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The Impact of Economic Growth and Population on Co_2 Emissions from Transport Sector. Azerbaijan Case

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Abstract *In this study, we have examined impacts of energy consumption, real GDP and population on the pollution from the automobile transport in Azerbaijan case. We employed annual time series data for the 1990-2014 time span. First the data tested for stationarity and then we employed the Autoregressive Distributed Lags Bounds Testing approach to cointegration. Estimation results indicated that population has significant impacts on the transport emission in Azerbaijan; however impacts of energy consumption are not trivial. Real GDP has statistically insignificant but positive impact over emission. Findings of the study may be useful in making appropriate decisions in the fields of diminishing atmospheric pollution from automobile transport.*

Key words Atmosphere emission from transport, energy consumption, real GDP, population, STIRPAT, Azerbaijan

JEL Codes: C13, Q48, N75, R41

1. Introduction

Energy is a remaining stimulating strength of the economy. In addition to other factors, energy is considered as the main driving force of economic and social development (Khalifa and El-Sakka, 2004). However, energy consumption, particularly the use of fossil fuels as an energy source might have negative impacts on the environment. Energy consumption is one of the main sources of greenhouse gas emissions. Although greenhouse gases support the normal maintenance of the Earth temperature, greenhouse gases that are the result of human activities contribute global warming by absorbing the heat. Global warming cause's climate change which is currently considered as one of the biggest global problems.

Carbon dioxide (CO_2) has an important share between environmental pollutants. According to the reports of the World Bank, carbon dioxide is mainly welded from the burning of crude fuel and cement production (World Bank, 2015). For the purpose to eliminate the negative effects of greenhouse affected gases Kyoto protocol was ratified by the majority of the world countries, this protocol proposed developed countries requirements of emission reduction. Quantitatively the main greenhouse affected gas is CO_2. According to the information by Intergovernmental Panel on Climate Change (IPCC) (2016), 77% of anthropogenic greenhouse gases belong to carbon dioxide. However, the reduction of carbon dioxide emissions was accepted as the obligation of developed countries as the biggest producers of emissions (UNFCCC, 2016)), developing countries within the framework of a consensus are also called to participate actively in the struggle against global climate change (Wrinkler *et al.,* 2002) In recent years developing countries have rapidly reached developed countries in terms of emissions of CO_2. Which according to the reports of 2003 almost the 50% of global carbon dioxide emissions is related to developing countries.

Global warming and the energy crisis in the 21st century lead to the necessity of international low-carbon-emission economic development. Cities rapidly developed economically and socially have become main producers of emission, while the urban transport has become the main source of carbon emission formation (Fengyan and Lei, 2015). Based on the statistics of UN, cities have 75% of total carbon emission 17.5 % of which belongs to transport (Li *et al*., 2014). Increased traffic emissions have become an important factor in limiting the growth rate of the global economy.

When we look at the share of atmosphere pollution of Azerbaijan from stationary and non-stationary sources we see rapid emission increase in transport sector relatively to stationary sources (SSCAR, 2016). Since 2006 surpassing the stationary pollution in 2014 transport sector has increased its difference more than 4 times (EEPO, 2016). In addition, if to focus on the atmospheric pollution of transport sectors separately, we can see that 67% of it belongs to automobile sector. The second most important source of contamination is international shipping that contains 20% of pollutions. Other sources take over pollution in local shipping 6%, international air transport 5%, rail and local transport 1% (EEPO, 2016). The rapid increase in the numbers of cars to over 1200000 from 2003 to 2014 reveals the largest shareholder of atmospheric pollution of transport in Azerbaijan (EEPO, 2016).

Taking into account all the above mentioned facts, in the current study we focus on the impacts on the emissions from automobiles.

In general, the use of cars and trucks has been continuously polluted the air throughout the life. Thus during the production and the use of cars, as well as refueling and burning and making useless processes certain pollutants gets into the air (ASUO, 2016). However, over than 67% of atmospheric pollutants in Azerbaijan belongs to carbon dioxide emissions (Apergis and James, 2010). CO_2 concentration shares 60% of the shape of global warming in which road transport sector is the largest source of gas emission after energy production and since 1971 starting with 1.9% annually global emissions has increased to 106% (IEA, 2016).

The economic development and energy consumption also might have negative impacts on the environment. To put it differently, damaged environment and natural resources influence negatively on people, earth and society. In this case, the balance between the economic elements should be maintained, in other words in order to ensure sustainable development resources should be used efficiently and with the minimum level of negative environmental effects. The most effective ways of reducing CO_2 level is considered as one of the main precautions in developed and as well as in developing countries. Though, the differences between developed and developing countries and also between countries at the same level of development require specific cogitation of proper activities for each country separately. On purpose of achieving this goal, in the mid of 1990s, there were implemented the variety of programs by the Ministry of Ecology and Natural Resources and the Ministry of Economic Development and Industry, and in 1999 a decree was signed on the protection of the environment in Azerbaijan (MENRAR, 2015). And in 2000 Azerbaijan signed the Kyoto Protocol (SSCAR, 2016). On the 29th of December in 2012, the President of Azerbaijan signed the concept of economic development, "Azerbaijan-2020: The vision of the future". In the frame of this concept one of the main aspects is the realization of programs and reforms in order to achieve sustainable development (MENRAR, 2015). Also within this concept it is aimed to reduce the carbon dioxide emission to the level of the member countries of Organization for Economic Cooperation and Development (Prezident.az, 2015).

For this reason, it is significant for the economy of Azerbaijan to work up the econometric model associated with road transport emission, economic and social factors. The environmental impacts of energy consumption and economic development related to other countries have been studied from a number of publications. However, these investigations have revealed distinctive results. These differences are welded from various periodicals, econometric methodologies and the application of different variables (Pao *et al*., 2011). One of the contributions of this study to the existing literature is the exploration of impacts of economic and social factors not on general carbon dioxide emission, but on the pollutant substances released into the atmosphere by road transport. Additionally, this study has tested the Environmental Kuznets Curve (EKC) hypothesis linked dependence between income level of Azerbaijan and road transport emissions, has employed co-integration method.

2. Literature review

The relationships between the economic development and environment, with the environment and energy, have been the subject of numerous investigations. But, within the framework of this research both relationships, including environment and the population will be given together (EEPO, 2016; IEA, 2011; Khalifa and El-Sakka, 2004; Mustapa and Hussain, 2015; York and Rosa, 2012) and in this section, the review will be carried out including the country and research methodology conducted.

Liddle (2011) has examined the effects of CO2 emissions from transport in 22 member countries of the OECD for the years 1960-2007 and the residents' on energy consumption through STIRPAT methodology. He has divided population among 4 age's categories. According to the estimation results has been identified the intensive impact of transport emissions for 20-34 age group, while the coefficient for other age groups has been negative.

Fengyan and Lei (2015) have analyzed the impacts of Multivariate Generalized Fisher Index influencing the carbon dioxide emission from transport for Beijing, using annual data from 1995 to 2012. The results shown that the components of the Fisher index, namely the economic growth, energy intensity and population size have positive (sign) impact on carbon emission, the coefficient of the economic growth found to be 3.35. The impacts of transport intensity and energy structure, which are considered as other components of the index, on emission have been determined as negative, and it has been identified that the value obtained from single motion turnover has M shaped impact on emission.

Liu and Cirillo (2016) have studied the emissions of greenhouse gases from private cars (1182 first class, 852-second class, 257 third class cars) on the basis of 1289 observation in Washington. During the calculations of greenhouse gases, authors have used 4 components in the Metropolitan area of Washington: the number of cars, type and the operation of the vehicle, the travelled distance, and the emission level of greenhouse gases, and have explored average emission of the greenhouse gases of each car equivalent to 5.15 tons of carbon dioxide per year. 3 types of tax schemes were estimated on cars: a) the implementation of fuel tax is considered as the best way in decreasing the amount of greenhouse gases, especially shows the impact for households with a small number of transport; b) the implementation of purchasing tax influences the decrease of the emission of the greenhouse gases for the households have a huge number of cars; c) the implementation of ownership tax affects the use of the transport and reduces travelled distance which also indirectly impacts the reduction of the emission of the greenhouse gases.

Jinxue *et al*. (2013) used Logarithmic Mean Divisia İndex (LMDİ) method to investigate the effects of carbon emission from transport for China, using 1991-2008 time period. The study employed transport energy efficiency, transport structure and transport development indicators as drivers of the emissions from transport. According to the results impact of transport development indicator on emission is monotonically increasing. The impact of the transport structure, on the contrary, is U shaped. That is, although initially, transport structure influenced the increase of carbon emission from transport, the ongoing structure begins influencing emission-reducing effects over time. The energy efficiency in transports affects reducing transport emissions.

Based on approximately 9.7 times (annual average growth 7.4%) increases of the carbon dioxide emissions from transport sector in China between 1980-2012 years, Xu and Lin (2015) have investigated how to reduce carbon dioxide emission from transport sectors of China. The authors have assessed the impacts on emission by using VAR (Vector Auto Regression) model on the basis of statistic materials of 1980-2012 years. The results have shown that energy efficiency plays an important role in reducing CO_2 emissions. The excess in number and low level of energy efficiency in passenger cars causes the pollution of atmosphere more than trucks.

Mustapa and Hussain (2015), considering the fact that in Malaysia 28% of carbon dioxide emission shared by the transport sector and its 85% belongs to automobile transport, have investigated the factors influencing carbon emission of road transport using statistical data of 1990-2013 years. They have assessed carbon emission on 4 factors- fuel consumption, fuel efficiency, fuel price and distance travelled. The authors have discovered the positive impact of fuel efficiency and travelled distance on carbon emission, while the negative linear relationship with the price and consumption of fuel.

On the basis of analyzed and reviewed studies we can say that this is the first research on the factors affecting the emission of pollutants from the automobile transport of Azerbaijan by the cointegration methods considering stationary characteristics of time series data.

3. The Modeling Framework (STIRPAT)

As a theoretical context we used the so-called STIRPAT framework. The STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology) modeling framework was put forward by Rosa and Dietz (Dietz and Rosa, 1994,1997). STIRPAT model can be expressed as follows:

$$I = a \times P^b \times A^c \times T^d \times e \qquad (1)$$

Here, equation (1) shows environmental effects (Impact), P-population (Population), A-the welfare level (Affluence) and T-the technology (Technology). a, b, c and d – are coefficients to be estimated, and e - the stochastic error term. Taking logs of both sides of the equation can easily written in the following form:

$$Log(I) = q + b \times Log(P) + c \times Log(A) + d \times Log(T) + \omega \qquad (2)$$

Here Log - natural log sign. While “q” and “ω” are accordingly a’s and e's natural logarithms.

4. Data

In this study statistical data for evaluation of the effects of transport sectors on atmospheric pollution in Azerbaijan has been taken from two sources. The *real Gross Domestic Product* (GDP), *population* of Azerbaijan in 1990-2014s, and *total energy consumption* in Azerbaijan in 1990-2012 has been taken from the base of “World Development Indicators” (World Bank, 2015). The indicators of energy consumption in 2013-2014s have obtained based on previous figures through extrapolation method. While the statistics of emitted transport *pollutants* into atmosphere during 1990-2014 years are included in the model according to the data from the State Statistical Committee of Azerbaijan Republic. Real GDP is indicated with US dollars in 2005, the population in persons, energy consumption with kilograms of oil equivalent, and emitted transport pollutants into the atmosphere are shown with kilograms.

The total road transport emission in Azerbaijan was 738 kilotons in 1990, while 966 kilotons in 2014. Including the 30.9% of total emission increase, the annual growth rate was 2.57% between 1990-2014 years. Although according to the figures of 10 years between 2003-2013 annual emissions was 2.25%, during the 5 years period which covers 2008-2013, the annual growth rate has declined to 1.13% (World Bank, 2015). Having a look at Figure 1, we can see the decline of the amount of atmospheric emission in the transport sector from 1990 to 1996 within the same trend, its recover with small fluctuations during 1996-1998, and the constant growth since 1998. The initial decrease in the chart is explained with the breakup of industrial enterprises as a result of Azerbaijan cutting ties with the former Soviet states and with the war of Karabagh, which didn’t dispense ineffectively to the transport system of the country. Thus, the existing transport infrastructure was substantially destroyed, as well as the low level of welfare of the population had reduced use of private cars. The stability

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followed by decline and the subsequent increase is explained by the revival of the economy of Azerbaijan, the creation of new transport infrastructure, the development of trade and economic relations with neighboring countries, and with the growth of welfare in the result of oil industry development. In the graph of energy consumption is shown the rapid decline for the first few years, which continues until 2000. As it was mentioned above the reason of this decrease was associated with war and economic collapse. However, during the period after 2000, there is no substantial increase in energy consumption unlike pollutions. This is the result of efficient use of energy resources in the industry and other sectors. The above-mentioned negative factors had also influenced gross domestic product of Azerbaijan until 1996. Following 1996, there was a leap in the amount of GDP that was caused by oil boom. Within the framework of economic development indicators, the GDP of Azerbaijan during 1996-2013 has increased 21.33 times, to be more specific it has risen from 2732.6 million manats in 1996 to 58182 million manats in 2013 (in nominal terms). The economy of Azerbaijan has reached significant economic growth since 2006 (World Bank, 2015). These considerable changes in economic development in the mid of 1990s are explained with the signed oil contracts, such as "The Contract of the Century" in 1994, which concluded a treaty with the world's 13 leading oil companies, 41 different oil companies from 19 different countries. In addition, one of the reasons causing rapid growth in economic development is the delivery of the Azerbaijani oil to the world market by the completion of Baku-Tbilisi-Ceyhan oil pipeline construction project in 2005.
The same trend is observed if to pay attention to the graph of population growth. Hence, he level of the country's population has been growing at a steady pace.

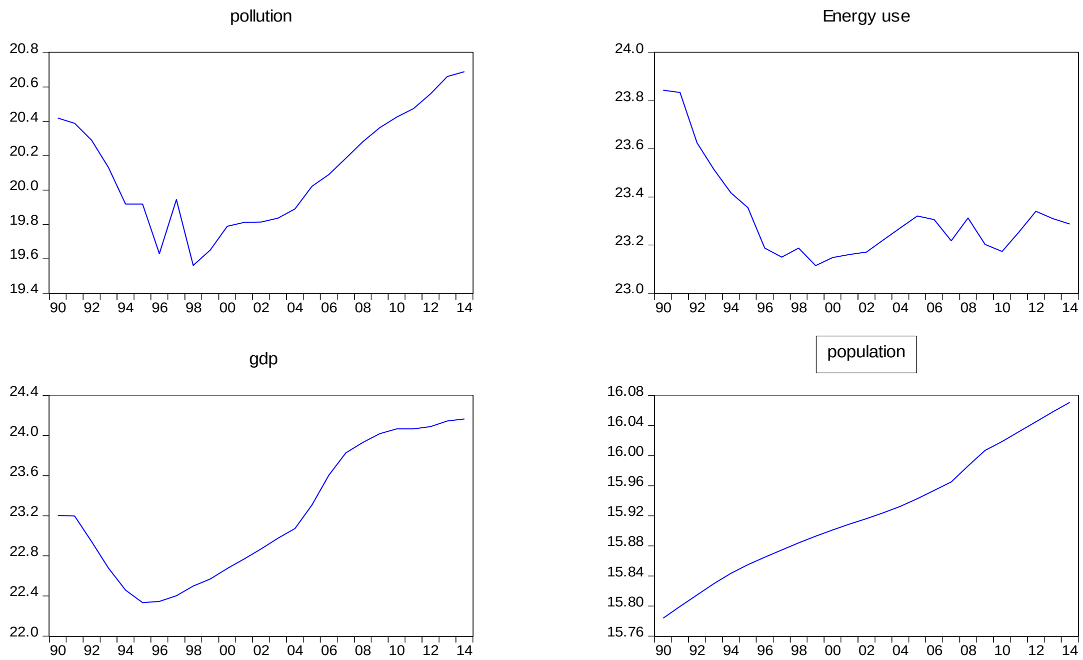

Figure 1. The graphs of the logged variables, Azerbaijan 1990-2014

According to the Table 1 Azerbaijan was compared with the world, European and Central Asian countries on four indicators used in the model. In the table is shown the annual changes in the amount of energy consumption, GDP, population size, and emitted transport pollutants into atmosphere is given in the average percentage per year during the last 10 years (World Bank, 2015).

Table 1. The percentage of the average growth rates (2005-2014)

Region	Azerbaijan	Europe and Central Asia	World
Increase in energy consumption (average %)	0.593919361	0.137184837	2.291368525
Increase in GDP (average %)	12.10490151	1.275255106	2.503170266
Population growth (average %)	1.382269215	0.371620259	1.21565677
Increase in CO_2 transport emission (average %)	7.255155599	0.191310352	1.710626373

Source: the table has been prepared by the authors on the basis of statistical data obtained from the official website of World Bank and State Statistics Committee of Azerbaijan Republic

In as much as, in Azerbaijan, carbon dioxide emissions from transport during the last 10 years has reached annual average 7.26%, that is approximately 4.2 times more than world, and 37.9 times more than Europe and Central Asia indicators of the corresponding figure. This case can be explained with the operating vehicles in Azerbaijan that might not meet the standards of environmental and technical malfunctions, and as well as the use of the vehicles that have ended the period of operation. If to look at the figures in GDP of Azerbaijan, with the annual average 12.1% growth we see the overgrow compared to 4.48 times world average, and 9.5 times Europe and Central Asia average. Whilst, the world energy consumption has an annual increase of approximately 2.29%, in Azerbaijan, it is 0.59%, which is based on the efficient energy use and preventing losses. But in the case of comparison of these indicators with corresponding European and Central Asian indicators, in Azerbaijan, the average annual growth rate is 4.3 times higher (Khalifa and El-Sakka, 2004; World Nabk, 2015). However, in respect of observed 12.1% growth of GDP, this figure is expectable. Average annual growth of population is close to the world growth level. But, in comparison with European and Asian countries, we witness 3.7 times higher growth in Azerbaijan. The logged forms of all variables are used in the model to interpret the estimated coefficients not by quantity but in percentage. The mnemonics of the variables, as well as their units of measurement have been introduced by formulas in Table2, and hereupon the nomenclature will be presented in this way.

Table 2. The mnemonics and units of measurements of variables included in the model

Variables	Formula	Units of measurements
Pollution	pol	kilogram
Energy Consumption	enuse	kilograms of oil equivalent
Real GDP	gdp	2005 US dollars
Real GDP's square	gdpsq	
Population	pop	persons

5. Methodology of research

5.1. Model

In this study, the specification below will be used to indicate the long-run relationship of the emission of pollutants from motor transport with GDP, population, and energy consumption.

$$pol = b_0 + b_1\,enuse + b_2\,gdp + b_3\,pop + b_4\,gdp^2 + u \quad (3)$$

Here, *pol* is the transport pollutants into the atmosphere, *enuse* - energy consumption, *pop* – population, *gdp* - real GDP, *gdp2* - real GDP square, *u* – error term, b_1, b_2, b_3 and b_4 are regression coefficients for the parameters of the long-term period. b_1 and b_2 are expected to have positive signs. Based on Environmental Kuznets Curve hypothesis the expected signsfor b_3 and b_4 should be positive and negative in accordance. Based on the EKC procedure, if the coefficient of the squared term is insignificant we drop it and conclude the monotonic relationship between income and emissions. This means that the Environmental Kuznets Curve hypothesis does not hold for the case under investigation.
First we begin with the model (3) model and in the case of insignificant quadratic term we will use specification (4):

$$pol = b_0 + b_1\,enuse + b_2\,gdp + b_3\,pop + u \quad (4)$$

5.2. Econometric procedure

In order to identify the long-term relationship between included variables, we will use the Autoregressive Distributed Lag Bound Test (ARDLBT) approach suggested by Pesaran and Shin (1999) in 1999 and broaden by Pesaran *et al*. (2001). The ARDL approach in comparison to other methods has some advantages (Oteng-Abayie and Frimpong, 2006; Sulaiman and Muhammad, 2010; Pesaran *et al*., 2001). First, it is possible to apply regardless of regressions being exclusively I(0) and I(1) and or being mutually co-integrative (Akpan and Akpan, 2012). Also, for the models with small number of observations, this approach can give adequate results. Henceforth, ARDL approach compiled by Pesaran and Shin (1999) is more reliable for small sample properties than the cointegration method by Johansen and Juselius (1990), Oteng-Abayie and Frimpong (2006). The use of bound test is simple. Suppose that z_t is the vector of two variables, which is $z_t=(x_t,y_t)$, and here y_t is dependent, x_t is an independent variable. For the analysis of cointegration we model Δy_t as follows:

$$\Delta y_t = c_0 + \theta_{yy} y_{t-1} + \theta_{yx} x_{t-1} + \sum_{i=1}^{n} \varpi_i \Delta y_{t-i} + \sum_{i=0}^{n} \varphi_i \Delta x_{t-i} + u_t \quad (5)$$

Here, y is dependent variable; x is independent variable, u - white noise error, c_0 – intercept,θ_i are long-term term coefficients, ϖ_i and φ_i while are short-term coefficients. The lagged values, namely Δy_t and Δx_t are used to model the short-term dynamic structure of variables. To check the existence of the cointegration relationship among variables the zero and alternative hypothesis below are used.

$$H_0 : \theta_{yy} = 0,\ \theta_{yx} = 0 \tag{6}$$

$$H_1 : \theta_{yy} \neq 0,\ \theta_{yx} \neq 0\ or\ \theta_{yy} = 0,\ \theta_{yx} \neq 0\ \ yaxud,\ \theta_{yy} \neq 0,\ \theta_{yx} = 0 \tag{7}$$

The calculated F-statistic is compared with two set of critical test values, lower and upper bounds. If calculated F-statistics exceeds the upper limit of critical value the zero hypotheses is rejected, otherwise, i.e., if the lower limit also gets small value, the alternative H_1 is rejected, so there is no cointegration between variables. If assessed F value apprises between two borders, it is not possible to make an accurate decision, decision varies depending on the circumstances.

If the variables are I(2) or have higher order of integration then the use of Bounds testing might be questionable. Therefore, it is necessary to test the stationarity features of variables through the unit root test in advance. For checking the stationarity we will use the traditional Augmented Dickey-Fuller (ADF) test. For the ADF test, the zero hypotheses is non stationarity of variables, namely has unit root, while alternative hypotheses is the case of the stationarity of variables (Dickey and Fuller, 1981).

6. Empirical Results

According to the results of the ADF test, energy consumption and pollution are I(1), while GDP, GDP-square and population variables are I(2). However, on the basis of the graphic analysis of variables and general theoretical approach we concluded *gdp* variables to be integrated of order one and move to the next stage of the research.

With the squared term model, the coefficient of the squared term of the income found to be statistically insignificant. Hence, we continue with the linear model, and conclude that the relationship between emissions from the transport and income does not satisfy the EKC hypothesis. As a next step, on the basis of equation (5), we check the cointegration relationship among the variables (Pesaran *et al*., 2001). As our variables are I(1), the cointegration relationship can be checked through Pesaran's bound testing approach. In the Table 3 below is given the results of cointegration bound test. As it is seen from the table, F-statistics values are higher than critical values at all levels. From here, we reject zero hypotheses of no cointegration and come to a conclusion that there is a long-run relationship among emissions from road transport with GDP, energy consumption and the population size.

Table 3. The results of cointegration test

Test Statistic	Value	k
F-statistic	10.30230	3
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.37	3.2
5%	2.79	3.67
2.5%	3.15	4.08
1%	3.65	4.66

The residuals of the model estimated by ARDLBT approach have been tested for serial correlation, heteroskedasticity, and normality tests, and also the specification of the model has been checked by Ramsey RESET test and all of the received results are adequate (The test results are not provided here, but they can be obtained upon request).

The estimated long-run coefficients of the model are given in Table 4. The coefficients of energy consumption and population variable are statistically and economically significant. Although GDP is significant economically by positive sign of coefficient, the 10.83% *p-value* shows its statistic insignificance.

Table 4. The estimated long-run coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
energy use	1.003568	0.215546	4.655930	0.0003
gdp	0.134004	0.078462	1.707880	0.1083
pop	3.356437	0.752122	4.462625	0.0005
c	-59.881574	14.345895	-4.174126	0.0008

According to the estimation results provided in Table 4, 1% increase in energy consumption in Azerbaijan leads to 1.004% increase of emissions of road pollutants from transport, and the 1% increase of population results in 3.356% increase in emission from transport.

7. Conclusions and recommendations

This research, investigated the impacts of the social and economic factors on atmospheric pollutants from road transports in Azerbaijan during 1990-2014 years. Based on the estimation results the EKC hypothesis does not hold for the emissions from transport and income relationship for Azerbaijani case. The impacts of real GDP, energy consumption and population size on emission have been studied for the long-run period employing ARDLBT approach.

On the basis of the obtained results of the assessment, 1% growth of energy consumption increases emission from motor transport to 1.004%, while the 1% increase in population size raises emission by 3.356 % in the long run period in Azerbaijan. The results of the study may be useful in terms of making adequate decisions in the decision-making mechanisms about the economic policy measures to reduce the emissions of road pollutants from the road transport sector.

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