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GDP GROWTH CONSEQUENCES FOR THE AIR POLLUTION LEVELS IN ARMENIA

Every year scientists, especially economists, pay more and more attention to environmental issues, since their existence and the risks of further aggravation threaten the possibility of sustainable economic development and ensuring public welfare. In general, the most urgent and risky of the environmental issues is the atmospheric air pollution, which is a negative result of the economic activity of the society, which causes the involvement of economic thought in assessing the impact of economic activity on atmospheric emissions.

In this work taking into account the best international experience in assessing the impact of economic activity on atmospheric emissions and in order to get an idea of the compliance of the RA economy with the green standards, with the help of econometric models, an assessment of the impact of GDP volumes on atmospheric emissions in Armenia has been carried out. In particular, within the framework of the study using the

ARDL model with time series, the dependencies between two key indicators have been studied: the volumes of harmful substances released into the atmosphere and the volumes of GDP in the period from 2000 to 2022, taking into account the impact of global economic crises. As a result, it has been revealed that in the short and long term there is a direct relationship between atmospheric emissions and GDP volumes, in particular, an increase in GDP by 1% in the short term in a given year, all other things being equal, leads to an increase in emissions by an average of 0.2% in a given year, and in the long term, an increase in GDP by 1%, all other things being equal, after 12 years will be accompanied by an increase in emissions by an average of 0.6%, which is quite worrying and is an impetus for the need of greening the RA economy.

Keywords: *atmospheric emissions, GDP, economic crisis, green economy, econometric models, ARDL model.*

JEL: Q53, Q57

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INTRODUCTION. Current events in the world force the public to pay more attention to ensuring the physical security of their own country. However, the remaining global problems are by no means gone and require immediate solutions. The transition from the brown economy to the green economy can be singled out among those problems.

In this regard, the study of the dynamics of the volume of harmful substances emitted into the atmosphere over a long period of time is of great importance. Note that the volume of emissions depends on many factors that describe different aspects of the country's economic development. In particular, one of the most important economic indicators - the dynamics of the country's gross domestic product, can be identified. This problem - the assessment of the possible impact of changes in GDP on atmospheric emissions - is not new in world scientific circles, but the time has come to understand the essence of these processes for the Armenian economy as well.

Nevertheless, the relevance of the analysis is due not only to the requirement for the formation of a stable and innovative economy, but also to the fact that much attention is paid to the problem of the formation of a green economy in Armenia, in particular, it is noted in the “Strategic Program for the Long-term Development of Armenia for 2014-2025” that environmental development priorities will be based, in particular, on the key provision that the environmental impact assessment and control system should be reviewed: business entities should be given a differentiated approach according to the degree of impact on the environment as a result of their activities. This will reduce the administrative impact on enterprises that have a limited impact on the environment, promoting the introduction of the best environmentally safe and resource-saving technologies, in the future ensuring the removal of old technologies with harmful emissions (p. 167). The following point is also

extremely important: appropriate economic and legal mechanisms for encouraging the introduction of green innovations will be developed in line with the decisions of the UN "Rio+20" sustainable development summit, including state and international support (p. 170). As a result, the successful implementation of the above-mentioned measures will lead to the creation of such a GDP, when the continuous decrease in the volumes of harmful atmospheric emissions will have a stable and long-term nature. There is still huge work to be done here, taking into consideration the current economic and geopolitical complex situation, as well as the various crises that have hit Armenia's economy. Therefore, the purpose of this analysis is to find out what effect the change in the RA GDP has on the volumes of harmful substances emitted into the atmosphere, if we consider the period of more than 20 years. On the other hand, it is interesting to understand whether there is a connection between the volume of atmospheric emissions and the crises of 2008-2009 and the coronavirus.

LITERATURE REVIEW. Any trend of changes in the volume of emissions has always been in the center of attention of researchers. Many analysts, researchers and experts, from different angles, have addressed the factors influencing the volumes of harmful substances emitted into the atmosphere. The approaches that try to connect the change in the abovementioned emission volumes with various spheres of people's economic activity are noteworthy.

At the same time, the quality of economic development is important here, which nowadays strongly depends on the level of environmental friendliness or “greenness” of the economy. In other words, humanity is currently striving to ensure such economic activity that causes the least damage to the environment. Analizing the experience of the countries that have been able to generate such a GDP, which was created, for example, through the significant use of renewable energy sources, we can state with high probability that the increase in GDP will lead to a decrease in emissions. The opposite process is also observed, when the economies are still operating in the brown zone, and time is required for a new transition. The conflicting results recorded by different researchers are conditioned by these realities. For instance, calculations carried out for large oil-producing countries in Africa revealed an inverse relationship between the volume of electricity production from renewable sources and emissions. On the other hand, there was a direct link between economic growth and emissions, as well as the level of trade openness and emissions. It follows that petrodollar revenues should be directed towards the introduction of renewable energy sources and the latest technologies that will contribute to the formation of a new quality of the economy, which will ensure a continued reduction in emissions (Abban et al., 2022, p. 12). The results of the study of the economy of post-Soviet and EAEU member Kazakhstan showed that a 1% increase in economic growth, energy consumption and urban development leads to an increase in

emissions on average by 0.14%, 0.81% and 1.28% respectively (Raihan & Tuspekova, 2022, Dynamic impacts of economic growth, p. 13). The results of the time series analysis of data from 1994-2018 in Vietnam showed that there was an inverse relationship between GDP and emissions on the one hand and FDI and emissions on the other. The researchers have come to the conclusion that the development of the economy and the growth of investments contribute to reducing the volume of emissions of harmful substances into the atmosphere, as they are aimed at maintaining the balance of environmental and economic policies (Bui et al., 2023, p. 10): In the period of 1990-2019 period, the dependence between per capita emissions and per capita GDP, electricity consumption and industrial output index was studied by including the leading countries with CO_2 emissions: Canada, Germany, Japan, Mexico, South Korea, Turkey and the United States. Interestingly, with an increase in GDP and the industrial production index by 1%, emissions increased by an average of almost 0.04% and 0.02%, and with an increase in electricity consumption by 1%, the increase in emissions was more significant - by 0.84%. In this case, the researchers emphasize the importance of promoting green technologies and renewable energy and the need to increase the rate of its implementation (Puntoon et al., 2022, p. 417-418). Another study examines the long-term relationship between economic growth and emissions in Peru. The results again show a positive relationship (Raihan & Tuspekova, 2022, The nexus between economic growth, p. 7). Similar relationships are also observed in Bangladesh. The analysis conducted with respect to the latter covers the period from 1990 to 2019, during which ARDL time series models were considered. The results indicate that economic growth increases emissions (Raihan et al., 2022, p. 13).

A significant part of the analyses is devoted to the study of the relationship between the crises and emissions. The researchers consider various crises, ranging from the financial and economic crisis of 2008-2009 to the coronavirus and the Russian-Ukrainian conflict. One of the studies emphasizes the fact that the coronavirus led to a decrease in emissions in the short term, but its impact on emissions in the long run remains uncertain. The researchers point out that during the active period of the coronavirus there was a decrease in emissions mainly as a result of a sharp decrease in activity in industry and other sectors, but in the long run the situation was starting to change again, taking into account the declines of coronavirus period (Guérin & Suntheim, 2021, p. 4-5). The situation observed in terms of emissions in China before and after the coronavirus crisis is explained in the same way (Wang et al., 2020, p. 6). One study on the relationship between crises and emissions examined the impact of the 1997 Asian financial crisis and the 2008 global financial crisis. Here, the results show that countries with different income levels react differently. In general, after the 1997 crisis and before the 2008 crisis, the relationship between renewable electricity and emissions was positive, and after the 2008 crisis it was negative (Wang et al., 2021, p.11).

As for the economic studies on atmospheric emissions in the RA, it should be noted that there are few of them, nevertheless, in one of the conducted studies, the national economic mechanism of atmospheric air protection was studied, the tools used and trends of atmospheric emissions by sources were analyzed, recording the necessity and possible ways of increasing the efficiency of atmospheric air protection (Gasparyan, 2022). And as for the research involving quantitative estimates of the relationship between atmospheric emissions and economic indicators in Armenia, it should be noted that, in our opinion, such investigations have not yet been conducted, which, in turn, emphasizes the relevance of this study.

RESEARCH METHODOLOGY. Within the framework of the research, dependencies between two main indicators are studied. One of the indicators is the volume of harmful substances emitted into the atmosphere (from stationary sources). This indicator includes such dangerous substances as sulfur anhydride, carbon monoxide, nitrogen oxides, etc. The statistical data on the volumes of harmful substances emitted into the atmosphere were taken from the Statistical Committee of the Republic of Armenia. The dynamics of the emission was studied with the help of a chart, including data from 2000-2022. The second key indicator is GDP, expressed in US dollars. This indicator is also considered for the period of 2000-2022 and the data are again taken from the RA Statistical Committee. Regarding the GDP indicator, we have a gap due to the change in methodology. We have the methodology of 1993, with the help of which the GDP is calculated for 2000-2014, as well as the methodology of 1998, in which the calculations are made for 2012-2022. In order to make the indicator comparable for the entire period under review from 2000 to 2022, the data were calculated using the 1993 methodology, which includes the period from 2000 to 2011, and were adjusted using the appropriate coefficient. The dynamics of GDP was also studied with the help of a chart. To study the impact of GDP on the indicator of harmful substances emitted into the atmosphere, ARDL models with time series were used. Both indicators are logarithmic to ensure the same dimensionality. In addition, a check of the stationarity of the considered time series was carried out, the results of which proved that the series presented above become stationary with second-order differences. The models were evaluated with different GDP lags, as a result of which the best one was selected from a variety of models according to quality criteria. In addition to the main factors, the "crisis" factor was also included to account for crisis situations between 2000 and 2022 and its impact on emissions. The latter is a dummy variable that takes the value 1 in the period from 2008 to 2009 and from 2019 to 2022 and zero in other years. The indicator describes two crisis situations: the global financial and economic crisis of 2008-2009 and the coronial epidemic crisis that began in 2019. It should be noted that the coronavirus problem is currently not critical, but it is not over yet. Other econometric tests and model

corrections were also applied to ensure the qualitative performance of econometric models.

ANALYSIS. Based on the paragraph of the "Strategic Program for the Long-term Development of Armenia for 2014-2025", which states the priorities for the development of the environmental sector, as well as the study of the literature presented within the framework of the research, we can note that the relationships between harmful substances emitted into the atmosphere and indicators of key economic importance are not only relevant from the point of view of their study, but also they differ greatly depending on the selected period, observed crises, countries, regions, income levels, levels of economic development, etc. Taking into account the points of view presented by various authors, this study examined the relationship between emissions and GDP, as well as between emissions and crises in Armenia. There are different versions regarding them. In particular, it can be assumed that the change in GDP in Armenia does not affect the change in emissions, which is the most unlikely option. It is possible that an increase in GDP leads to an increase in emissions. This version has been observed in many countries and some justifications have been given to it. And, finally, it is possible that GDP will increase and emissions will decrease. This version was also considered in a number of analyses and was explained by the fact that economic growth led to an increase in green investments, which, in turn, contributed to a reduction in emissions of harmful substances. The first level of testing these hypotheses for Armenia is to examine the dynamics of emissions and GDP indicators in the period 2000-2022 (see Figure 1).

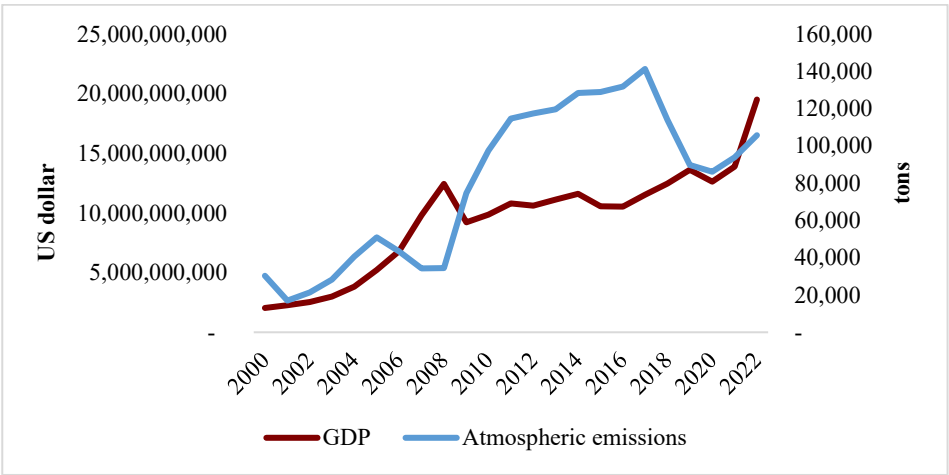

Figure 1. ***Atmospheric emissions (from stationary sources) and GDP dynamics in the RA in 2000-2022 (Statistical Committee of the RA)***

According to statistical data, in 2022, the GDP of the RA amounted to 19.5 billion US dollars. The latter has increased by 41% compared to 2021, and

about 10 times compared to 2000. Let us pay attention to the declines in GDP in 2008-2009 as a result of the global financial and economic crisis and in 2019-2020 due to the coronavirus crisis. In the period of 2000-2022, the maximum level of GDP was observed in 2022, and the minimum in 2000 - 2.04 billion US dollars. The volumes of harmful substances released into the atmosphere in 2022 amounted to 105,700 tons. The latter increased by 13% compared to 2021, and almost 4 times compared to 2000. Studying the dynamics of the emissions, we note that since the crisis of 2008-2009, an increase in the volume of emissions has been observed, and after the coronavirus crisis, there has been a decline. During the observed period, the maximum level of the volumes of harmful substances emitted into the atmosphere was observed in 2017 – 141,300 tons, and the minimum in 2001 - 17,000 tons.

In order to study the impact of GDP and crises on the volumes of harmful substances emitted into the atmosphere more deeply and thoroughly, let us turn to econometric models for help.

To achieve the above-mentioned goal, let us look at the ARDL econometric model below in a general way (1).

$$EM_t = \beta_0 + \beta_1 \cdot GDP_t + \beta_2 \cdot GDP_{t-1} + \beta_3 \cdot GDP_{t-2} + \cdots + \beta_i GDP_{t-i} + \cdots + \beta_k \cdot GDP_{t-k} + \gamma \cdot CR_t + \varepsilon_t, \quad (1)$$

Where:

EM_t – is the volume of harmful substances emitted into the atmosphere in the RA in year t,

GDP_t, GDP_{t-i} – are the volumes of the RA GDP in the t-th and t-i-th years, respectively,

$\beta_0, \beta_1, \cdots, \beta_i, \cdots, \beta_k, \gamma$ – are the unknown parameters of the model,

ε_t – is the random error of the model in year t,

t – is the year index, $t = \overline{2000,2022}$,

i – is the log index, $i = \overline{1,k}$.

Before evaluating the econometric (1) model, the indicators were logarithmized and the problem of stationarity of all variable series was considered. The performed calculations have shown that the series are not stationary and can become stationary after applying second-order differences. As a result, we can evaluate an econometric model with the following stationary series:

$$d(d(\log(EM_t)) = \beta_0 + \beta_1 \cdot d(d(\log(GDP_t)) + \beta_2 \cdot d(d(\log(GDP_{t-1})) + \beta_3 \cdot d(d(\log(GDP_{t-2})) + \cdots + \beta_i d(d(\log(GDP_{t-i})) + \cdots + \beta_k \cdot d(d(\log(GDP_{t-k})) + \gamma \cdot CR_t + \vartheta_t, \quad (2)$$

Where:

$d\big(d(\log(EM_t)\big)$ – are the variables defined above in logarithm and double-differenced form,

$d(d(\log(GDP_t)), d(d(\log(GDP_{t-i}))$ – GDP variables are in logarithm and second-order differences,

ϑ_t – is the random error of the (2) model in year t.

Different specifications of the (2) model were proposed, which were estimated by the method of least squares (Magnus et al., 2004, p. 10). As a result of the calculations, the following estimated econometric model has been selected.

$$d\left(d(\widehat{\log(EM_t)}\right) = \underbrace{-0{,}02}_{(0.2577)} + \underbrace{0{,}19}_{(0.0220)} \cdot d(d(\log(GDP_t)) - \underbrace{0{,}12}_{(0.0299)} \cdot$$
$$d(d(\log(GDP_{t-8})) + \underbrace{0{,}34}_{(0.0088)} \cdot d(d(\log(GDP_{t-9})) + \underbrace{0{,}36}_{(0.0031)} \cdot$$
$$d(d(\log(GDP_{t-10})) - \underbrace{0{,}14}_{(0.0050)} \cdot d(d(\log(GDP_{t-12})) + \underbrace{0{,}07}_{(0.0312)} \cdot$$
$$CR_t, R^2_{adj.} = 0.992, \quad (3)$$

Where:

$d\left(d(\log(EM_t)\right)$ – is the predicted value of the variable with the second order difference of the index of harmful substances emitted into the atmosphere at the t-th observation. The significance levels of each coefficient are indicated in parentheses below the coefficients.

$R^2_{adj.}$ – is the coefficient of directional determination that characterizes the quality of the model.

The evaluated model is of high quality. This is evidenced by the fact that the coefficient of determination is close to 1. As well as key econometric and statistical indicators are within the normal range. In particular, there is no autocorrelation in the model. The model is important in itself.

The obtained results show that in both the short and long term, there is a direct relationship between GDP and the amount of harmful substances released into the atmosphere. In particular, a 1% increase in GDP in the short term in a given year, all other things being equal, leads to an increase in emissions by an average of 0.2% in a given year. In the long term, when GDP grows by 1% in a given year, then, all other things being equal, emissions will increase by an average of 0.6% after 12 years. During the crisis years, emissions were on average 7% higher than in non-crisis years. It is noteworthy that in both post-Soviet states, Armenia and Kazakhstan, there is a direct relationship between emissions and GDP. This circumstance is also important from the point of view of general policy development within EAEU. First of all, this stems from the need to keep the competitiveness of the EAEU high. In this context, both countries are moving towards increasing the share of renewable energy sources in the energy sector. In Armenia, attention is paid to energy saving. In addition, a positive factor in these processes may be the development of the economic

activity of the society with the help of the latest green technologies, which will reduce emissions into the atmosphere. The obtained results once again remind the government of the need to act immediately, having in hand the short-term and long-term effects of GDP on the volumes of harmful substances emitted into the atmosphere. In the long term, the cumulative nature of emissions must be taken into account. That is, the fact that some types of emissions appear rather late. The significance of lagged GDP indicators is due to this circumstance. It is extremely important to study the experience of countries that have recorded concrete results in developing policies to direct economic growth to the reduction of emissions. Based on the relationship between emissions and GDP in the case of Armenia, as well as the new realities prevailing in the economy of Armenia and the South Caucasus, it is necessary to consider countries comparable to Armenia for comparison. It is important to take into account not only the successes recorded in the country under study, but also the period of failures. The latter will allow to review the situation around Armenia and offer unique solutions to the problem, avoiding mistakes that other countries have made. When considering the achievements, it is necessary to focus on those approaches that are realistic in the case of Armenia and will allow to ensure results at a progressive pace. In other words, if successful countries have achieved their goals in a certain period of time, then Armenia should study the possibility and strategy of localizing these results in shorter periods. In this case, an important circumstance may be the analysis carried out above, where the studied relationships are considered at once in two perspectives: long-term and short-term.

CONCLUSIONS. This analysis has focused on the impact of GDP and crises on atmospheric emissions in Armenia. The dependencies between these two factors can be traced in the investigations of many analysts. A number of studies have revealed positive relationships between the above-mentioned quantities, inverse connections between others, and there are also studies where the proposed connections are too weak. In any case, the state should pursue a balanced policy in order to ensure such an economic development that will not contradict the agenda of the green economy. For Armenia, the transition to the green economy, with the active use of the latest technologies, has a security significance. As the dynamics of the volume of atmospheric emissions in Armenia shows, in 2022, compared with 2021, emissions increased by 13%, and compared with 2000 - by about 4 times. At the same time, analyzing the dynamics of GDP volumes, we note that in 2022, compared with 2021, GDP increased by 41%, and compared with 2000 - by about 10 times. In this context, it is also necessary to understand the behavior of the above-mentioned indicators in the pre-crisis and post-crisis periods. In particular, there was a decline in GDP in 2008-2009 as a result of the global financial and economic crisis and in connection with the crisis caused by the coronavirus in 2019-2020.

In the case of the emissions indicator, it can be seen that since the beginning of the 2008-2009 crisis, there has been an increase in emissions, and after the coronavirus crisis, there has been a decline. By the way, these results are observed in different corners of the world and are evidenced by different authors' investigations. For a deeper understanding of the dependencies of harmful substances released into the atmosphere, GDP and crises, the ARDL econometric model was used in the study, this made it possible to observe the dependence of the volume of harmful substances emitted into the atmosphere on the lagged variables of GDP. Models with different specificity were considered, and the stationarity of the variable series was also taken into account. As a result, from a number of models with specification, the most optimal one has been selected according to quality criteria. The results obtained within the framework of the model reveal 4 important circumstances:

- Both in the short term and in the long term, there is a direct relationship between the atmospheric emissions and the GDP.
- In the short term, a 1% increase in the level of GDP in a given year, other things being equal, leads to an average increase in emissions in a given year by 0.2%.
- In the long term, when GDP volumes increase by 1% in a given year, then, other things being equal, emissions volumes will increase by an average of 0.6% after 12 years.
- Emission volumes in crisis years were on average 7% higher than in non-crisis years.

Such results are quite worrying and justify the need to implement measures aimed at greening the RA economy, particularly in the context of reducing atmospheric emissions.

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Application 1. (2) Econometric model estimation results

Dependent Variable: D(D(LOG(EMISSIONS__T)))
Method: Least Squares
Sample (adjusted): 2000 2022
Included observations: 9 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(D(LOG(GDP__USD(-9))))	0.34	0.0322	10.6	0.0088
D(D(LOG(GDP__USD(-8))))	-0.12	0.0218	-5.7	0.0299
CRISIS	0.07	0.0135	5.5	0.0312
D(D(LOG(GDP__USD(-10))))	0.36	0.0203	17.9	0.0031
D(D(LOG(GDP__USD)))	0.19	0.0290	6.6	0.0220
D(D(LOG(GDP__USD(-12))))	-0.14	0.0099	-14.1	0.0050
C	-0.02	0.0113	-1.7	0.2577

R-squared	0.998	Mean dependent var	0.01
Adjusted R-squared	0.992	S.D. dependent var	0.14
S.E. of regression	0.01	Akaike info criterion	-5.83
Sum squared resid	0.0003	Schwarz criterion	-5.68
Log likelihood	33.25	Hannan-Quinn criter.	-6.16
F-statistic	149.48	Durbin-Watson stat	2.09
Prob(F-statistic)	0.007	Wald F-statistic	568.31
Prob(Wald F-statistic)	0.002		

Application 2. Statistical data of the indicators used in the analysis

Date	*GDP (USD)*	*Harmful substances released into the atmosphere from stationary sources, (tons)*	*Crises*
2000	2,037,624,906	30,300	0
2001	2,258,176,615	17,000	0
2002	2,533,093,415	21,400	0
2003	2,992,318,531	28,200	0
2004	3,812,591,806	40,700	0
2005	5,223,738,994	51,000	0
2006	6,805,763,123	43,300	0
2007	9,813,751,592	34,200	0
2008	12,431,483,991	34,400	1
2009	9,218,613,750	74,700	1
2010	9,871,314,629	97,500	0
2011	10,811,297,701	114,600	0
2012	10,619,400,000	117,400	0
2013	11,121,300,000	119,700	0
2014	11,609,500,000	128,400	0
2015	10,553,300,000	128,900	0
2016	10,546,100,000	131,800	0
2017	11,527,400,000	141,300	0
2018	12,457,900,000	114,000	0
2019	13,619,200,000	89,700	1
2020	12,641,700,000	86,200	1
2021	13,878,900,000	93,800	1
2022	19,513,500,000	105,700	1