economic output 57%
(Tang, Tan, & Ozturk, 2016)	Vietnam	cointegration and Granger causality	1971-2011	energy → growth
(Inglesi-Lotz, 2016)	34 countries-members of OECD	panel data	1990-2010	The impact of renewable energy consumption on economic growth is positive.
(Kais & Sami, 2016)	58 countries (European and North Asian region, Latin American and Caribbean region, and the Middle Eastern, North African and sub-Saharan region)	panel data	1990-2012	Energy use has a positive impact on carbon dioxide emissions. GDP per capita has a positive impact on carbon.
(Antonakakis, Chatziantoniou,	106 countries classified by	PVAR, IRF	1971-2011	energy ↔ growth

&Filis, 2017)	different income groups			
(Kahia, Aissa, & Lanouar, 2017)	11 MENA Net Oil Importing Countries	panel Granger causality	1980-2012	energy ↔ growth
(Iyke, 2017)	19 African countries	the non-parametric triple test, the Bai-Perron test, and the KSS test	1971-2011	evidence of deepness and steepness asymmetries, structural breaks, and nonlinear persistence in energy consumption and economic growth

Notes: Notes: Energy ↔ Growth means that bi-directional causality exists between energy consumption and growth. Energy → Growth means that the causality runs from energy consumption to growth. Growth → Energy means that the causality runs from growth to energy consumption. Energy ↮Growth means that no causality exists between energy consumption and growth.

The development experience of developed countries suggests that more energy types are being used in energy consumption. The main reason for this development are economic growth, increasing use of production factors (when energy is considered as an input of production), effective use of these factors and effective demand for goods and services (Berndes, Hoogwijk, & den Broek, 2003). As the growth rate in GDP increases, the possibility of converting energy-using capital stock increases and energy demand increases because energy is included in complementarity with capital factor.

According to studies, there is no general consensus on the characteristics of the relationship between oil consumption and economic growth. This diversity of results is due to various reasons, such as heterogeneity in country conditions, varying consumption patterns of oil, the degree of economic development of the country, the econometric methodology used and the different temporal horizons used (Behmiri & Manso, 2012).

The current literature suffer from a clear lack of study on the causality relationship between crude oil consumption and economic growth in oil-exporting countries. All current studies have focused on oil prices with economic growth.

3. Structure of the model, data, methodology and results

In order to study this relationship empirically, we use a multivariate panel framework. In the first step, we perform using the panel unit root tests to determine whether the series is stable or not stable by(Im, Pesaran, & Shin, 2003). In the second step, we implement Pedroni, (1999) and Kao, (1999) panel co-integration and Pedroni, (2001) panel Fully Modified Ordinary Least Square (FMOLS) approaches and Dynamic Ordinary Least Square (DOLS) methods.to investigate the existence of long-run relationships between the series. And in the third step, we apply a dynamic panel data Granger causality approach in order to determine and measure the direction of the causal relationship between the variables under study.

3.1. Structural of the model and Data

In this study, a linear multiple regression model was used to test the long-run relationship between oil consumption and economic growth:

$lnCONS_t = f(lnOILP_t, lnGDPG_t, lnCOP_t)$…….. (1)

The analysis of this study was conducted on energy consumption and economic growth. It is used the data set of GDP growth (annual %) (GDPG) for the period 1997-2013, Crude oil consumption by Year (CONS), crude oil Production by Year (COP) and global crude oil prices (OILP).Time series for the economy of the crude oil exporting countries (Algeria, Angola, Canada, Russian, Iran, Nigeria, Kuwait, and Venezuela) are derived from the United States Energy Information Administration. Eight countries are selected in this study according to the availability of data for the period 1997-2013. All variables are employed with their natural logarithms form to reduce heteroscedasticity.

3.2. Results for panel unit root tests

In the analysis of oil consumption and economic growth, panel unit root tests (Levin, Lin and Chu t & Breitung t-stat) can be applied. The modern literature suggests several methods for unit root tests in panel data. Because of different results of these methods, it is selected Levin, Lin, & Chu, (2002), Breitung, (2001)and Im, Pesaran, & Shin, (2003)to perform panel data unit root tests. In all these tests, the null hypothesis is that the

variable contains the unit root (i.e., it is not stationary). Panel unit root test results applied to both the level and the first difference of the variables are given in Table 2.

Table 2. Results for panel unit root tests.

Method	Variable name			
	LNCONS	LNOILP	LNGDPG	LNCOP
Levels				
Levin, Lin and Chu t*	0.32663	-3.08643***	-3.51187***	-0.09607
Breitung t-stat	-0.77687	-5.51804***	-1.23494	0.46794
Im, Pesaran and Shin W-stat	1.04891	-0.44969	-2.14497**	0.53424
ADF-Fisher Chi-square	7.48478	14.7695	28.0223**	12.6648
PP-Fisher Chi-square	10.7862	34.0404***	37.5179***	6.72216
Hadri Z-stat	3.83389***	3.11306***	3.76152***	4.17093***
First differences				
Levin, Lin and Chu t*	-3.32653***	-9.83104***	-8.35131***	-2.59721***
Breitung t-stat	-3.39574***	-5.75316***	-3.65922***	-1.87291**
Im, Pesaran and Shin W-stat	-3.27592***	-6.84735***	-6.35467***	-1.66983**
ADF-Fisher Chi-square	39.3018***	70.4454***	65.0266***	25.4545*
PP-Fisher Chi-square	79.8054***	147.365***	111.969***	46.3353***
Hadri Z-stat(Hadri, 2000)	2.55025***	29.3320***	9.77456***	3.79376***

*Denotes the rejection of the null of a unit root.
* Significant at 10% level. ** Significant at 5% level. *** Significant at 1% level.

According to the panel the unit root tests results given in Table 3, it was determined that LNCONS,LNOILP, LNGDPG and LNCOP series are not stable in the level but all series at first difference are stationary. Thus, the root unit problem which is in first difference is eliminated.

3.3. Pedroni Panel Cointegration Test results.

After panel unit root tests, cointegration test apply to investigate the long-run relationship for series. Thus, in this part of study, it is applied Pedroni, (1999) and Kao, (1999) cointegration test to expain the long-run relationship between oil consumption (CONS) and economic growth (GDPG), and it is used oil consumption and economic growth data for the period of 1997-2013 in 8 oil exporting countries. This test developed by Pedroni, (1999, 2004) proposed seven panel cointegration statistics under null hypothesis H_0: P_i=0. The seven tests are based on the absence of cointegration. The cointegration panel model of relationship between economic growth and oil consumption for these countries is given as follows:

$$lnCONS_{it} = \beta_{0it} + \beta_{1it} lnOILP_{it} + \beta_{2it} lnCOP_{it} + \beta_{3it} lnGDPG_{it} + u_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

I=1,…….., N and t=1,…..,T

The results are shown in table 3 below.

Table 3. Pedroni Panel Cointegration Test results

Test (Trend assumption: No deterministic trend)	Statistic	Weighted statistic
Within dimension		
Panel v-Statistic	0.282235	0.218187
Panel ρ-Statistic	0.314004	0.590274
Panel t-Statistic: (non-parametric)	-2.042753**	-1.323812*
Panel t-Statistic (ADF): (parametric)	-2.551517***	-1.727734**
Between dimension		
Group ρ-Statistic	1.548937	
Group t-Statistic: (non-parametric)	-2.331088***	
Group t-Statistic (ADF): (parametric)	-2.224999**	
Test (Deterministic intercept and trend)	Statistic	Weighted statistic
Within dimension		
Panel v-Statistic	5.509415***	2.713287***
Panel ρ-Statistic	1.702609	1.458131
Panel t-Statistic: (non-parametric)	-1.058879	-1.192136

Panel t-Statistic (ADF): (parametric)	-2.047445**	-1.923204**
Between dimension		
Group ρ-Statistic	2.559016	
Group t-Statistic: (non-parametric)	-1.884104**	
Group t-Statistic (ADF): (parametric)	-1.942271**	
Kao test		
ADF	-3.874044***	(0.0001)

Notes: Lag length selection is based on Modified Akaike information criterion.
Variables: CONS, OILP, GDPG and COP.
***, ** and * denote rejection of null hypothesis of no cointegration at the 1%, 5% and 10% significance levels, respectively.

Pedroni and Kao for Co-integration Test which investigates the long-term relationship between oil consumption and economic growth based on the hypothesis H_0 (no cointegration between the series) was rejected. Three of the test results of the panel statistics are statistically significant level of 1%. All of group statistics are statistically significant at 1% level. With the overall evaluation, six test results (panel and group statistics) in Pedroni Panel cointegration test illustrate the cointegration relationship between the series.

3.4. Panel Fully Modified Least Squares (FMOLS) estimates and DOLS

After applying the cointegration tests, we use the Dynamic Ordinary Least Square (DOLS) method developed by Pedroni, (1999, 2001, 2004). To test the coherence of the estimators within our expectation to estimate the final unbiased coefficients of this relation and FMOLS (Full Modified Ordinary Least Square) method. While the FMOLS method corrects deviations in standard fixed effect estimators (such as autocorrelation, varying variance), the DOLS method is a method with the ability to remove deviations in the static regression (especially due to problems of internalization), including model dynamic elements (Kök et al., 2010: 8). This FMOLS method, which permits a significant degree of heterogeneity between the individual sections of the Pedroni, accounts for the existence of a possible correlation between the constant term and the difference between the error term and the independent variables.

Table 4. Co-integrated Regressions: Panel FMOLS and DOLS

Dependent Variable: LNCONS $lnCONS_{it} = \beta_{0it} + \beta_{1it} lnOILP_{it} + \beta_{2it} lnCOP_{it} + \beta_{3it} lnGDPG_{it} + u_{it}$		
	Method	
	FMOLS	DOLS
LNOILP	0.139987*** (0.0000)	0.257801*** (0.0000)
LNGDPG	0.035126* (0.0626)	0.066012*** (0.0004)
LNCOP	0.775323*** (0.0000)	-0.549536*** (0.0074)
R-squared	0.488681	-166.349859
Adjusted R-squared	0.480500	-639.546012

Note: ***,* denotes statistical significance at the 1% and 10% level.

Table 3 shows the Panel DOLS test results. When Panel DOLS test results are evaluated on a panel basis, the sign of economic growth is positive and statistically significant at 1% level. In other words, the increase in oil consumption in the long term affects the economic growth positively throughout the panel.
In addition, FMOLS results demonstrate that ECONS series for eight oil exporting countries have positive and statistically significant signs at 1% and 10% level. That means, there is a positive relationship between oil consumption and economic growth. Generally, increases in oil consumption leads to increases in economic growth (GDPG).

The direction of causality can be detected through the Vector Error Correction model (VECM) of long-run cointegrating vectors. After the determination of the series to be cointegrated in the long term, whether there is any causality relationship between the variables and it is tried to determine the direction of causality. Variables have defined as dependent variables and independent variables using a two-period lag length with the help of Schwarz criterion and the analysis have been performed. Any errors or extreme values were observed in the specification of the model and test results are reported in Table 5 below.

Table 5. Panel Vector Error Correction Estimates

Error Correction:	D(LNCONS)	D(LNOILP)	D(LNGDPG)	D(LNCOP)
CointEq1 (ECT)	-2.95E-05***	-0.002012***	-0.000478***	-0.000398***
	(0.00011)	(0.00047)	(0.00115)	(0.00014)
	[-0.27972]	[-4.28614]	[-0.41742]	[-2.89293]
D(LNCONS(-1))	-0.014917	-0.700878	-0.515970	-0.405096
	(0.10200)	(0.45480)	(1.11000)	(0.13314)
	[-0.14625]	[-1.54105]	[-0.46484]	[-3.04257]
D(LNCONS(-2))	0.013456	0.028263	-0.743229	0.059171
	(0.10181)	(0.45396)	(1.10793)	(0.13290)
	[0.13216]	[0.06226]	[-0.67083]	[0.44525]
D(LNOILP(-1))	0.028411**	-0.367888*	-0.315412	-0.006319**
	(0.01907)	(0.08505)	(0.20756)	(0.02490)
	[1.48957]	[-4.32574]	[-1.51959]	[-0.25382]
D(LNOILP(-2))	0.008355**	-0.366663*	-0.064426	-0.037677**
	(0.01688)	(0.07527)	(0.18369)	(0.02203)
	[0.49497]	[-4.87156]	[-0.35072]	[-1.70998]
D(LNGDPG(-1))	-0.013299***	-0.014477**	-0.247443*	-0.008182*
	(0.00804)	(0.03585)	(0.08750)	(0.01050)
	[-1.65405]	[-0.40382]	[-2.82805]	[-0.77956]
D(LNGDPG(-2))	-0.005408***	-0.048171**	-0.169389*	-0.012638***
	(0.00736)	(0.03283)	(0.08013)	(0.00961)
	[-0.73440]	[-1.46711]	[-2.11382]	[-1.31482]
D(LNCOP(-1))	0.008024*	0.264498	-1.258146	0.275169*
	(0.07142)	(0.31845)	(0.77721)	(0.09323)
	[0.11235]	[0.83058]	[-1.61880]	[2.95165]
D(LNCOP(-2))	0.014625*	0.262150	-0.326502	0.088424*
	(0.07129)	(0.31789)	(0.77585)	(0.09306)
	[0.20513]	[0.82465]	[-0.42083]	[0.95016]
C	0.026100***	0.225665**	0.073463*	0.030261***
	(0.00689)	(0.03072)	(0.07498)	(0.00899)
	[3.78826]	[7.34585]	[0.97983]	[3.36486]
R-squared	0.047833	0.429102	0.168440	0.275378
Adj. R-squared	-0.036181	0.378728	0.095067	0.211440

Note: *, ** and *** indicate stationary at 10%, 5%, and 1% significance levels, respectively.

From the above table we notice that the error correction coefficient is -2.95. According to Narayan & Smyth, (2006) if the error correction coefficient (ECT) is greater than 1, indicating that the system fluctuates, this oscillation decrease each time to return to the long-term equilibrium. The error correction coefficient (ECT) was statistically significant and negative for all study variables as expected. According to Jones & Joulfaian, (1991), changes in the values of the length of delayed independent variables show short-term effects, and as a result, there is a positive correlation between oil consumption and short-term growth. According to this finding, increased short-term oil consumption has a positive impact on growth. The values in bracket refer to the t-statistic values of variables. T-statistic of variable GDPG shows the -0.41 value. This value is statistically significant at the 1% level. This means that there is the long-term causality from CONS to the GDPG. Likewise, t-statistic of variable CONS is -0.27. This value is statistically significant at the 1% level. Accordingly, the long-term causality from GDPG to CONS is available. Thus, it is observed that there are long-term two-way causality between GDP and ECONS.

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4. Conclusion

In the present day, the importance of economic growth in terms of states has increased considerably and has become indispensable in terms of economic policies. The phenomenon of economic growth has also been examined by many economists in history and various studies have been conducted on economic growth.

These studies are still being carried out. Today, as global warming and energy become debatable, the role of energy on economy and economic growth has also become very important. Nowadays, when production technologies are highly developed, an energy production process has become unthinkable. Therefore, determining the relationship between economic growth and oil consumption is very important. Many researchers have examined the relationship between economic growth and energy intensively since the late 1970's. Besides the empirical results that oil consumption supports economic growth, the results that economic growth affects oil consumption are also common. These conclusions are significant for countries in the context of economic policies(Akpolat & Altintaş, 2013). In this study, the relationship between economic growth and oil consumption was examined using the Panel Data Analysis method. The effect of oil consumption on economic growth was investigated by panel cointegration and panel vector error correction modeling techniques based on the annual data of the eight oil exporting countries (Algeria, Angola, Canada, Russian, Iran, Nigeria, Kuwait, and Venezuela) for 1997-2013 period. For this purpose, the validity of the estimations made under the panel Fully Modified Ordinary Least Square (FMOLS) approaches and Dynamic Ordinary Least Square (DOLS) methods. The results showed that the data are unstable at the level and are stable when taking the first difference. In applying the integration tests, the results of these tests showed a long-term equilibrium relationship between the consumption of crude oil and the economic growth of the countries concerned. In this context, the results of the study indicate the significance of all the independent variables means that there is a short-term relationship between the variables, and through the negative signal and the significance of the coefficient of error correction coefficient means that there is a long-term relationship between the variables. Consequently, there is a two-way causality relationship between economic growth and crude oil consumption in the short and long term.

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