HEALTH EFFECTS OF TRANSPORT-RELATED POLLUTANTS: THE CASE OF FRANCE

RIHEM ZEIRI
Doctoral student and researcher
Faculty of Economics and Management of Sousse, Tunisia
zeiririhem111@gmail.com
AIDA BOUZIR
Higher Institute of Transport Services of Sousse, Tunisia
aidabouzir@gmail.com
SALOUA BENAMMOU
Faculty of Economics and Management of Sousse, Tunisia
saloua.benammou@yahoo.fr

Abstract

The objective of this work is to study the links and the effects of pollutants mainly from road transport on health, from an economic point of view. We will adopt an econometric approach inspired by ARDL (Autoregressive Distributed Lag) models. These models allow us to deal with the interactions between three spheres (transport, environment, and health) and the process of the mechanisms of the short and long-run effects. Our results show that the pollutants (NOX, NMVOC, PM10, SO2 and CH4) have statistically significant effects on life expectancy in the short-run as well as in the long-run, and that PM10 is the most dangerous for health in France.

Keywords: Transportation, Health, Environmental pollution, ARDL.

JEL Classification : L90, I12, K32, C10

1. INTRODUCTION

We know that transportation is an essential part of modern life. The economic development of entire regions depends on the easy access to people and goods that modern transport technologies provide. Because of its flexibility, road transport is a major mode of transport, and cars are objects of desire and curiosity in many societies (Krzyzanowski & al., 2005).

Mostly road transport, and, in particular, the car, is a major source of pollution. Indeed, internal combustion engines are by far the first cause of emissions of nitrogen oxides and various hydrocarbons. Despite the many technological advances made in recent years, the contribution of transport to pollution continues to increase due to the growth in traffic directly linked to economic development.

Environmentally speaking, air pollution is one of the most important risk factors to public health. Although, almost two hundred air pollutants are known, the main pollutants are carbon monoxide (CO2), sulfur dioxide (SO), nitrogen dioxide (NO2), ozone (O3) and particulate matter (PM2.5). Particles, smaller than 2.5 micrometers; also known as PM2.5, are the most dangerous pollutants for human health. Indeed, short and long-run exposure to particulate matter (PM2.5) leads to major pulmonary and respiratory disorders, creating a significant pressure on public health Özocakli & Özdemir (2020). In this framework, Yahaya (2017) shows that the increase in the number of people who fall ill due to air pollution leads to an increase in health care expenditures, as it increases the demand for health care.

According to UNEP (United Nations Environment Programme), it is impossible to ensure sustainable development without social well-being, good health, economic prosperity, and environmental sustainability.

The health effects of air pollution related to transport are one of the main concerns for the sustainability of the transport sector. Particularly in urban areas, transportation is a major contributor to air pollution and affects a large proportion of the population due to the high number of motor vehicles and urban population.

The French transport sector, heavily dependent on petroleum products (mainly gasoline and diesel), is the main emitter of particulate matter (PM), the critical levels of which induce harmful effects on the health of urban residents (Magazzino & al., 2020).

Transportation-related air pollution and its effects on public health have been a major concern. Much research has demonstrated the negative effects of outdoor air pollution on human health. We are primarily interested in air pollution related to urban, suburban, and freight transportation and human exposure to these greenhouse gas emissions from transportation.

2. LITERATURE REVIEW

The interactions between public health and the environment have attracted researchers and other stakeholders over the past decades. We propose a systematic review of the literature on the causes of air pollution due to different sources and its effects on the health of the human beings.

According to the EEA, the different means of transport (except international maritime and air transport) contributed by about 56% of the greenhouse gas emissions in Europe, 70% of which are due to road transport alone. It presents and will continue to present significant environmental problems (EEA, 2006).

To examine the relationship between environmental quality and health status, Narayan, P.K., & Narayan, S (2008) used panel data on eight OECD countries over the period 1980-1999. They found that NO2, SO2 and carbon monoxide emissions have an inverse effect on health status. Similarly, they suggested that health policy should be formulated considering the status of environmental quality for the well-being of the community.

Kuschel et al. (2012) showed that air pollution is caused by motor vehicles in New Zealand, particularly in the Auckland area, and that vehicle emissions (from gasoline and diesel combustion) contain particulate matter (PM2.5 and PM10), as well as nitrogen dioxide, carbon monoxide and other gases. They estimated that in 2006, there were 256 deaths due to air pollution (PM10) from motor vehicles. This is consistent with the study by Briggs et al. (2016) who estimated that in 2012, air pollution from road transport caused 283 deaths in New Zealand; of which 218 were due to PM10 and 65 deaths were due to nitrogen dioxide exposure.

Indeed, exposure to particulate matter, especially the finest PM2.5 can lead to chronic respiratory and cardiovascular diseases, as well as some cancers and low birth weight (Beelen et al., 2014; Hoek et al., 2013; Pedersen & al., 2013; Stafoggia et al., 2014). Nitrogen dioxide is associated with acute respiratory effects such as asthma symptoms, particularly with children (Hoek & al., 2013; Jacquemin & al., 2009).

To examine the short-run health effects of air pollution in Sfax (Tunisia), Elkadhi & Hmida (2014) used the ARDL method on daily data from January 2009-to July 2010. They showed that there is a significant association between pollutant emissions, especially sulfur dioxide (SO2) and ozone (O3), and hospital admissions for cardiovascular and respiratory diseases.

Badamassi & al. (2017) conducted an analysis of the impact of emissions on life expectancy .This analysis was triggered by domestic fires together by controlling the environmental emissions (PM2.5) produced by other sectors taking into account the various covariate variables. To do so, they used panel data from 43 sub-Saharan African countries over the period 1995-2010 and they used GMM and co integration methods. The results of the study show that long-term life expectancy and PM2.5 emissions are negatively related to both methods. They determined that this effect is higher for female life expectancy and that the control variable from the transportation sector (PM2.5) emissions was more effective in male life expectancy.

According to Badulescu & al. (2019), the consequences of environmental degradation on human health include not only its influence on the quality of life, but also on health expenditures, lost income, and productivity. Thus, it is possible to deduce the direct and indirect costs of the impact of environmental degradation on public health. Indeed, the estimations show that the measures to improve the quality of the environment can be valuable investments in the health and prosperity of individuals and society.

Ullah & Awan (2020) examined the relationship between long-term health and environmental quality indicators by using balanced panel data for 20 Asian countries. They showed that all CO2, SO2 and PM10 emissions negatively affect health. In other words, air pollution worsens human health in developing Asian countries.

Le Thi (2020) studied the health impact of traffic-related air pollution. He shows that, despite significant improvements in reducing vehicle emissions; the transportation of hazardous goods by road continues to increase in many parts of the world and becomes a global threat to human health.

Gavaev & Ertman (2020) addressed several issues related to the identification of pollution coming from the combustion gas emissions of vehicle engines in urban areas at low ambient air temperatures. Recently, data from epidemiological studies on the effects of transportation on health have increased substantially. They indicate that transport increases the risk of mortality and morbidity.

Using an atmospheric model based on data to calculate global exposure to PM2.5 and ozone pollution, Lelieveld & al. (2020) studied the effects of different pollution sources on mortality and life expectancy at birth. The results show that ambient air pollution is one of the major global health risks, leading to a significant excess in mortality and low life expectancy, particularly through cardiovascular disease. They showed that the global average of life expectancy due to air pollution largely exceeds that due to violence.

Khojasteh & al. (2021) examined daily variations in respiratory mortality and morbidity attributed to air pollutants in Ahvaz over a 9-year period. They showed that carbon monoxide and nitric oxide have a significant effect on total respiratory mortality. The results of the sensitivity analysis and the ADF test showed that the other pollutants (NO2, SO2, O3, PM10) had no significant effect on total respiratory morbidity and mortality.

Tolis & al. (2021) investigated the air quality and thermal comfort of the cabin of two passenger ‘cars running on different fuels. The survey was conducted in the town of Kozani, in the north of Greece. Air samples were taken near the exhaust pipes to compare the concentration of compounds found inside. The results showed that the air quality of a diesel car with open windows is only affected by the emissions of neighboring vehicles, while for the car running on LPG, the fumes from its own exhaust system can contribute to the outdoor air pollution.

3. DATA AND METHODS

3.1. DATA

This study aims to examine the impact of road transport pollutants on health in the case of France, over the period 1990-2020. The data are taken from the World Health Organization and the CITEPA (Centre interprofessionnel technique d'études de la pollution atmosphérique).

Indeed, the explanatory variables of our equation (1) were selected based on the literature.

$$LE = f(NOX, PM10, NMVOV, SO2, CH4) \qquad (1)$$

- **Dependent variable (LE)**

Our dependent variable is life expectancy at birth as an indicator of health. It is an estimate of how long an individual will live, derived from the average age of all individuals who die in a given year (Chen & Ching, 2000).

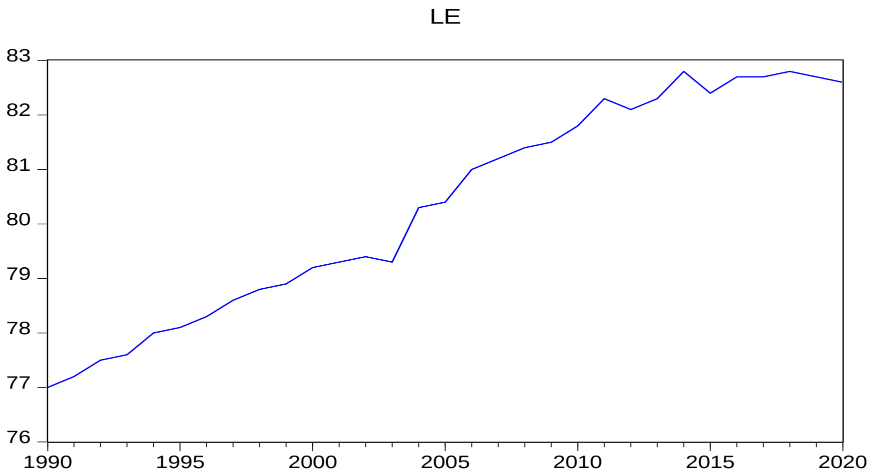

Figure 1. *Evolution of life expectancy at birth from 1990 to 2020 for France (in years)*
Source: Eviews 10 (2021)

In the past, improvements in life expectancy were primarily due to decreases in mortality before the age of one. Today, it is primarily the result of gains after a period of 70 years. Thus, in 2017, life expectancy at birth in France was 85.3 years for women and 79.5 years for men. (INSEE, 2017)

Figure 1 shows that life expectancy at birth increased at a slower rate over the period 1990-2020. The infant mortality has almost disappeared and mortality after the age of 70 accounts for most of the change.

- **NOX**

Nitrogen oxide emissions comprise two molecules (nitrogen monoxide NO and nitrogen dioxide NO2). They are linked to human activities such as road transport due to exhaust fumes, industry (fossil fuel combustion and the manufacture of glass, cement, metal, etc.) and maritime transport.

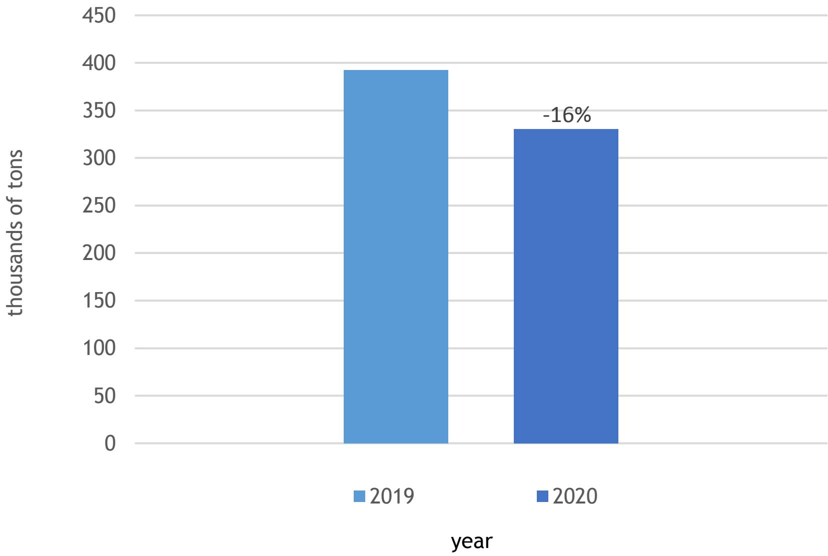

Figure 2. *Evolution of NOx emissions from road transport in France (in %)*
Source : CITEPA (2020)

As early as 1966, the main NOx emitting sector was road transport. Studies show that emissions from this sector have been decreasing since 1993, despite the increase in the number of vehicles and traffic. This overall decrease in emissions from the transport sector is linked to the introduction of European emission standards since 1970 (CITEPA, 2020).

Figure 2 shows that nitrogen dioxide emissions from road transport decreased by 16% between 2019/2020.

- **PM**

Particulate matter has been classified into different size categories such as PM0.1, PM2.5 and PM10, also known as ultrafine, fine, and coarse particles. Our study focuses on PM10 because these particles are more harmful to human health than others. Not only do particles affect human health in the form of premature deaths, but they also damage plants and cultures in the form of acid rain when they mix with moisture (Ullah & Awan, 2020).

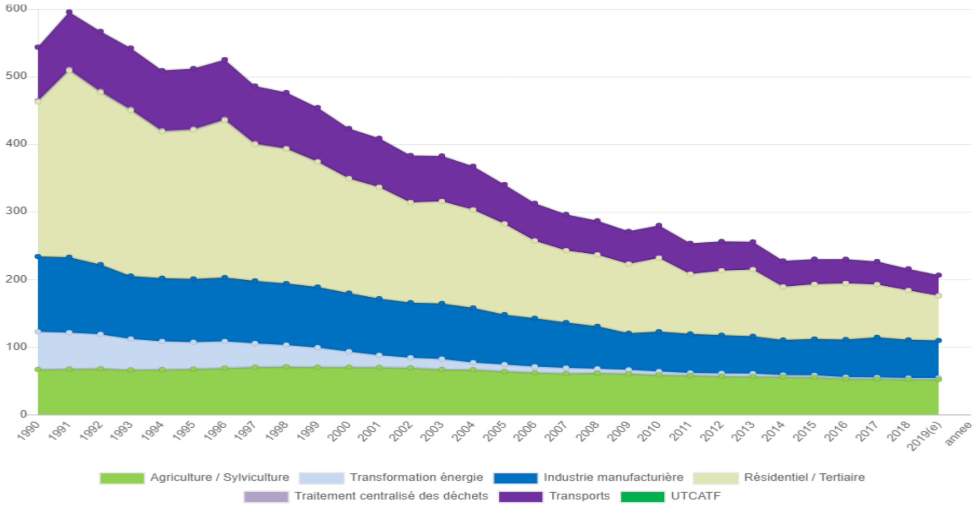

Figure 3. *PM10 emissions evolution from 1990 to 2018 for metropolitan France (in kt)*
Source : CITEPA (2020)

▪ NMVOC

These are emissions of non-methane volatile organic compounds. They are a complex and heterogeneous group of substances, originating from very different sources such as combustion, solvent use, certain industrial processes based on alcoholic fermentation or vegetation (CITEPA, 2016).

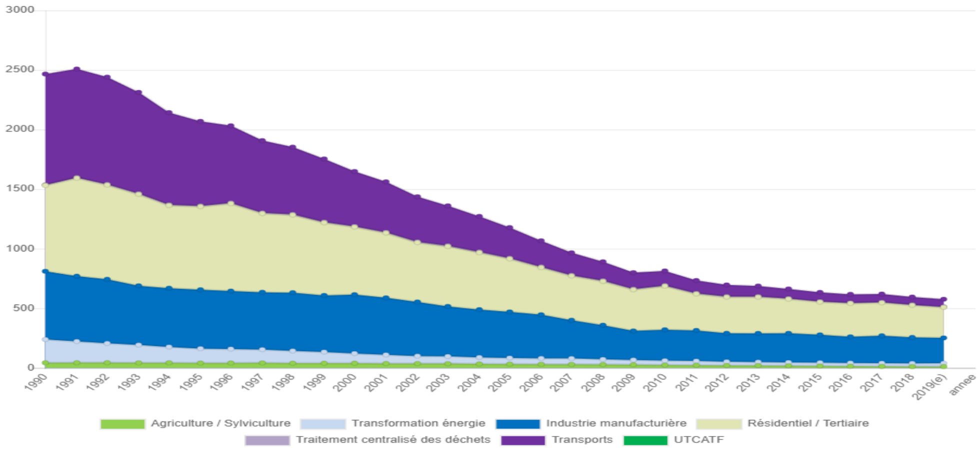

Figure 4. *Evolution of NMVOC emissions from 1990 to 2018 for metropolitan France (in kt)*

Figure 4 shows that the decrease in NMVOC emissions started in 1992, without interruption until 2010, with the largest annual decreases observed between 2005 and 2009 and more than 10% in 2009. Indeed, the 94% decrease in NMVOC emissions from road transport between 1990 and 2018 is linked to the fitting of catalytic converters to gasoline vehicles since 1993.

- **SO2**

Sulfur dioxide emissions are one of the historical substances of air pollution. They contribute to acid pollution. In other words, they lead to the deposition of sulphates and sulphuric acids that disrupt ecosystems.

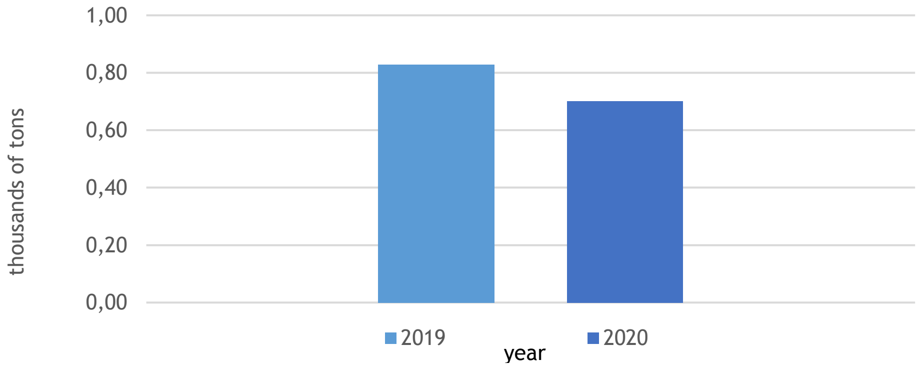

Figure 5. *Evolution of SO2 emissions from road transport for France (in %)*
Source: CITEPA (2020)

Figure 5 shows that sulfur dioxide emissions from road transportation decreased by 15% between 2019/2020.

- **CH4**

Methane is one of the simplest volatile organic compounds. On a global level, more than 2/3 of methane emissions are linked to human activities. Emissions of natural origin come mainly from moist areas.

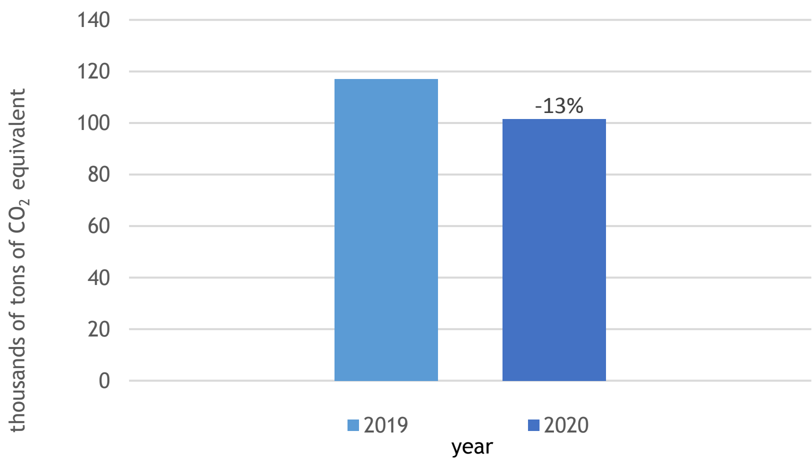

Figure 6. *Evolution of methane emissions from road transport in France (in %)*
Source: CITEPA (2020)

From Figure 6, we conclude that methane emissions from road transport decreased by 13% between 2019/2020.

3.2. METHODS

The interest of our work is to study the impact of road transport pollutants on life expectancy at birth in France. Indeed, our study is based on a dynamic model, which is the Autoregressive Distributed Lag (ARDL) model.

The ARDL model was proposed and developed by Pesaran & Shin (1999) and Pesaran & al. (2001). This technique has several advantages. On the one hand, it allows us to test the short-run relationships as well as the long-run relationships on series that are not integrated of the same order. On the other hand, it helps to obtain better estimates with small sample sizes (Narayan, 2005). In addition, this model allows us to simultaneously estimate both short- and long-run dynamics in the same econometric model (Akpan, G. E., & Akpan, U. F, 2012).

This method is increasingly used in research studies and is preferred for several reasons. It allows us to obtain more efficient results for studies with small sample sizes, unlike traditional co integration tests that require a large sample size to obtain better results such as the Engle Granger (1986) co integration test, the Johansen (1988) test and the Johansen & Juselius (1990) test. However, the ARDL technique can only be applied when the variables are stationary at the I (0) level or the I (1) level or a combination of both. More precisely, the order of integration of the series must be less than 2.

In general, in the case of this study, the ARDL model can be written in the initial form given by equation (2).

$$LE_t = \alpha_0 + \alpha_1 NOX_{t-1} + \alpha_2 PM10_{t-1} + \alpha_3 NMVOC_{t-1} + \alpha_4 SO2_{t-1} + \alpha_5 CH4_{t-1} + \varepsilon_t \quad (2)$$

The specification of the ARDL model is presented by equation (3).

$$\begin{aligned}\Delta LE_t &= \alpha_0 + \sum_{i=1}^{k} \alpha_i \Delta LE_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta NOX_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta PM10_{t-1} + \\ &\sum_{i=1}^{k} \alpha_i \Delta NMVOC_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta SO2_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta CH4_{t-1} + \beta_1 LE_{t-1} + \\ &\beta_2 NOX_{t-1} + \beta_3 NMVOC_{t-1} + \beta_4 SO2_{t-1} + \beta_5 CH4_{t-1} + \varepsilon_t \end{aligned} \quad (3)$$

In equation (3), Δ reflects the difference operator, β_i presents the coefficients that express the short-run dynamics, and ε_t presents the error term.

In order to test the presence of a long-run co integrating relationship between the regressors, an F-test was performed where the hypotheses are presented as follows:

H0: $\beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$ indicates the absence of a long run co integrating relationship.

H1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq 0$ indicates the presence of a co integrating relationship.

4. RESULTS AND DISCUSSIONS

4.1. DESCRIPTIVE ANALYSES

Table 1 summarizes the descriptive statistics of our ARDL model of the relationship between life expectancy and explanatory variables.

***Table 1** . Descriptive statistics*

	LE	NOX	PM10	NMVOC	SO2	CH4
Mean	80.32903	783.8124	55.66169	341.3294	40.27668	448.6239
Median	80.40000	747.9087	52.87325	231.1000	4.238134	376.2510
Maximum	82.80000	1261.648	85.43142	908.9000	157.4344	1017.196
Minimum	77.00000	330.5581	21.83951	42.81158	0.702056	101.5772
Std. Dev.	1.981446	288.8874	20.98297	296.2384	56.58847	314.5955
Skewness	-0.174401	0.235726	0.014017	0.683408	1.220444	0.511150
Kurtosis	1.554081	1.748569	1.561984	2.041613	2.825554	1.878267
Observations	31	31	31	31	31	31

To better understand the role of the variables used in our study on health, we will present in Table 1 the descriptive statistics of six variables in our study. These are life expectancy at birth, NOX emissions, PM10, non-methane volatile organic compounds (NMVOC), CO_2 and SO_2 emissions, and methane emissions.

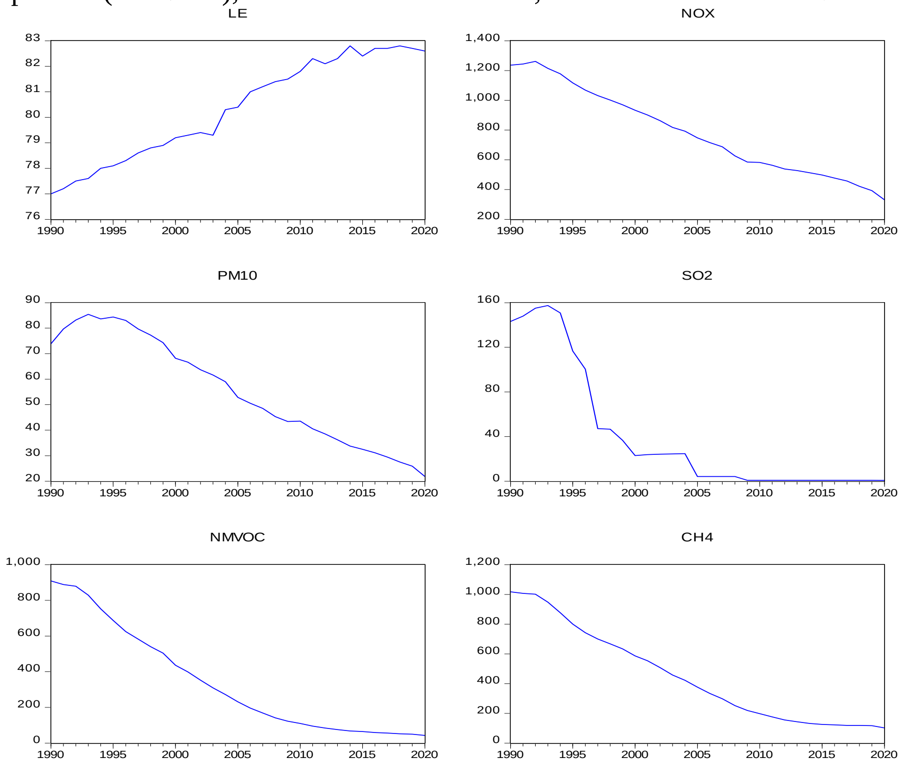

***Figure 7**. The trend of the study variables for France*
Source: Eviews 10 (2021)

4.2. STATIONARITY TEST

To determine the order of integration and the stationarity of the variables, we propose to use the Phillips-Perron (PP, 1988) and Augmented Dickey-Fuller GLS (ADF, 1992) unit root tests. The results of these two tests are shown in Table 2.

***Table 2**. Stationarity test*

	ADF		PP	
	I(0)	*I(1)*	*I(0)*	*I(1)*
LE	-1.809715	-7.092609***	-1.687767	-6.932014***
NOX	-6.330463***	-	-0.195958	-3.537258**
PM10	1.486999	-3.874320***	0.856206	-3.954613***
NMVOC	-6.330463***	-	-3.691662***	-
SO2	-4.566215***	-	-1.780152	-4.105393***
CH4	-3.251501**	-	-2.853174*	-

Note: ****, ** and * indicated significance of the coefficients by 1%, 5% and 10% levels, respectively*

The ADF test shows that the variables of NOX emissions, NMVOC emissions, SO2 emissions and CH4 emissions are stationary in I(0). On the contrary, PM10 emissions and the dependent variable (LE) are stationary in I(1), with a threshold of 1%. Applying the PP test, we notice that all the variables I(0) are non-stationary except for the variable NMVOC and CH4. But, as a first difference, the variables (LE, NOX, PM10 and SO2) are stationary at the 1% threshold (5%, for NOX emissions).

The results in Table 2 suggest that the variables have different integration orders I(0) and I(1). As a conclusion, the main condition for performing the ARDL technique is satisfied.

In order to ensure that none of the variables is I(2), we first check the existence of a long-run relationship by applying the linked tests that assume a lower bound for the I(0) series, and an upper bound for the I(1) series; the critical values are taken from I(2).

The long-run relationship between the variables is measured by using the Bounds test proposed by Pesaran & al. (2001) and Narayan (2005).

***Table 3** . Bound Test*

K	F-Statistic	Level of significance	I(0)	I(1)
5	6.769182	10%	2.08	3
		5%	2.39	3.38
		1%	3.06	4.15

Note : *k represents the number of regressors*

The F-statistic (6.76) indicates a cointegrating relationship if the values are above the critical upper bound value.

For our model, we find a long-run relationship between LE, life expectancy at birth and pollution variables from road transport (Table 3). This allows us to reject the null hypothesis of non-cointegration.

In order to verify the stability of our model, we applied the CUSUM test which is based on the cumulative sum of recursive residuals and the CUSUM SQ test based on the cumulative sum of the square of recursive residuals (Brown & Clarke, 1975). Figures 8 and 9 indicate that the lines remain within the critical limit of 5%. This asserts that the estimated parameters of the model are stable.

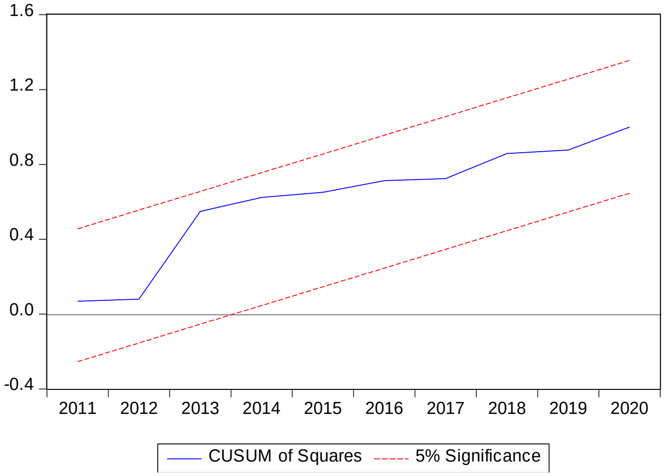

***Figure 8**. Cumulative sum of residuals curve*

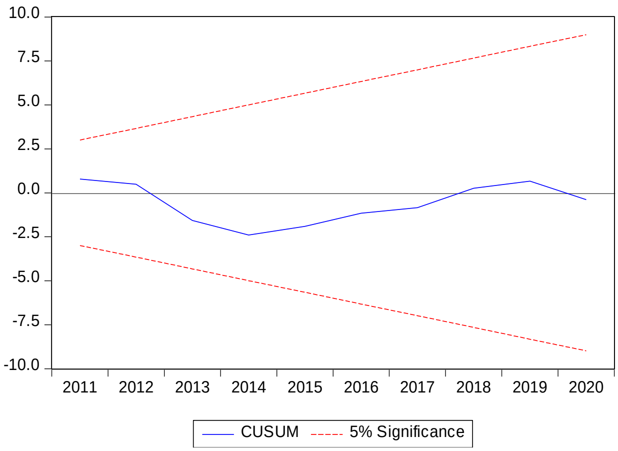

***Figure 9**. Cumulative sum of squares curve of the residual*

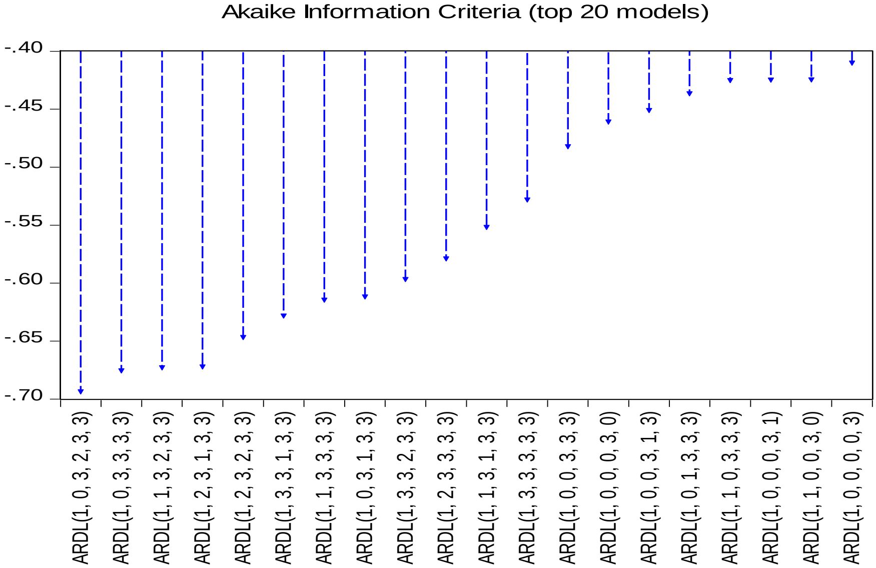

Figure 10. *The optimal choice of delays for the ARDL model according to the Akaike information criterion*

According to the Akaike information criterion, the optimal number of delays for our model is ARDL (1,0, 3, 2, 3,3). The optimal number of delays is selected by choosing the model with the smallest value of the Akaike information criterion. (see figure 10)

The results of the short-run relationship between the variables estimated from using the ARDL (1, 0 , 3, 2, 3, 3) approach are reported in Table 4.

Table 4 *. Short-run effects*

Variable	Coefficient	t-Statistic
D(PM10)	-0.204753	-7.176604***
D(PM10(-1))	-0.021530	-1.046286
D(PM10(-2))	0.188696	7.073865***
D(NMVOC)	-0.032828	-6.583161***
D(NMVOC(-1))	-0.011589	-2.142536**
D(SO2)	0.030606	7.001493***
D(SO2(-1))	0.011395	3.659586***
D(SO2(-2))	-0.024192	-6.064338***
D(CH4)	0.005931	1.145462
D(CH4(-1))	-0.002700	-0.599883
D(CH4(-2))	-0.038596	-8.567626***
CointEq(-1)*	-1.431629	-8.707172***

Note: ****, ** and * indicated significance of the coefficients by 1%, 5% and 10% levels, respectively*

The results in Table 4 reveal that all coefficients of the variables are statistically significant except for the CH4 variable.

The ECT(t-1) coefficient, estimated at -1.431, is both negative and significant at the 5% level.

This coefficient reveals the great speed of the adjustment process to return to equilibrium following a long-run disturbance. This confirms that the variables are cointegrated in the short run. After confirming the existence of a short-run cointegration relationship between the dependent variable and its determinants, it is fundamental to test this relationship in the long-run.

Table 5 *. Estimation of the long-run model*

Variable	Coefficient	t-Statistic
NOX	0.008792	4.517532***
PM10	-0.187459	-4.129813***
NMVOC	0.013788	2.746811**
SO2	-0.003700	-0.452703
CH4	-0.016068	-5.314776***
C	85.34231	129.7000***

Note: ****, ** and * indicated significance of the coefficients by 1%, 5% and 10% levels, respectively*

Table 5 shows that NOX, PM10, CH4 and NMVOC' emissions from road transport are statistically significant at the 1% and 5% thresholds. However, sulfur oxide emissions have no long-term effect on life expectancy at birth.

As we can see in figure 7, nitrogen oxide (NOX) emissions decrease by 73.27% between 1990-2020 (from 1236,657 thousand tons in 1990 to 330,558 MT in 2020). This explains the increase in life expectancy at birth in France (from 77 years in 1990 to 82.6 years in 2020). The long-run estimation shows that a 1% increase in NOX results in a 0.008% increase in LE. We find that even a 1% increase in NOX emissions is accompanied by a very slight improvement in LE, perhaps explained by other variables that determine health in France.

We note that PM10 emissions affect life expectancy at birth negatively. Indeed, a 1% increase in fine particles results in the decrease of the dependent variable by 0.187%. In addition, the human health impacts of particulate matter vary according to size, intensity, and level of exposure. These substances pollute the air. This has a negative effect on human health by increasing the mortality rate. According to the WHO (2003), the short and long-term impacts of exposure to particulate matter (PM2.5) are of concern. Its effects on mortality are one of the main sources of concern. This finding is consistent with the literature. (Burnett & al., 2014; Aboubacar & al., 2018 ; Badamassi & al., 2017).

Particulate matter emissions are among those that have a negative impact on human health by reducing life expectancy and increasing health costs. In this context, public and private policy efforts should be combined to reduce PM10 in the transport sector.

The health effects of NMVOC are numerous. However, the results of our study show that there is a statistically significant and positive long-run relationship between life expectancy and non-methane volatile organic compounds from road transport. Indeed, a 1% increase in NMVOC improves LE by 0.013%. In contrast, the short-run dynamics show that NMVOC emissions negatively affect LE.

Thus, methane and sulfur dioxide emissions negatively affect life expectancy at birth. According to Table 5, a 0.003% decrease in life expectancy at birth results from a 1% increase in SO2 emissions, and when CH4 emissions increase by 1%, life expectancy decreases by 0.016%. Indeed, the relationship between SO2 emissions and the health indicator is reversed . This indicates a deterioration of environmental quality through air pollution that negatively affects human health. In the same vein, Narayan, P. K., & Narayan, S (2008) ; Abdolahnejad & al. (2018) and Ullah & Awan (2020), confirmed the existence of a negative correlation between SO2 and health variables.

The effects of environmental quality variables are assumed negative on health. However, our study gives results that are slightly different from the economic reality since emissions of non-methane volatile organic compounds (NMVOC) and nitrogen oxides (NOX) slightly improve long-run life expectancy in France. These effects are almost inadmissible because they are very weak. However, they could be explained by the efficiency of the French health care system, which lowers the mortality rate and consequently increases life expectancy. These results confirm the need for policy makers to set targets for reducing the concentrations of all pollutants from the various sources.

5. CONCLUSION

The land transport sector, and road transport, in particular, has a significant impact on the atmosphere and consequently on human health. This study provides an overview of past, present, and future road transport emissions and their impact on human health. The massive use of means of transportation, such as vehicles and automobiles, increases emissions of indoor and outdoor air pollutants.

According to Brunekreef & Holgate (2002), the degradation of health due to air pollution has been the subject of intense study. Many citizens around the world live in areas where air quality standards are violated, especially for nitrogen dioxide and particulate matter. In this context, it is essential to better understand how air pollution from transport affects health and it is also essential to compare the harmful effect of the main pollutants present in France.

This study examined the risks of pollutants from road transport on health determination in France. Our paper differs from previous work as it uses a different approach (the autoregressive lag model (ARDL)). This approach provides both accurate and convincing results.

Essentially, the results of this study show that the most dangerous pollutant for human health is the PM10. The latter represents only 14% as its share in road transport. This is contradictory to our predictions since 63% of NOX comes from road transport.

In line with previous research, we propose some policy measures to promote a further reduction of all road transport emissions in France. Indeed, these pollutants constitute serious threats to human health and daily life. It is therefore necessary for policy makers to take urgent decisions to control polluting emissions.

REFERENCES

Abdolahnejad, A., Jafari, N., et al. (2018). Mortality and Morbidity Due to Exposure to Ambient NO2, SO2, and O3 in Isfahan in 2013–2014. *International journal of preventive medicine*, 9.

Aboubacar, B., Deyi, X., et al. (2018). The Effect of PM2.5 from Household Combustion on Life Expectancy in Sub-Saharan Africa. *International journal of Environmental Research and Public Health*, 15(4), 748.

Akpan, G. E., Akpan, U. F. (2012). Electricity Consumption, Carbon Emissions and Economic Growth in Nigeria. *International Journal of Energy Economics and Policy*. 2(4), 292.

Badamassi, A., Xu, D., et al . (2017). The Impact of Residential Combustion Emissions on Health Expenditures: Empirical Evidence from Sub-Saharan Africa. *Atmosphere*, 8(9), 157.

Badulescu, D., Simut, R., et al . (2019). The Relative Effects of Economic Growth, Environmental Pollution and Non-Communicable Diseases on Health Expenditures in European Union Countries. *International journal of environmental research and public health*, 16(24), 5115.

Beelen, R., Raaschou-Nielsen, O., et al . (2014). Effects of Long-Term Exposure to Air Pollution on Natural-Cause Mortality: An Analysis of 22 European Cohorts within the Multi-center ESCAPE Project. *The Lancet*, 383(9919), 785-795.

Briggs, D., Mason, K., et al. (2016). Rapid Assessment of Environmental Health Impacts for Policy Support: The Example of Road Transport in New Zealand. *International Journal of Environmental Research and Public Health*, *13*(1), 61.

Brown, L. M., et al . (1975). Work Hardening Due to Internal Stresses in Composite Materials. *Acta Metallurgica*, 23(7), 821-830.

Brunekreef, B., Holgate, S. T. (2002). Air Pollution and Health. *The Lancet*, 360(9341), 1233-1242.

Burnett, R. T., Pope III, C. A., et al. (2014). An Integrated Risk Function for Estimating the Global Burden of Disease Attributable to Ambient Fine

Particulate Matter Exposure. *Environmental health perspectives*, 122(4), 397-403.

Chen, M., Ching, M. (2000). *A Statistical Analysis of Life Expectancy across Countries Using Multiple Regression*. A final year project submitted to Sys, 302.

CITEPA (Le Centre Interprofessionnel Technique D'études De La Pollution Atmosphérique): https://www.citepa.org/fr/.

EEA (European Economic Area) : EEA - Article presented in London 2006.

Elkadhi, H., Hamida, R. B. (2014). The Short-Term Effects of Air Pollution on Health in Sfax (Tunisia): An ARDL Cointegration Procedure. In 2014 International Conference and Utility Exhibition on Green Energy for Sustainable Development (ICUE) (pp. 1-4). IEEE.

Gavaev, A. S., Ertman, S.A. (2020). Assessment of Automobile Transport-related Pollution in Cities at Low Ambient Air Temperatures, In IOP Conference Series: Earth and Environmental Science (Vol. 543, No. 1, p. 012004). IOP Publishing.

Granger, C. W. J . (1986). Developments in the Study of Cointegrated Economic Variables, *In Oxford Bulletin of economics and statistics*.

Hoek, G., Krishnan, R. M., et al. (2013). Long-term Air Pollution Exposure and Cardio-Respiratory Mortality: A Review. *Environmental Health*, 12(1), 1-16.

INSEE (Institut National De La Statistique et des Etudes Economique): https://www.insee.fr/fr/accueil.

Jacquemin, B., Sunyer, J., et al. (2009). Home Outdoor NO 2 and New Onset of Self-Reported Asthma in Adults. *Epidemiology*, 20, 119-126.

Johansen, S., Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration-with Applications to the Demand for Money. *Oxford Bulletin of Economics and statistics*, 52(2), 169-210.

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control*, 12 (2-3), 231-254.

Khojasteh, D. N., Goudarzi, G., et al. (2021). Long-term Effects of Outdoor Air Pollution on Mortality and Morbidity–Prediction Using Nonlinear Autoregressive and Artificial Neural Networks Models. *Atmospheric Pollution Research*, 12(2), 46-56.

Krzyzanowski, M., Kuna-dibbert, B., et al. (2005). *Health Effects of Transport-Related Air Pollution*. WHO Regional Office Europe.

Kuschel, G., Metcalfe, J., et al. (2012). *Updated Health and Air Pollution in New Zealand Study*. Volume 1: Summary report. Health Research Council of New Zealand, Ministry of Transport, Ministry for the Environment and New Zealand Transport Agency.

Le Thi, H. (2020). Health Impacts of Traffic-related Air Pollution: Cause-effect Relationships and Mitigating Measures. In *CIGOS 2019, Innovation for Sustainable Infrastructure* (pp. 1031-1036). Springer, Singapore.

Lelieveld, J., Pozzer, A., et al. (2020). Loss of Life Expectancy from Air Pollution Compared to other Risk Factors: A Worldwide Perspective. *Cardiovascular Research*, 116(11), 1910-1917.

Magazzino, C., Mele, M., et al. (2020). The Relationship between Air Pollution and COVID-19-Related Deaths: An Application to Three French Cities. *Applied Energy*, 279, 115835.

Montero-Lorenzo, J. M., Fernández-Avilés, G., et al. (2013). A Spatio-Temporal Geostatistical Approach to Predicting Pollution Levels: The Case of Mono-Nitrogen Oxides in Madrid. Computers. *Environment and Urban Systems*, 37, 95-106.

Monzón, A., Guerrero, M. J. (2004). Valuation of Social and Health Effects of Transport-Related Air Pollution in Madrid (Spain). *Science of the Total Environment*, 334, 427-434.

Narayan, B. (2005). Domination: How the Fragments Imagine the nation: Perspectives from some North Indian Villages. *Dialectical Anthropology*, 29(1), 123-140.

Narayan, P. K., Narayan, S. (2008). Does Environmental Quality Influence Health Expenditures? Empirical Evidence from a Panel of Selected OECD Countries. *Ecological Economics*, 65(2), 367-374.

Özocakli, D., Özdemir, Ö. (2020). The Effect of Air Quality and Smoking Prevalence on Different Categories of Health Expenditures: An Empirical Evidence from Mena Countries. *Avrasya Sosyal ve Ekonomi Araştırmaları Dergisi*, 7(10), 85-103.

Pedersen, M., Giorgis-Allemand, L., et al. (2013). Ambient Air Pollution and Low Birthweight: A European Cohort Study (ESCAPE). *The Lancet Respiratory Medicine*, *1*(9), 695-704.

Pesaran, M.H., Shin, Y.(1999). *An Autoregressive Distributed Lag Modelling Approach to Cointegration Analysis*, Chapter 11 In Econometrics and Economic Theory in the 20th Century: The Ragnar Frisch Centennial Symposium, Strom, S. (Ed.). Cambridge University Press, Cambridge.

Pesaran, M.H., Shin, Y., et al. (2001). Bounds Testing Approaches to the Analysis of Level Relationships. *Journal of Applied Econometrics*, 16, 289-326.

Stafoggia, M., Cesaroni, G., et al. (2014). Long-term Exposure to Ambient Air Pollution and Incidence of Cerebrovascular Events: Results from 11 European Cohorts within the ESCAPE Project. *Environmental health perspectives*, 122(9), 919-925.

Tolis, E. I., Karanotas, T., et al. (2021). Air Quality into Cabin Environment of Different Passenger Cars: Effect of Car Usage, Fuel Type and

Ventilation/Infiltration Conditions. *Environmental Science and Pollution Research*, 1-10.

Ullah, S., Awan, M. S. (2020). Environmental Quality and Health Status: Dynamic Ordinary Least Square Estimation for Developing Asian Countries. *Forman Journal of Economic Studies*, 16.

World Health Organization (WHO), https://www.who.int/fr/emergencies/diseases/novel-coronavirus

Yahaya, A. (2017). *Impact of FDI, Environment and Institutional Quality on Health Outcomes, Health Expenditure and Healthcare System Efficiency*. Thesis, 43 pages.