Review of Finance and Markets
ISSN : 2392-5124
eISSN 2602-5191

VOL: 07 / N°: 01 (2020), p 01-19

Causality between Energy Consumption and Economic Growth: Evidence from Algeria

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Received	Accepted	Published
18-06-2019	20-03-2020	30-03-2020

Abstract :

This paper looks at the relationship between per capita GDP and per capita energy consumption for Algeria during the period from 1971 to 2016, utilizing a modified version of the Granger (1969) causality test proposed by Toda and Yamamoto (1995). The empirical results show that there is a unidirectional causality running from GDP per capita to energy consumption.

Key words: Energy Consumption, Economic Growth, Toda and Yamamoto Causality, Algeria.

الملخص:

الهدف من هذه الورقة البحثية هو دراسة العلاقة بين نصيب الفرد من الناتج الداخلي الخام و استهلاك الطاقة في الجزائر خلال الفترة من 1971 حتى 2016، و هذا باستعمال اختبار السببية المطور لـ Granger (1969) و الذي تم اقتراحه من طرف Tota and Yamamoto (1995) . و قد بينت نتائج الدراسة القياسية وجود سببية في اتجاه واحد من الناتج الداخلي الخام بالنسبة للفرد نحو استهلاك الطاقة.

الكلمات المفتاحية: استهلاك الطاقة، النمو الاقتصادي، اختبار السببية تودا و ياماموتو، الجزائر.

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1. Introduction:

Algeria is heavily dependent on its hydrocarbon sector, as it accounts for almost 40 percent of GDP, and 98 percent of the country's exports. The energy consumption in Algeria has significantly increased over the last ten years by approximately 35 percent. The residential sector represent more than the third of the final energy consumption. The expected increase in population growth and housing which are the two major factors of the energy consumption in the residential sector, together with a constant value of gas and oil reserve and production which are the main sources of energy in Algeria, will threaten the government ability to maintain balance between supply and demand on energy consumption.

Additionally, energy prices subsidy is another factor that drive up energy consumption in Algeria. The budgetary cost of energy subsidies in Algeria has increased considerably. In 2014, the size of implicit subsidies was estimated by US $ 14 billion (IAE, 2015). However, following the sharp decline in oil prices that started in mid 2014 and the subsequent fall in oil revenues, the Algerian government has become under pressure to reconsider the level of subsidies it provide for energy consumption , and hence its energy policy.

Theoretically appropriate energy policy choice depends on the actual direction of causality between energy consumption and economic growth. Thus, investigating the causality direction between energy consumption and GDP in Algeria is important because if the causality between these two variables in Algeria follows the conservative hypothesis then phasing out energy subsidy will not have a negative impact on GDP growth.

The purpose of this paper is to investigate the long run causality relation between economic growth and energy consumption in Algeria. The paper is structured as follow. In section 2 we present the literature review. Section 3 offers an analytical framework of energy consumption in Algeria. Section 4 presents the data and methodology used. Section 5 discusses the empirical results. Finally, Section 6 provides policy implications and concludes the paper.

2. Literature review on energy consumption and economic growth nexus:

The causal relationship between energy consumption and economic growth is a well studied topic in the literature. This is since the pioneer work of Kraft and Kraft (1978) who found evidence in favour a unidirectional causality running from economic growth to energy consumption in the case of the USA. However, the empirical outcomes of studies in this issue have been inconclusive and conflicting for every country.

Literature on energy consumption-growth nexus is generally synthesized into four hypotheses (Apergis and Payne, 2009a,2011). The growth hypothesis assumes a unidirectional causality running from energy consumption to GDP. Therefore, a decrease in energy consumption due to a partial removal of subsidies will have a detrimental impact on economic growth. The conservation hypothesis is that causality runs from economic growth to energy consumption. In this cases energy conservation policies such as phasing out energy subsidies will have no adverse effects n economic growth (Mulugeta and al.,2011). The feedback hypothesis postulates a bidirectional causal relationship between economic growth and energy consumption , then, increasing energy consumption will stimulate growth, and conversely economic growth will boost consumption of energy. The neutrality hypothesis suggests that economic growth does not cause energy consumption and at the same time energy consumption does not lead higher rates of economic growth.

The empirical literature available on the energy consumption and growth nexus is enormous, and direction of causality revealed by different studies has been mixed and controversial for both developed and developing countries.

The examination of the causal relationship between energy consumption and economic growth in developing and oil exporting countries was the subject of a number of studies. Chien-chiang (2005) investigated the causality relationship between energy consumption and GDP in 180 developing countries during the period from 1975 to 2001.His empirical findings suggested the presence of a unidirectional causality running from energy consumption to GDP, indicating that energy conservation policies may harm economic growth in developing countries. In contrast, the conservation hypothesis was confirmed by Mehrara (2007) , conducted a study on energy consumption and economic growth in a panel of 11 oil exporting countries. The author mentioned that the energy conservation through reforming energy prices policies will have no damaging impact on growth for these oil exporting countries.

Another study was conducted by Al Iriani and Trabelsi (2016) to investigate the impact of phasing out energy consumption subsidies on the Gulf Cooperation Council (GCC) during the period 1980-2013, using causality analysis between GDP and energy consumption. The estimated results supported the feedback hypothesis between the two variables for Qatar and Saudi Arabia, the conservation hypothesis for Bahrain and Kuwait , the growth hypothesis for Oman, and the neutrality hypothesis was supported for UAE. The authors suggested that phasing out energy subsidies in the GCC countries is likely to have different impact across their economies due to differences in the results of causality running from energy to GDP in these countries.

Moreover, Mulugeta and al.,(2011) investigated the causality between GDP and energy consumption in sub-Saharan African countries . These countries were classified into low income and middle income countries. The results of their study supported the neutrality hypothesis in the short run for low income countries, while a bidirectional causality was found in the long run for both income categories. The authors indicated that the different results for low and middle income SSA countries provided evidence for the importance of the level of income in the causal relationship between energy and growth.

Concerning the relationship between energy consumption and economic growth for Algeria, there is limited number of studies that examined the above considered nexus. Belaid and Abderrahmani (2013) investigated the causal relationship between electricity consumption, oil price and economic growth in Algeria over the period 1971- 2010. Using a multivariate cointegration approach, the empirical results indicated that there is evidence of a short run and strong long run bidirectional causal relationship between electricity consumption and real GDP in Algeria. Another study was conducted by Eddrief-cherifi and Kourbali (2012) to find the impact of energy consumption on economic for Algeria. The estimated results indicated a unidirectional causality running from energy consumption to GDP.

In this paper we focus on energy use and its relationship with economic growth in Algeria, because investigating the causality direction between energy and growth in Algeria is important to investigate the potential effects of phasing out energy prices subsidy.

3. Overview of the energy consumption in Algeria:

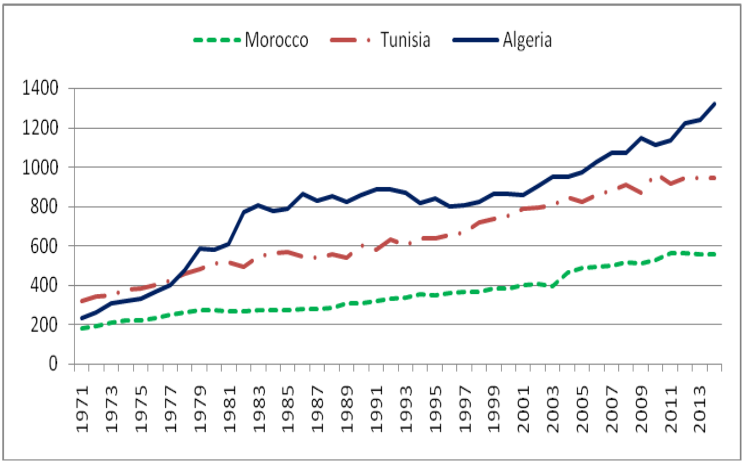
For the past few years final energy consumption in Algeria has increased fast, from 31.65 Mtoe in 2010 to 42.88 Mtoe in 2016, with an increase of 35.5 percent. Compared to their neighbouring countries in north Africa, Algeria's energy consumption is high. The energy consumption per capita in Algeria reached 1321 Kilograms of oil equivalent (Kgoe) in 2014, compared to 553 Kgoe per capita in Morocco which has nearly the same number of inhabitants, and 943,6 Kgoe per capita in Tunisia (Figure 1).

This enormous increase in energy consumption in Algeria is due in part to the local fuel prices, which have remained artificially very low thanks to generous government subsidies. Domestic prices for fuels in Algeria are below the prices in the European

Union and America, and lower than the prices in the Middle East. Gasoline prices , which are generally below market in oil exporting countries, are lower in Algeria than in most oil exporting countries, except for Saudi Arabia. Algerian diesel prices are also among the lowest in the MENA region. As of mid-August 2017, diesel and gasoline prices in Algeria were less than one third the prices in most neighbouring countries (diesel prices are 0.22, 0.63, and 0,93 US dollar per liter in Algeria, Tunisia and Morocco respectively).

Additionally, two other factors have substantially contributed in increasing energy consumption in Algeria. First, the rapid increase in Algeria's population growth. The average population growth rate was reported at 1.8 percent from 2006 to 2016 compared to 1.32 percent in Morocco and 1.1 percent in Tunisia. Second, the unprecedented increase of cars import over the last five years, leading to a significant increase in the number of cars on the road in Algeria, from 3 211 052 car in 2005 to 5 986 181 car in 2016, which means more fuel is needed.

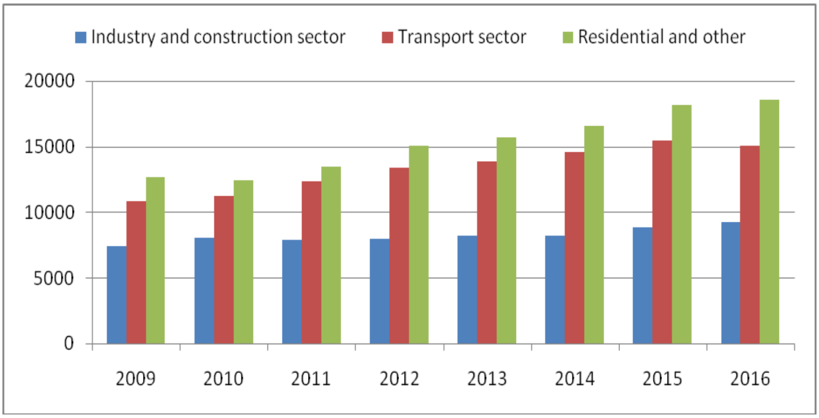
Figure 1. Energy use (kg of oil equivalent per capita)



Source: World Bank Database, World Development Indicators (2017)

The total energy consumption distribution by sector shows that the residential sector is the greatest consumer of energy in Algeria. The figure 2 shows that the household sector and other represent 43 percent of the repartition of the final energy consumption, followed by transport sector (35 percent) and the sector of industry and construction (21 percent).

Figure 2. The final energy consumption by sector



Source: Algeria Ministry of Energy and Mining

The recent significant increase of final energy consumption in the residential sector is partly explained by the raising of electrification and gas penetration rate in Algerian houses. By 2016 Algeria has achieved 100 percent national electricity coverage. As well as, the rate of gas penetration in houses has been reached more than 50 percent in 2016.

In addition, a key variable impacting on energy consumption in the residential sector is the improvements on income per capita (US 4827 Dollar in 2016), which is a sign of improvement in the living standard of Algerian families. Thus, allowing the access of Algerian citizens to more electrical appliances such as refrigeration, clothes washing, air conditioning equipments, central heating, etc, which has greatly contributed in raising on energy consumption.

However, the fast growing of final energy consumption and its economic and environmental cost has pushed the Algerian government to realize the importance of energy conservation and emissions reductions. Algeria has made the reduction of energy consumption a strategic objective. Since 2015, Algeria has launched some energy conservation programs, including a partial reduction of energy prices subsidies. The government has taken step to raise energy prices as part of 2016 budget law corrective measures. The increases is the first in the subsidized prices on fossil fuels products in Algeria in more than decade. In November 2017 Algeria's parliament approved increase in fuel prices for the third year consecutive as part of the 2018 budget law. Thus, new pump price of fuel will be increased next year (2018), reflecting the willingness of the government to reform energy prices.

Algeria launched a renewable energy development program in 2011, in order to limit dependency on fossil resources and reduce green house gases emissions and their adverse impact on the environment. The program consists of generating 22000 MW of renewable energy capacity between 2035-2040, of which 12000MW will be meant for domestic consumption and the rest for export. By 2030, renewable energy is intended to cover 27 percent of the Algerian energy mix.

4. Methodology:

4.1. Econometric Methodology and Data:

Before we proceed to Toda and Yamamoto (1995) causality approach , unit root test is needed to determine the order of integration of the variables, which will determine the maximum number of lags (dmax). We test for unit roots assuming that there are no structural breaks using both Augmented Dickey Fuller (1981) and Philips-Perron

(1988) tests. We also implement Zivot and Andrews (1991) unit root test to deal with the presence of structural breaks.

The co-integration procedure was used to test the existence of long-run equilibrium relationship among the variables .There are many possible tests for this purpose, but the most general of them is the multivariate test based on the vector autoregressive representation of Johansen's maximum likelihood estimation approach (Johansen and Juselius , 1990).

Unlike the traditional Granger (1969) causality test , Toda and Yamamoto (1995) augmented Granger causality test method does not require knowledge of the integration and co-integration properties of the system. This approach can be applied whether a series is I(0) , I(1) or I(2), non co-integrated or cointegrated of an arbitrary order (Toda and Yamamoto,1995) . This technique requires estimation of an augmented VAR (k+dmax) model, where, k is the lag length of the original VAR process, and dmax is the maximum order of integration of the variables in the VAR system. Once this is done, a (k+dmax) order of the VAR is estimated to perform the causality test .The Toda and Yamamoto (1995) technique uses a Modified Wald test for restrictions on the parameters of the augmented VAR (k+dmax) in levels, to ensure an asymptotic distribution of the Wald statistic. In the bivariate case this model can be written as:

$$LGDPPC_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} LGDPPC_{t-i} + \sum_{j=k+1}^{d\max} \alpha_{2j} LGDPPC_{t-j} + \sum_{i=1}^{k} \delta_{1i} LEU_{t-i} + \sum_{j=k+1}^{d\max} \delta_{2j} LEU_{t-j} + \lambda_{1t} \text{........(1)}$$

$$LEU_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i} LEU_{t-i} + \sum_{j=k+1}^{d\max} \beta_{2j} LEU_{t-j} + \sum_{i=1}^{k} \phi_{1i} LGDPPC_{t-i} + \sum_{j=k+1}^{d\max} \phi_{2j} LGDPPC_{t-j} + \lambda_{1t} \text{.......(2)}$$

Finally, the short run analysis is examined through generalized variance decomposition analysis. The Generalized Variance Decomposition Analysis (VDC) apportions the variance of forecast errors in a given variable to its own shocks and those of the other variables in the system .

The variables considered in our models and tests are: the logarithm of GDP per capita (constant LCU), and the logarithm of energy use measured in kg of oil equivalent per capita. The annual data of both variables (LGDPPC and LEU) are available from 1971 to 2016 from World Development Indicators (World Bank, 2018).

4.2. Results and discussions:

As mentioned earlier unit root test is required to obtain the maximum integration order of the variables. We employ ADF, and Phillips-Perron test statistics . We run the test both in level and first differences . The results of unit root tests are reported in tables 1 and 2. In this study, these tests give the same results, namely that each of these series are integrated of order 1. The results for Zivot and Andrew unit root test are presented in Table 3.These results suggest that we cannot reject the null of unit root for all the variables in level at 5 percent significance level. However , the Z-A unit root test shows that the series are stationary in first differences, i.e., the series are I(1).The results of these three tests indicated that the maximum order of integration is equal to one.

Table 1. Augmented Dickey Fuller Unit Root test results

Variables	Augmented Dickey Fuller unit root test				
	Level		First Difference		Decision
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	
LGDPPC	-0.3413	-0.9883	-8.5238***	-8.1809***	I(I)

LEC	-3.9011	-2.9494	-4.9792***	-5.3844***	I(I)
Note: The Augmented Dickey Fuller unit root test was performed both at level and first differenced (intercept, and both the trend and intercept) .The automatic lag selection has set 04 maximum lags by using the Schwarz info criteria (SIC). *, **, *** represents significant at 10%, 5%, and 1%.					

Table 2. Philips-Perron (PP) Unit Root test results

Variables	Philips Perron (PP) Unit Root test				
	Level		First Difference		Decision
	Intercept	Intercept and Trend	Intercept	Intercept and Trend	
LGDPPC	-2.6796	-3.0623	-7.5699***	-7.3555***	I(I)
LEC	-3.9548*	-2.9158	-5.0693***	-5.3723***	I(I)
Note: Philips Perron (PP) Unit Root test was performed both at level and first differenced (intercept, and both the trend and intercept) . The EVeiws 10 has been used for performing the unit root tests with Newey-West using Bartlett Kernel. *, **, *** represents significant at 10%, 5%, and 1%.					

Table 3: Zivot and Andrews (1992) unit root test one-break

Variables	Zivot and Andrews (1992) Unit Root Tes				
	Level		First Difference		Decision
	Z-T statistic	Break Date	Z-T statistic	Break Point	
LGDPPC	-3.765948	1990	-11.86420	1995	I(I)
LEC	-3.189108	2008	-7.806234	1984	I(I)
For the variables we assumed structural break in both intercept and trend. The critical values for Zivot and Andrews (1992) test are -5.57, and -5.08 at 1 % and 5% levels of significance respectively.					

In the second step we select the optimal lag length, K, using the Akaike (AIC) information criterion considering a maximum of four lags. The lag 3 was determined on the basis of AIC. For the optimal k selected, the diagnostic testing of VAR model for autocorrelation and stability were performed and results are presented in tables 4, 5 and figure 3.As can be seen from the results, serial correlation of residuals in model are absent, and the model is stable .

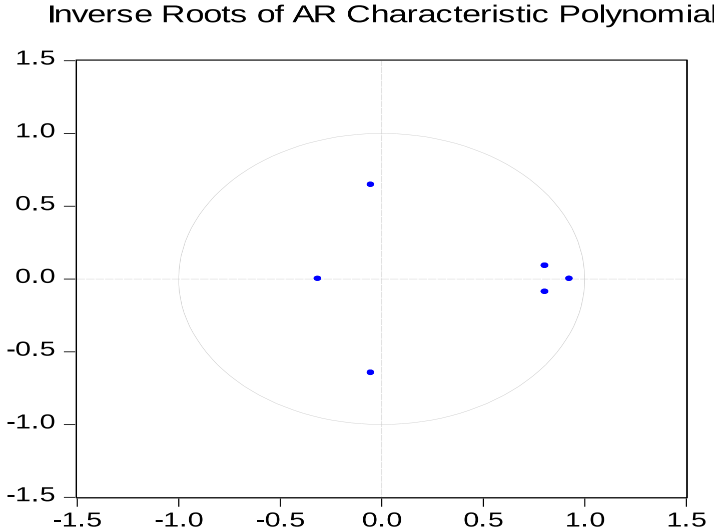
Table 4. VAR Residual Serial Correlation LM Tests

Lags	LM-Statistics	P-value
1	1.029422	0.9053*
2	1.152760	0.8858*
3	2.034274	0.7295*
**Denotes acceptance of null hypothesis (Ho: There is no serial correlation),		

Table 5. Roots of Characteristics Polynomial

Roots of Characteristic Polynomial Endogenous variables: GDPPC EU	
Root	**Modulus**
0.927946	0.927946
0.806432 - 0.090011i	0.811439
0.806432 + 0.090011i	0.811439
-0.049815 - 0.644942i	0.646863
-0.049815 + 0.644942i	0.646863
-0.312480	0.312480
No root lies outside the unit circle. VAR satisfies the stability condition.	

Figure 3. Roots of Characteristics Polynomial



Since all series are integrated of order one , cointegration can be investigated using the Johansen cointegration approach . Johansen and Juselius (1990) develop two test statistics: Trace statistics (λtrace) and maximum eigenvalue statistic (λmax). The cointegration tests were carried out by testing k=3.

The results in table 6 show that both the trace and the maximum eigenvalue statistics indicate the presence of one cointegrating vector at 5 % significant level . We therefore conclude that there is a long run relationship between GDP per capita and energy consumption.

Table 6. Johansen Cointegration test results

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.319918	16.49691	15.49471	0.0352
At most 1	0.026522	1.075217	3.841466	0.2998
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.319918	15.42170	14.26460	0.0327
At most 1	0.026522	1.075217	3.841466	0.2998
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				

After finding the long run relationship between the variables of our model based on johansen-Juseluis (1990) cointegration test , in what follows we proceed with Toda Yamamoto approach to test for granger causality. To conduct T and Y causality test we have determined the maximum order of integration (d) to be one, and the optimal lag length (k) based on Akaike information criterion to be three. The results of the causality are estimated through MWALD test and reported in table 7.

Table 7. Toda-Yamamoto Granger Causality Test (Modified Wald Test)

From (Dependent Variable)	**To (Independent Variable)**	**F- Statistics M. Wald Statistics**	**P-Value**	**Causality Direction**
EU	GDPPC	2.455826	0.4833	EU≠> GDPPC
GDPPC	EU	6.480567	0.0904*	GDPPC => EU
*Note: ** and * denotes the significance at 5 and 10% level respectively.*				

The MWALD statistic test results in table 7 reveal that, at 10 percent significance level, GDP per capita Granger causes the energy consumption in the long run, but energy consumption does not Granger cause GDP per capita in the long run in Algeria. That is, an increase in GDP brings about an increase in energy consumption. However, higher consumption of energy is not likely to directly influence economic activity, which is an unexpected result, given the fact that energy prices are heavily subsidized in Algeria. In other words, the T and Y causality test support the conservation hypothesis between economic activity and energy use in Algeria.

As can be seen from the results of variance decomposition between GDP growth and energy consumption in table 8, the variance in GDP per capita is explained by its own variance , which accounts for approximately 99% in the five year period. This states that economic growth leads to increasing demand for energy use in Algeria. It can also be noticed from the table 8 , that GDP growth explains about 10 percent of the changes in energy consumption in the first year period, and more than 50 percent in the five year period. This implies that there is a unidirectional causality from economic growth to energy consumption in the context of Algeria. This result also confirms Toda and Yamamoto Granger causality test reported above. It also indicates that energy conservation policies aimed at reducing energy consumption will have a little effect on economic growth.

Table 8. Variance decomposition

Variance Decomposition of GDPPC			
Period	**S.E.**	**GDPPC**	**EU**
1	0.024074	100.0000	0.000000

2	0.041259	99.99509	0.004907
3	0.057609	99.30023	0.699766
4	0.072580	99.44189	0.558114
5	0.087397	99.58237	0.417631
Variance Decomposition of EU			
Period	**S.E.**	**GDPPC**	**EU**
1	0.050534	**8.926226**	**91.07377**
2	0.066294	**21.32335**	**78.67665**
3	0.072097	**31.07769**	**68.92231**
4	0.079488	**39.42113**	**60.57887**
5	0.090438	**47.18033**	**52.81967**

5. Conclusion and policy implications:

The aim of this paper was to analyze the long run causality relationship between GDP per capita and energy consumption in Algeria, and the implications to the effects of phasing out energy subsidy on the Algerian economy over the period 1971-2016. We used the Toda and Yamamoto's (1995) approach in testing causality.

The results of the analysis suggest a unidirectional causality running from GDP per capita to energy consumption. This result implies that an energy conservation policy may not harm the economic growth in Algeria. This in turn implies that, in the short term, energy conservation policy geared at phasing out energy prices subsidy can be a good opportunity for the government to reduce the fiscal cost and the unequal benefits of subsidies. In the long term, Algeria could pursue the conservation energy policy aimed at promoting generating power from renewable energy such as solar and wind power, in order to contribute to curb green house gas emissions, while promoting energy efficiency.

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