The consumption of petroleum products by the transport sector in Algeria: Should we think about the transition to electric cars?

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Abstract:

Through this study, the evolution of petroleum products consumption by the transport sector in Algeria was followed in order to arrive to forecast the future consumption levels. The empirical study applied time series analysis method (ARIMA models) and arrived to develop forecasts of consumption by 2030. This future consumption has been shown to increase steadily and controllable in the event that the evolution will continue at the same current rate. However, it is recommended to start the transition to electric cars for environmental reasons.

Key words: consumption of petroleum products, transport sector, forecast, Algeria.
Jel Classification Codes :Q42, Q43, Q47, O13, P17.

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استهلاك المنتجات البترولية من طرف قطاع النقل في الجزائر: هل يجب أن نفكر في الانتقال إلى السيارات الكهربائية ؟

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ملخص:

من خلال هذه الدراسة تم متابعة تطور استهلاك قطاع النقل للمنتجات البترولية في الجزائر وذلك بغية الوصول إلى تقديرات دقيقة لمستويات الاستهلاك المستقبلي. اعتمدت الدراسة القياسية على أسلوب تحليل السلاسل الزمنية (نماذج ARIMA) وتوصلت إلى تقدير الاستهلاك في غضون 2030 والذي تبين أنه سيعرف زيادة منتظمة يمكن التحكم فيها في حال استمرار الوثيرة على ما هي عليه الآن. إلا أنه مع ذلك يوصى ببداية التفكير في الانتقال للسيارات الكهربائية وذلك لاعتبارات بيئية.

الكلمات المفاتيح: استهلاك المنتجات البترولية، قطاع النقل، التنبؤ، الجزائر.

التصنيف JEL: Q42، Q43، Q47، O13، P17.

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I- Introduction:

Total national energy consumption in Algeria stood at 65 MTOE (Million Ton of Oil Equivalent) in 2018. It represents more than a third (39.3%) of total production.Final energy consumption reached 48.1 MTOE broken down as follows: 10.5 MTOE (21.82%) for industry, buildings and public works; 15.3 MTOE (31.8%) for transport and 22.4 MTEP (46.56%) for households and others(bilan énergétique national 2018, 2019).

Therefore, the transport sector accounts for roughly a third of final national energy consumption. The question that arises is the following:

What will be the evolution of the consumption of petroleum products by the transport sector in Algeria by the year 2030? And are we forced to make a transition to electric cars to cope with this development?

This problem implies two hypotheses:

The first one assumes that with the revival of the vehicle market and the reopening of imports; Algeria's car fleet will be expanded causing much greater demand,this rapid growth will force policy-makers to take appropriate policy decisions to effectively reduce energy use by Algerian transportation sector. There are several alternatives available: diversification in the modes of transport, the replacement of conventional vehicles (powered by gasolineand diesel) with electric vehicle zero and low emission that is widely identified also as a solution to the problem of Co_2 emissions.

In the second, it is assumed that the state maintains restrictions on the importation of vehicles, which will limit the expansion of the national fleet of automobiles, implying moderate growth in the consumption of petroleum products. This solution saves time so that Algeria can increase its electricity production capacities and meet the future demand for this type of energy.

In this context, this study aims to forecast the future consumption of petroleum products by the transport sector in Algeria in order to build a vision on the latter (consumption) in the 2030 horizon.

The technique used was time series analysis (ARIMA models) and the study was based on the "IMRAD" method which is most suitable in this kind of empirical study. The presentation is divided into four parts: introduction which covers the problem and the objectives of this work, methods: in which is exposed the methodology of the work and the statistical techniques used, results and discussion: covers the estimates of consumption and the analysis of the results and finally a conclusion which brings together the most important recommendations.

I-1- Some data about the transport sector in Algeria:

Road transport in Algeria represents 85% of the total internal transportation, so it is the most used mode of transport by travelers. The National vehicle Park reached 6418212 cars at the end of the year 2018 compared to 6162542 cars at the end of 2017, recording an increase of 255670 units, or about (4.15%).

In Algeria, the national vehicle park has almost tripled in 20 years, going from (2.7) million to more than (6.5) million vehicles from 1997 to 2018, i.e. a growth rate of (140.74%). this increased growth in the park is the cause of many negative externalities, namely pollution and increased consumption of fuels.

With regard to dividing the national vehicle park according to categories, we find that the park consists of 4151041 tourist cars (64.68%), 1204552 small trucks (18.77%), 421689 trucks (6.57%) and 164477 agricultural tractors (2.56%) and 139,780 motorcycles (2.18%). The park also contains 154,243 trailers (2.40%) and 87,968 buses (1.37%).

The share of the gasoline energy source is the most important, ie 65.04%, compared to the diesel energy source which is 34.96% which represents about a third of the national automobile fleet.

An exceptional effort was made by the state during the period (1999-2017) to bring the necessary dynamics to the transport sector so that it can play its natural role of engine of growth thanks to the integration of the different modes of transport. Road, rail and maritime transport.

Investment in the railway sub-sector has enabled modernization and considerable development at the national level, in particular through the doubling of the northern bypass, the creation of the highland bypass, also the penetrating ones: Oran / Béchar, Annaba / Touggourt realization line connecting: Constantine / Hassi Messaoud, Ghardaia / Adrar / Bechar, El Menia / Ain Salah / Tamanrasset, Béchar / Tindouf and Hassi Messaoud / Illizi.

Regarding the national rail network, it was 1769 km in 1998 connecting only the wilayas of the north, at the end of 2012, it multiplied by two arrivals to almost 3,919 km of rail line and which also serves some wilaya in the south such as Bechar and Ouargla. In 2017, the network exceeded 6,000 km connecting several wilayas in the north and south of Algeria. By 2015, the state plans to achieve 12,500 exploitable linear km, thus creating a rail network that connects all the Algerian wilaya.

For investment in the road and motorway sub-sector, the Algerian state has allocated a substantial budget for the development and construction of infrastructure at the national level, communal road, wilaya road, national road, east-west motorway. And north-south highway.

We can quote in this context some statistics of realization, for the national roads moderately the period (2000-2017), paved and unpaved (new realization and maintenance of the already existing heritage) is of 29,905 km, for the paved only is of 25,960 Km.

For the average wilaya roads in the same period is 24,127 km, the average communal roads is 59,918 km. The consistency of the realization of the east-west highway that was issued at the end of 2012 is 1059 km.

The maritime sub-sector, and in particular maritime and port infrastructures, constitute the greatest challenge and the major concern of the Algerian state, given its place in the economy. 95% of foreign trade transits by sea, mainly 98% of hydrocarbons. Algeria has a coastline of more than 1280 km and a port infrastructure comprising 46 ports in service, including 11 mixed trade ports (trade, fishing and hydrocarbons), two ports specializing in hydrocarbons (Skikda and Béthioua) , 31 harbors and fishing shelters including six inside commercial ports, a marina in Sidi Fredj and 200 maritime traffic lights.

The airport sub-sector, by virtue of its primordial role in the development of any country as well as its specificity, necessitates a permanent search for its modernization, something which results in the readjustment of airport pavements to new aircraft technologies.

The projects selected during the 2010-2014 five-year period are distinguished by several actions, recommended within the framework of various projects, whose work is identified as follows: 14 reinforcement projects at the aerodromes of: Adrar, Timimoun, Béchar, Tébessa , Tiaret, Algiers, Jijel, Annaba, Oran, Ouargla, Illizi and Ain Amenas, Tindouf and El Menia. A rehabilitation project: Mostaganem aerodrome, two parking extension projects at El Menia and Annaba aerodromes, a runway extension project at Sétif aerodrome, three projects for the completion of ends of hydraulic concrete runways at the aerodromes of: Adrar, Bordj Badji Mokhtar, Chlef, Biskra, Tamenrasset, Elbayadh. Three projects dealing with the protection of platforms and the remediation of aerodromes in: Béjaia, Jijel and Tébessa. Algeria seeks through these efforts to diversify the transport sector on the one hand, and on the other hand to seek more efficient and less harmful means for the environment.

I-2- Previous studies:

There are few studies that have addressed this issue, we cite some ones:

In a paper published at the revue "transportation research", the impact of transport energy consumption and transport infrastructure on economic growth was investigated using panel data on MENA countries (the Middle East and North Africa region) for the period (2000-2016). Using the generalized method of moments (GMM), the study finds that transport energy consumption significantly adds to economic growth in MENA countries, and the Dumitrescu-Hurlin panel causality analysis shows the feedback effect of transport energy consumption and transport infrastructure with economic growth(SAIDI, SHAHBAZ, & AKHTAR, The long-run relationships between transport energy consumption, transport infrastructure and economic growth in MENA countries, 2018).

In another paper published at the revue "Energy", the study analyses data from 18 Asian countries spanning from 1980 to 2017 to determine panel long-run causality between income growth, transport energy consumption and environmental quality. A bi-directional long-run Granger causality between transport energy consumption, environment and GDP growth is found (NASREEN, BEN MBAREK, & ATIQ-UR-REHMAN, 2020).

II- Methods:

Through the annual energy balances for Algeria,The data related to the consumption of petroleum products by the transport sector were collected for the period between 1980 and 2018 in unitsKilotons of Oil Equivalent (KTOE).

A time series containing 39 observations was obtained and was statistically processed using the (Eviews) program. The time series analysis began with a study of stationnarity based on the Augmented Dickey-Fuller tests, it was found that the series was not stationary; to get rid of this problem the first differences were used.

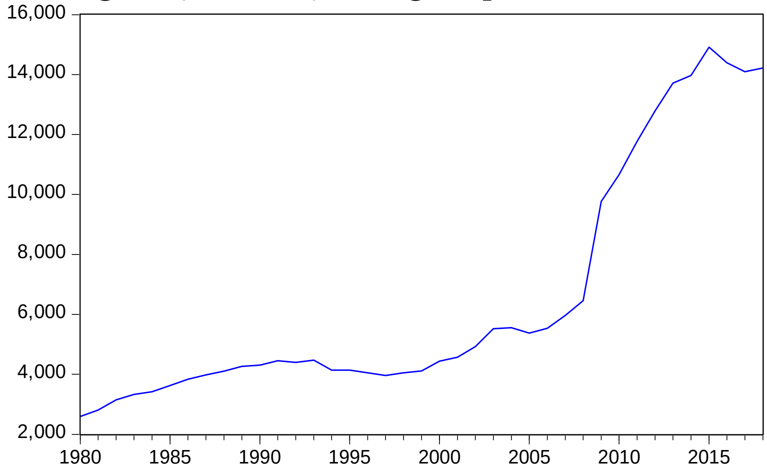
The examination of the simple and partial autocorrelation functions gives several possibilities of ARIMA models: ARIMA(0,1,0), ARIMA(1,1,0), ARIMA(0,1,2), ARIMA(1,1,2). We estimated all these models and selected the one most representative of them.

The results showed that the most representative model of the consumption of petroleum products by the transport sector in Algeria is ARIMA (1,1,0). Therefore, we used this model to estimate the future consumption in 2030 horizons.

II-1- Study of stationarity:

We are going to study the consumption of petroleum products by the transport sector ($transp$) over the period 1980 to 2018, that is to say 39 annual observations. Graph (01) illustrates the evolution of consumption.

Figure n° 1: evolution of the consumption of petroleum products by the transport sector in Algeria (in KTOE) during the period 1980 - 2018.



Source: developed by the author using data from the annual energy balances of Algeria

The simple and partial autocorrelation functions, for $h = 16$ lags, are represented in table (01):

Table n°1: autocorrelation functions

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.925	0.925	35.985	0.000
		2	0.838	-0.116	66.364	0.000
		3	0.737	-0.150	90.468	0.000
		4	0.618	-0.164	107.94	0.000
		5	0.505	-0.020	119.94	0.000
		6	0.392	-0.057	127.40	0.000
		7	0.284	-0.046	131.43	0.000
		8	0.188	-0.005	133.26	0.000
		9	0.106	0.006	133.87	0.000
		10	0.033	-0.041	133.93	0.000
		11	-0.001	0.183	133.93	0.000
		12	-0.031	-0.059	133.98	0.000
		13	-0.056	-0.072	134.18	0.000
		14	-0.080	-0.085	134.59	0.000
		15	-0.107	-0.060	135.36	0.000
		16	-0.133	-0.034	136.59	0.000

Source: developed by the author using Eviews software

Table (01) provides the results of the simple autocorrelation function (column AC) and partial autocorrelation function (column PAC), with the respective correlograms. We notice that until the lag h = 6 the terms of the partial autocorrelation are outside the confidence interval. We also note that the autocorrelations decrease very slowly. So the process is not a white noise, it even seems to be a non-stationary process.

The Ljung-Box Q statistic confirms this fact, the critical probability of this test is indicated $\alpha_c = 0.000 < 0.05$ so we reject the hypothesis H_0 of nullity of the coefficients ρ_k. The process $(transp)$ is not white noise.

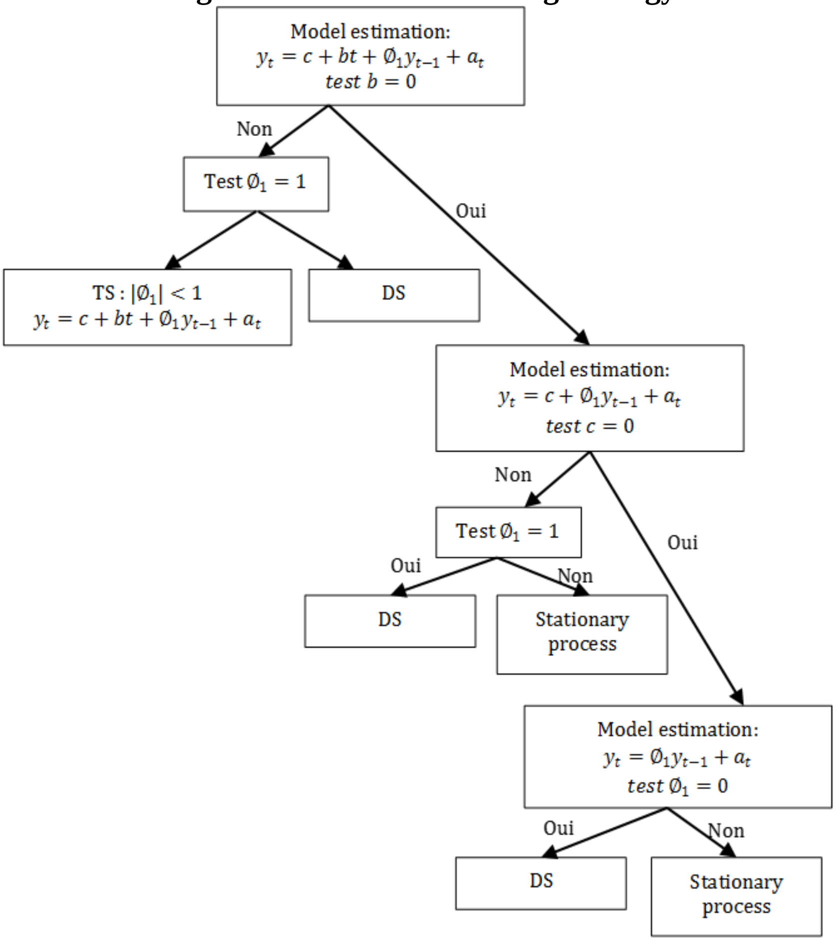
From the "Dickey-Fuller Augmented" tests(DICKEY & FULLER, 1981) we will examine whether the process is non-stationary and this following the strategy of unit root tests represented by figure (01). The Augmented Dickey-Fuller test consists of estimating the following three models(BOURBONNAIS, 2007):

$\Delta X_t = \rho X_{t-1} - \sum_{j=2}^{p} \emptyset_j \, \Delta X_{t-j+1} + c + bt + \varepsilon_t$ Model (1) : autoregressive model with trend and constant

$\Delta X_t = \rho X_{t-1} - \sum_{j=2}^{p} \emptyset_j \, \Delta X_{t-j+1} + c + \varepsilon_t$ Model (2) : autoregressive model with constant

$\Delta X_t = \rho X_{t-1} - \sum_{j=2}^{p} \emptyset_j \, \Delta X_{t-j+1} + \varepsilon_t$ Model (3) : autoregressive model without trend and constant

Figure n° 2: Unit root testing strategy



Source : Régis Bourbonnais, « Econométrie », 6e édition, Dunod, Paris,2007, p 234.

The ADF tests for the time series ($transp$)leads to the results shown in Table 2 (for detailed results see appendix 01):

Table n°2: the unit root tests($transp$)

Hypothesis H_0: $transp$ has a unit root		
Number of lags (minimum of Schwarz criterion) = 1		
Test ADF	t Statistic	Prob
Model [1]	-1.266320	0.8808
Model [2]	0.280040	0.9740
Model [3]	1.632903	0.9728

Developed by the author based on the results from Appendix 01

The critical probabilities are all greater than 0.05 we do not reject the hypothesis H_0 so we can conclude that the process $(transp)$ has a unit root and is therefore not stationary.

The OLS estimation of the parameters of model (1) has shown that the coefficient of the trend line is not significantly different from 0, therefore we reject the hypothesis of a TS (Trend Stationary) process. So $(Transp)$ represents a DS (Differency Stationary) process.

To get rid of the problem of non stationarity, we must proceed to the first differences(BOURBONNAIS & TERRAZA, 2004):

$$dtransp_t = transp_t - transp_{t-1}$$

Next, we will examine the new process $(dtransp)$ through the simple and partial autocorrelation functions supplemented by the unit root tests. Table (03) represents the values of the autocorrelation functions and table (04) collects the unit root tests:

Table n°3: autocorrelation functions $(dtransp)$

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.356	0.356	5.2062	0.023
		2	0.346	0.251	10.268	0.006
		3	0.209	0.034	12.171	0.007
		4	0.071	-0.097	12.394	0.015
		5	-0.076	-0.168	12.663	0.027
		6	0.126	0.231	13.413	0.037
		7	-0.170	-0.227	14.830	0.038
		8	-0.144	-0.133	15.884	0.044
		9	-0.016	0.166	15.898	0.069
		10	-0.023	0.078	15.927	0.102
		11	-0.002	0.022	15.927	0.144
		12	-0.036	-0.254	16.004	0.191
		13	-0.099	-0.027	16.604	0.218
		14	-0.133	0.034	17.723	0.220
		15	-0.182	-0.220	19.902	0.176
		16	-0.127	0.020	21.022	0.178

Source: developed by the author using Eviews software

Table n°4: the unit root tests$(dtransp)$

Hypothesis H_0: $dtransp$ has a unit root		
Number of lags (minimum of Schwarz criterion) = 1		
Test ADF	t Statistic	Prob
Model [1]	-4.259014	0.0092
Model [2]	-4.069385	0.0031
Model [3]	-2.140103	0.0328

Developed by the author based on the results from Appendix 01

The critical probabilities of the ADF tests are all less than (0.05) so the process $(dtransp)$ is stationary and the consumption of petroleum products by the transport sector in Algeria can be represented by an ARIMA model.

The examination of the simple and partial autocorrelation functions gives several possibilities of ARIMA models: ARIMA(0,1,0), ARIMA(1,1,0), ARIMA(0,1,2), ARIMA(1,1,2). We have to estimate all these models and select the one most representative of them(Dor, 2009).

II-2- Model estimate:

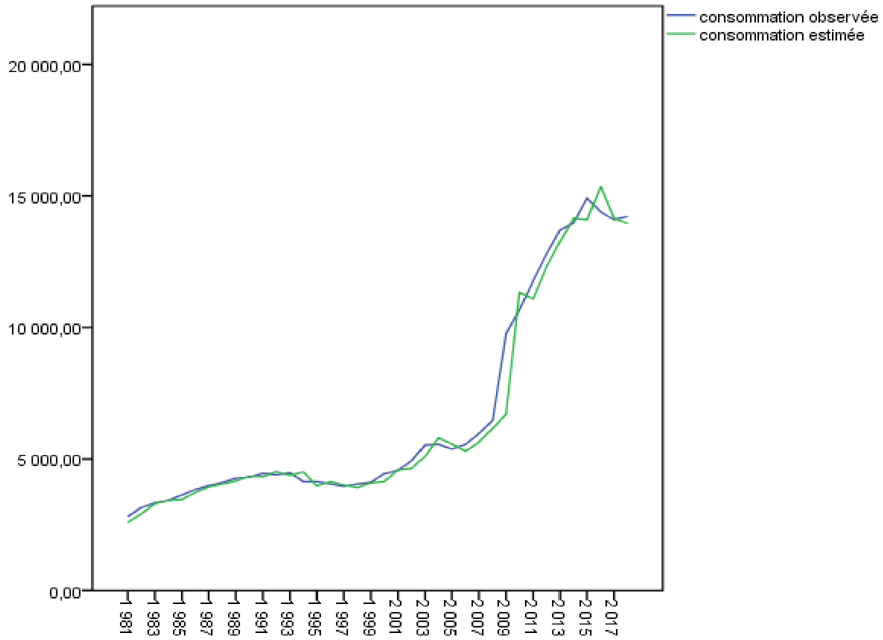
We estimate the following models:
Model (1): ARIMA(0,1,0) $transp_t = transp_{t-1} + \mu + \varepsilon_t$
Model (2): ARIMA(1,1,0) $dtransp_t = \varphi_1 dtransp_{t-1} + \varepsilon_t$
Model (3): ARIMA(0,1,2) $dtransp_t = \mu + \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2}$
Model (4): ARIMA(1,1,2) $dtransp_t = \mu + \varphi_1 dtransp_{t-1} + \varepsilon_t - \theta_1\varepsilon_{t-1} - \theta_2\varepsilon_{t-2}$

The estimation results of the models using the Eviews software are provided in appendix (02). We can see from the estimation results that for the model (1) the value of the constant coefficient is significant while the value of AIC (Akaike information creterion) is (15.72).

For model (2) the value of criterion (AIC) is (15.70) and the coefficient (θ_1) is significant. For the model (3) AIC is equal to (15.64) and the two coefficients (μ) and (θ_1) are not significant.

And for the model (4) AIC is equal to (15.68) but all the coefficients are not significant. Finally we can conclude that the model (2) is the most representative model of the consumption of petroleum products by the transport sector in Algeria. This choice is confirmed by the graphical representation of the two curves: observed consumption, estimated consumption using model 2.

Figure n° 3: graphical representation of observed consumption and estimated consumption of petroleum products by the transport sector in Algeria



Source: Developed by the author using SPSS software

II-3- Suitability of the model:

The coefficient for AR (1) is significantly different from 0. The other empirical statistics suggest a good fit. It is now necessary to analyze the residual from its autocorrelation function.

The correlogram of the residuals (see appendix 03) shows that no term is outside the two confidence intervals and the Q statistic has a critical probability much greater than (0.05) whatever the lag. The residue can be likened to a process of white noise.

The estimate of the ARIMA model (1,1,0) is therefore validated, the consumption of petroleum products by the transport sector in Algeria can be validly represented by an ARIMA type model (1,1,0).

III- Results and discussion:

Using the estimated equation of the ARIMA model (1,1,0), the forecasts of the consumption of petroleum products by the transport sector (in KTOE) are provided by the following table:

Table n° 5: forecasts of consumption of petroleum products by the transport sector in Algeria for the period (2019 – 2026)

Year	Consumption	Year	Consumption
2019	14283,553471	2023	14338,250799
2020	14313,386776	2024	14339,897052
2021	14327,846173	2025	14340,694946
2022	14334,854173	2026	14341,081663

Developed by the author using the estimated model

From the values in table (05) we note that the consumption of petroleum products by the transport sector in Algeria increases each year with increasingly smaller increases, for example the increase during the year (2020) is (29.83) compared to the year (2019) and the increase of the year (2021) is (14.46), while that of (2022) is (7.008). This slowed increase can be explained by the import constraints of new vehicles while the increase in consumption remains equally important in such a situation of the vehicle market in Algeria.

We can conclude that if the import constraints of vehicles will be maintained, the situation of consumption of petroleum products by the transport sector will be brought under control. And this because the increase will not be accelerated.

Regarding the automotive industry in Algeria, several projects are being studied and if these projects will be realized, the production of automobiles will cause a significant increase in the national park which will generate a significant increase in consumption of energy.

The transport sector is also a major emitter of air pollutant and greenhouse gas (GHG) emissions. In 2017, transport was responsible for about 24 % of word wide Co_2 emissions. 8 gigatonnes of Co_2emitted by transport globally (International Energy Agency IEA, 2019).

The United Nations Framework convention on climate change highlighted the critical role transport plays in the context of climate change.

To reduce these negative externalities, many countries in the word has put forth policies to encourage the adoption of alternative fuels vehicles, plug-in electric vehicle (PEVs) in particular, PEVs include pure battery vehicles (BEVs) and plug-in hybrid vehicles (PHEVs).

Therefore Algeria must think as of now about the introduction of electric cars and especially that the automobile manufacturers operate profound changes to respond to the challenges of globalization and societal evolutions, the basic question of energy and technologies of automotive traction becomes essential and strategic(MARTINET & MACAUDIERE, 2011).

Ensuring energy security, mitigating climate change, and mitigating urban-air pollution are increasingly included in government agendas, and the transportation sector significantly contributes to these problems.

One of the many actions taken by governments to address these issues is the formulation of public policies related to the diffusion and adoption of electric vehicles.

Sustainable transportation considers three dimensions: economic development, environmental preservation, and social development.One of the objectives that is being focused on by sustainable transportation is the car-ownership transition to ultra-low-emission and zero-emission vehicles.

In Algeria, transport accounts for roughly a third of final national energy consumption. This consumption increased by (2.6%) in 2018 compared to 2017.This increase is mainly driven by that of road fuels as shown in the following table:

Table n° 6: energy consumption in the "transport" sector

Unit: KTOE Transport including:	2017	2018	Evolution %
Road fuel	14138	14342	1.4
Aviation fuel	496	608	22.6
Sum of consumption in the "transport" sector	14895	15281	2.6

Source: national energy balance 2018

Numerous studies have shown that the use of traditional fossil fuels lead to economic growth. However, the excessive utilization of non-renewable resources emits a high quantity of Co2 into environment(SHAHBAZ, CHANDRASHEKAR, KRISBNA REDDY, ZHILUN, & XUAN, 2020).

The reduction of global greenhouse gas emissions has become the main global objective of a sustainable environment.Owing to increasing Co_2 emissions and energy consumption, environmental economists and policy analysts shifted their attention toward the use of renewable energy rather than traditional energy consumption.and among the solutions in the transport sector there is the transition to electric cars which has been very successful in recent years in developed countries which is not the case in Algeria which has not yet done any step in that sense.

Stimulated by technological innovation and the need to reduce oil demand and emissions in the transport sector, alternative powertrains have been introduced in the vehicle market. Since 2011, electric vehicles (EVs) have been gaining traction in the global car market. Accompanying the EV market development, various methods have been applied by the research community to investigate this new technology.

The replacement of conventional vehicles (powered by gasoline and diesel) with zero- and low-emission vehicles is widely identified as a solution to Sustainable transportation problems.

A step towards cleaner transport was the declaration on electro-mobility signed by 44 countries, 5 regions/cities and 32 international and non-governmental organizations(COP24, 2018).

IV-Conclusion:

The transport has a great place among the main consumers of energy, furthermore among the main sources of pollutant gases (SORELL, LEHTONEN, STAPLETON, PUJOL, & CHANAPION, 2009). Moreover, the transport has an important role in the economic growth in all countries (FEDDERKE, PERKINS, & LUIZ, 2006). Several academics argue that the transport in the backbone of the economic development and its role is indispensable for the production activity and commercial exchanges between countries (SAIDI & HAMMANI, 2017).

In Algeria, it is necessary to adopt some options which can reduce the transport intensity and ameliorate the energy efficiency. These options allow a greater positive role of transport in the economic activity.

Also a set of instruments such as economic, fiscal, regulatory and technological should be applied by the government to control driving factors of economic growth related to transport, energy consumption and gas emissions.

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Appendices:

Appendix 01: ADF tests

ADF tests for the time series ($transp$)
Model (1) :

Null Hypothesis: TRANSP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.266320	0.8808
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TRANSP)
Method: Least Squares
Date: 06/28/20 Time: 19:57
Sample (adjusted): 1982 2018
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TRANSP(-1)	-0.061400	0.048487	-1.266320	0.2143
D(TRANSP(-1))	0.333252	0.166307	2.003837	0.0534
C	15.55229	206.1110	0.075456	0.9403
@TREND("1980")	29.30166	17.05739	1.717828	0.0952

R-squared	0.200573	Mean dependent var	308.5405
Adjusted R-squared	0.127898	S.D. dependent var	628.5656
S.E. of regression	586.9949	Akaike info criterion	15.68972
Sum squared resid	11370581	Schwarz criterion	15.86387
Log likelihood	-286.2597	Hannan-Quinn criter.	15.75111
F-statistic	2.759853	Durbin-Watson stat	2.190278
Prob(F-statistic)	0.057666		

Model (2) :

Null Hypothesis: TRANSP has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.280040	0.9740
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

***MacKinnon (1996) one-sided p-values.**

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TRANSP)
Method: Least Squares
Date: 06/28/20 Time: 19:59
Sample (adjusted): 1982 2018
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TRANSP(-1)	0.007777	0.027770	0.280040	0.7811
D(TRANSP(-1))	0.340055	0.170963	1.989056	0.0548
C	152.5716	195.4281	0.780704	0.4404

R-squared	0.129086	Mean dependent var	308.5405
Adjusted R-squared	0.077856	S.D. dependent var	628.5656
S.E. of regression	603.6010	Akaike info criterion	15.72131
Sum squared resid	12387363	Schwarz criterion	15.85192
Log likelihood	-287.8442	Hannan-Quinn criter.	15.76736
F-statistic	2.519731	Durbin-Watson stat	2.158918
Prob(F-statistic)	0.095406		

Model (3) :

Null Hypothesis: TRANSP has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		1.632903	0.9728
Test critical values:	1% level	-2.628961	
	5% level	-1.950117	
	10% level	-1.611339	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(TRANSP)
Method: Least Squares
Date: 06/28/20 Time: 20:01
Sample (adjusted): 1982 2018
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
TRANSP(-1)	0.025618	0.015689	1.632903	0.1115
D(TRANSP(-1))	0.333543	0.169804	1.964277	0.0575

R-squared	0.113474	Mean dependent var	308.5405

Adjusted R-squared	0.088145	S.D. dependent var	628.5656
S.E. of regression	600.2243	Akaike info criterion	15.68502
Sum squared resid	12609424	Schwarz criterion	15.77210
Log likelihood	-288.1729	Hannan-Quinn criter.	15.71572
Durbin-Watson stat	2.140538		

ADF tests for the time series ($dtransp$):

Model (1) :

Null Hypothesis: DTRANSP has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.259014	0.0092
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DTRANSP)
Method: Least Squares
Date: 06/28/20 Time: 20:22
Sample (adjusted): 1982 2018
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DTRANSP(-1)	-0.703561	0.165193	-4.259014	0.0002
C	-10.87000	206.8642	-0.052547	0.9584
@TREND("1980")	11.36210	9.584470	1.185470	0.2441

R-squared	0.348122	Mean dependent var	-2.378378
Adjusted R-squared	0.309776	S.D. dependent var	712.7881
S.E. of regression	592.1822	Akaike info criterion	15.68311
Sum squared resid	11923111	Schwarz criterion	15.81373
Log likelihood	-287.1375	Hannan-Quinn criter.	15.72916
F-statistic	9.078506	Durbin-Watson stat	2.118711
Prob(F-statistic)	0.000693		

Model (2) :

Null Hypothesis: DTRANSP has a unit root
Exogenous: Constant
Lag Length: 0 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-4.069385	0.0031
Test critical values:	1% level	-3.621023	
	5% level	-2.943427	
	10% level	-2.610263	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DTRANSP)
Method: Least Squares
Date: 06/28/20 Time: 20:24
Sample (adjusted): 1982 2018
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DTRANSP(-1)	-0.643214	0.158062	-4.069385	0.0003
C	197.6091	109.5571	1.803708	0.0799

R-squared	0.321178	Mean dependent var	-2.378378
Adjusted R-squared	0.301783	S.D. dependent var	712.7881
S.E. of regression	595.6014	Akaike info criterion	15.66956
Sum squared resid	12415934	Schwarz criterion	15.75664
Log likelihood	-287.8868	Hannan-Quinn criter.	15.70026
F-statistic	16.55989	Durbin-Watson stat	2.179993
Prob(F-statistic)	0.000255		

Model (3) :

Null Hypothesis: DTRANSP has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=1)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.140103	0.0328
Test critical values:	1% level	-2.630762	
	5% level	-1.950394	
	10% level	-1.611202	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DTRANSP)

Method: Least Squares
Date: 06/28/20 Time: 20:25
Sample (adjusted): 1983 2018
Included observations: 36 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DTRANSP(-1)	-0.351412	0.164203	-2.140103	0.0396
D(DTRANSP(-1))	-0.325844	0.162466	-2.005616	0.0529

R-squared	0.338732	Mean dependent var	-6.000000
Adjusted R-squared	0.319283	S.D. dependent var	722.5537
S.E. of regression	596.1470	Akaike info criterion	15.67280
Sum squared resid	12083304	Schwarz criterion	15.76078
Log likelihood	-280.1105	Hannan-Quinn criter.	15.70351
Durbin-Watson stat	2.054940		

Appendix (2) : estimation results

Model(1) :

Dependent Variable: TRANSP
Method: Least Squares
Sample (adjusted): 1981 2018
Included observations: 38 after adjustments
TRANSP=TRANSP(-1)+C(1)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	306.0789	100.6096	3.042245	0.0043

R-squared	0.976154	Mean dependent var	6664.500
Adjusted R-squared	0.976154	S.D. dependent var	4016.253
S.E. of regression	620.1990	Akaike info criterion	15.72392
Sum squared resid	14231931	Schwarz criterion	15.76702
Log likelihood	-297.7545	Hannan-Quinn criter.	15.73925
Durbin-Watson stat	1.285182		

Model (2) :

Dependent Variable: DTRANSP
Method: Least Squares
Sample (adjusted): 1982 2018
Included observations: 37 after adjustments
Convergence achieved after 2 iterations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AR(1)	0.484673	0.145621	3.328312	0.0020

R-squared	0.045937	Mean dependent var	308.5405
Adjusted R-squared	0.045937	S.D. dependent var	628.5656
S.E. of regression	613.9588	Akaike info criterion	15.70439

Sum squared resid	13570036	Schwarz criterion	15.74793
Log likelihood	-289.5312	Hannan-Quinn criter.	15.71974
Durbin-Watson stat	2.309559		
Inverted AR Roots	.48		

Model (3)

Dependent Variable: DTRANSP
Method: Least Squares
Sample (adjusted): 1981 2018
Included observations: 38 after adjustments
Convergence achieved after 35 iterations
MA Backcast: 1979 1980

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	300.1100	149.3074	2.010015	0.0522
MA(1)	0.059133	0.142935	0.413704	0.6816
MA(2)	0.537077	0.143015	3.755388	0.0006

R-squared	0.164875	Mean dependent var	306.0789
Adjusted R-squared	0.117154	S.D. dependent var	620.1990
S.E. of regression	582.7382	Akaike info criterion	15.64901
Sum squared resid	11885435	Schwarz criterion	15.77829
Log likelihood	-294.3312	Hannan-Quinn criter.	15.69501
F-statistic	3.454958	Durbin-Watson stat	1.737829
Prob(F-statistic)	0.042722		
Inverted MA Roots	-.03+.73i	-.03-.73i	

Model (4)

Dependent Variable: DTRANSP
Method: Least Squares
Sample (adjusted): 1982 2018
Included observations: 37 after adjustments
Convergence achieved after 13 iterations
MA Backcast: 1980 1981

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	296.7888	192.3243	1.543169	0.1323
AR(1)	0.447498	0.369734	1.210325	0.2348
MA(1)	-0.219578	0.363851	-0.603485	0.5503
MA(2)	0.328326	0.195429	1.680026	0.1024

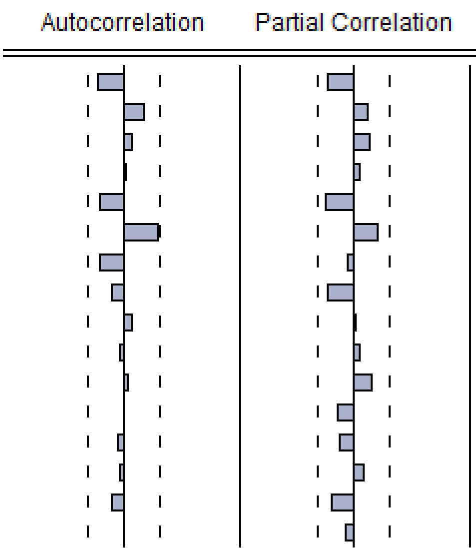
R-squared	0.201537	Mean dependent var	308.5405
Adjusted R-squared	0.128950	S.D. dependent var	628.5656
S.E. of regression	586.6407	Akaike info criterion	15.68851
Sum squared resid	11356863	Schwarz criterion	15.86266

Log likelihood	-286.2374	Hannan-Quinn criter.	15.74991
F-statistic	2.776474	Durbin-Watson stat	1.963639
Prob(F-statistic)	0.056635		

Inverted AR Roots	.45	
Inverted MA Roots	.11+.56i	.11-.56i

Appendix 03 : Correlogram of residuals

Sample: 1980 2018
Included observations: 37
Q-statistic probabilities adjusted for 1 ARMA term



Lag	AC	PAC	Q-Stat	Prob
1	-0.240	-0.240	2.3033	
2	0.173	0.123	3.5394	0.060
3	0.070	0.147	3.7484	0.153
4	0.021	0.050	3.7681	0.288
5	-0.211	-0.256	5.7787	0.216
6	0.306	0.215	10.146	0.071
7	-0.229	-0.062	12.670	0.049
8	-0.103	-0.243	13.196	0.067
9	0.073	0.013	13.471	0.097
10	-0.042	0.058	13.566	0.139
11	0.027	0.169	13.607	0.192
12	0.003	-0.155	13.607	0.255
13	-0.050	-0.116	13.759	0.316
14	-0.029	0.086	13.812	0.387
15	-0.109	-0.201	14.596	0.406
16	-0.005	-0.069	14.598	0.481