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Climate governance: Impact of air pollution Emittance on life expectancy of male and female in Uzbekistan

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Abstract
This study examines the impact of air pollution emissions on life expectancy in Uzbekistan, using panel data from 2011 to 2022. It assesses how air quality, alongside economic indicators, influences longevity. The findings indicate that increased air pollution significantly reduces life expectancy, with a one-million-ton rise in emissions decreasing life expectancy by about 5 years for males and 4 years for females. Economic factors such as GDP per capita positively affect life expectancy, while real income and the number of schools have varying impacts. Despite some insignificant results, the study suggests ongoing investment in environmental and educational improvements. Limitations include data constraints and methodological challenges, which could be addressed in future research. This study provides crucial insights into the complex relationship between air pollution and life expectancy, emphasizing the need for comprehensive policies to improve air quality and support economic development.

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Keywords: Air Pollution, Life Expectancy, Uzbekistan, Environmental Impact, GDP Per Capita

Introduction

In this research study, we will try to carry out empirical estimation of the impact of air pollution emittance on the life expectancy of people in Uzbekistan. Generally, this topic can be regarded as broader context of determining the true impact of air quality on life expectancy in the country. Apparently, sustainable development goals (SDG) initiated by the United Nations in 2015 is also a fundamental base for the wide range implementation in other countries as well. Specifically, World Health Organization (WHO) is also extensively engaged with indicators of Goal 9 on SDG, mainly regarding SDG target 3.9.1 that incorporates with significant reduction in deaths from air pollution [1]. However, we will try to indicate some variables in a way so that the impact of air pollution on life expectancy could be estimated in terms of air pollution emittances. In our empirical research, we do not only consider air pollution emittance as a main explanatory variable affecting life expectance but we also use economic indicators as well. The motivation for this research can be explained as a recent negative trends in air quality in different regions of the country with exceptional outlier referring to Tashkent. In recent months, air quality index of Tashkent has been recorded on upper part of ranking by air quality index revealed by WHO [2].

Even though admittance of the country to SDG and implementation of huge number of "green" projects, the environmental issues are still remaining one of the main causes negatively affecting the life expectancy in Uzbekistan. In line with theoretical views, we will review relevant research papers in the beginning of our study. Furthermore, a methodology part is supposed to provide detailed description of the methods and data that we use for empirical estimation.

[1] https://www.who.int/teams/environment-climate-change-and-health/air-quality-energy-and-health/policy-progress/sustainable-development-goals-air-pollution
[2] https://www.iqair.com/world-air-quality-ranking

Based on the empirical findings, we will describe the results highlighting the impact of air quality emittances and other economic and demographic factors on life expectance and provide relevant policy recommendations.

Literature Review

In this area denoting the impact of air quality on life expectancy, one may find limitless research papers conducted in different period. For example conducted a research on the impact of air pollution on life expectancy in China emphasizing its provinces during 1990-2017 and explored that the death rate due to air pollution declined up to approximately 60 percent from 1990 to 2017. In this regard, the authors found statistically significant impact of air pollution on life expectancy and the also highlighted that the average life expectancy of the population could have been 1.25 years longer under the condition of the absence of air pollution impact [3].

In the last decade also stated significant relationship between PM 2.5 (air pollution rate) and increased mortality, which, in turn, can be measured as a proxy variable in identifying the factors affecting the life expectancy. However, this issue may not be solved by efforts to achieve higher level of life expectancy through engagements in improving the quality of air. In fact, a fundamental matter lies between the government and scientific researchers in the context of possible biased results stating weather life expectancy could be improved by reducing the air pollution emittances. Because it costs not less to the economy to decrease air pollution emittance and to green the economy no matter whether life expectancy increases or not. In order to address this question, Tatyana conducted a research project on the effects of air pollution on the mortality and medical costs to the public in the example of the US. As a result, they found an interesting outcome that major impact of air pollution on life is observed mainly among vulnerable part of the society. The last statement also indicates that the impact of air pollution on life has some relevance to the welfare of the population that could be measured in terms of income or GDP per capita. In this occasion, we can dominantly refer to the impact of economic indicators on life expectance as well in accordance with air pollution rate [4].

Furthermore, causal relationship between the environmental quality and life expectancy over years revealed that the field of environmental economics plays considerable role in this case but this does not necessarily support permanent significance of air quality on the duration of life. Fabio conducted a research study by implementing the OGL model in order to determine the dynamic relationship between air quality and the life expectancy. In their findings, the major attention is focused on the attribution of investment in environmental "wellbeing", which might further add contribution to the average length of lifetime in the country. As a result, they explored that investment in environmental quality positively leads to life expectancy [5].

Finally, A. Rodriguez-Alvarez carried out empirical research using panel data on 29 countries in Europe for the period from 2005 to 2018 and discovered negative impact of air pollutants such as PM 10 and PM 2.5 and positive effect of investment in green projects including renewable energy on life expectancy [6].

Methodology

Basically, this part of the research focuses on detailed description of the dataset followed by the explanation of the methodology to be applied for conducting the regression analysis. In this project, empirical research approach has been selected and panel data containing demographic and economic indicators for the period 2011-2022 has been collected from the open data source of Statistics Agency of Uzbekistan. The data is sorted out by years and regions accordingly and it has the following indicators for the country:

Table 1: General statistics of variables

```
Summary statistics: count mean sd min max kurtosis skewness
     for variables: lifeexp_male lifeexp_female air_pollution ln_real_inc water_supply gdp_sh
> are ln_gdppc hospitals schools
```

	e(count)	e(mean)	e(sd)	e(min)	e(max)	e(kurto~)	e(skewn~)
lifeexp_male	168	71.44502	1.479632	67.9	74.9	2.694186	-.1860132
lifeexp_fe~e	168	76.00581	1.705889	72.1	82.2	4.61255	.7132601
air_pollut~n	168	65.49702	98.57636	2.9	619.2	12.52389	2.998675
ln_real_inc	168	8.762265	.6055179	7.512182	10.40857	2.450066	.1933207
water_supply	168	74.8227	15.28401	34.81801	100	3.093692	-.5711086
gdp_share	168	.0608777	.0319459	.0199997	.1669008	4.766379	1.356952
ln_gdppc	168	8.961514	.7409458	7.414573	11.09522	2.970664	.4057244
hospitals	168	82.81548	36.96732	28	164	2.010944	.3118984
schools	168	704.0476	278.679	298	1285	2.168867	.285316

The first two variables indicate average life expectancy of male and female in the country in different years and it is equal to about 71.4 years for men and 76 years for women respectively according to 168 observations. The variable in the third row expresses the average volume of air pollution emittances in thousands of tons. In addition, the dataset has economic indicators including GDP per capita and real income in logarithmic form as we are interested in the rate of increase over time rather than absolute. Furthermore, water supply factor refers to the share of houses with water supply

[3] https://www.thelancet.com/pdfs/journals/lanplh/PIIS2542-5196(20)30161-3.pdf

[4] https://www.nber.org/system/files/working_papers/w22796/revisions/w22796.rev0.pdf

[5] https://docs.iza.org/dp4564.pdf

[6] https://www.sciencedirect.com/science/article/pii/S004896972103552X

and GDP share represents the share of GDP of a particular region in overall GDP of the country during different years. Finally, number of hospitals and schools are also included in the dataset since they might have indirect impact. In addition, the following table represents correlation between individual variables:

Table 2: Correlation matrix

Matrix of correlations									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) lifeexp_male	1.000								
(2) lifeexp_female	0.677	1.000							
(3) air_pollution	-0.138	0.049	1.000						
(4) ln_real_inc	0.226	0.266	0.047	1.000					
(5) water_supply	-0.242	-0.026	0.040	-0.118	1.000				
(6) gdp_share	-0.039	0.284	0.372	0.294	0.460	1.000			
(7) ln_gdppc	0.229	0.300	0.144	0.976	-0.065	0.333	1.000		
(8) hospitals	0.147	0.146	0.023	0.098	0.445	0.606	0.049	1.000	
(9) schools	0.206	0.036	0.283	-0.237	-0.100	0.110	-0.261	0.351	1.000

For empirical estimations, we will apply OLS method followed by fixed effect and random effect models. For modification purposes, we will be estimating the impact of air pollution and other economic indicators on male and female life expectancy separately. Our econometric model is expressed as follows:

lifeexp_male /lifeexp_female = β0 + β1*air_pollution + β2*ln_real_inc + β3*water_supply + β4*gdp_share + β5* ln_gdppc + β6*hospitals + β7*schools + u

where the dependent variable will be lifeexp_male while conducting the impact of explanatory variables on it in case of male and lifeexp_female for the model estimation for female. Moreover, detailed description of explanatory variables is summarized on Table 1 above. Once we build our model, we can set the hypothesis in the following way:

Null hypothesis: air pollution emittances has negative impact on life expectancy;

Alternative hypothesis: air pollution emittances does not have any impact on life expectancy.

Based on a pair of models, we can estimate the true impact of air pollution emittances on the life expectancy using real data in the country.

Empirical findings and policy recommendations

Once we estimate our model to determine the impact of air pollution emittances and other factors on the life expectancy separately for male and female, we have obtained the following results on Table 3 and Table 4:

Table 3: Regression outcome for male

lifeexp_male	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
air_pollution	-.005	.001	-4.79	0	-.008	-.003	***
ln_real_inc	-4.274	.855	-5.00	0	-5.963	-2.585	***
water_supply	-.035	.01	-3.53	.001	-.055	-.015	***
gdp_share	-9.02	4.528	-1.99	.048	-17.963	-.077	**
ln_gdppc	4.158	.713	5.83	0	2.75	5.566	***
hospitals	.016	.004	4.46	0	.009	.023	***
schools	.001	0	3.22	.002	.001	.002	***
Constant	72.779	2.241	32.47	0	68.353	77.206	***

Mean dependent var	71.445	SD dependent var	1.480
R-squared	0.343	Number of obs	168
F-test	13.407	Prob > F	0.000
Akaike crit. (AIC)	552.794	Bayesian crit. (BIC)	577.786

Table 4: Regression outcome for female

lifeexp_female	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
air_pollution	-.004	.001	-3.02	.003	-.007	-.001	***
ln_real_inc	-3.455	1.116	-3.09	.002	-5.659	-1.25	***
water_supply	-.026	.008	-3.08	.002	-.043	-.009	***
gdp_share	15.514	5.708	2.72	.007	4.241	26.786	***
ln_gdppc	3.311	.927	3.57	0	1.48	5.141	***
hospitals	.004	.004	1.23	.22	-.003	.011	
schools	.001	0	1.35	.18	0	.001	
Constant	77.102	2.714	28.41	0	71.742	82.462	***

Mean dependent var	76.006	SD dependent var	1.706
R-squared	0.199	Number of obs	168
F-test	5.762	Prob > F	0.000
Akaike crit. (AIC)	633.974	Bayesian crit. (BIC)	658.966

According to the regression outcome, we can confidently state negative impact of air pollution emittances on the life expectancy of both male and female in the country. That is, additional million tons of air pollution emittance is supposed to decrease life expectancy by 5 years and 4 years for male and female respectively in Uzbekistan. On the contrary, real income has negative impact on the life expectancy even though it preferably contributes to the welfare of the population while GDP per capita has positive relationship. In addition, GDP per capita and the share of GDP of a particular region within overall GDP of the country have positive effect on the life expectancy. Finally, the number of schools and hospitals in the country has positive impact on the life expectancy of male but this impact is statistically insignificant in case of female. However, fixed effect and random effect models provide quite different tendency in the relationship between the life expectancy and other factors in the model. The following regression tables (Table 5 and Table 6) summarize empirical findings under the fixed effect model:

Table 5: Regression outcome for male under fixed effect model

Regression results							
lifeexp_female	**Coef.**	**St.Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**	**Sig**
air_pollution	.001	.002	0.50	.62	-.004	.006	
ln_real_inc	-2.92	1.209	-2.42	.017	-5.309	-.532	**
water_supply	.015	.009	1.78	.077	-.002	.032	*
gdp_share	-30.638	14.235	-2.15	.033	-58.769	-2.506	**
ln_gdppc	3.403	1.005	3.39	.001	1.418	5.389	***
hospitals	.007	.007	1.11	.268	-.006	.021	
schools	-.019	.005	-3.51	.001	-.03	-.008	***
Constant	84.429	3.154	26.77	0	78.196	90.662	***

Mean dependent var	76.006	SD dependent var	1.706
R-squared	0.336	Number of obs	168
F-test	10.611	Prob > F	0.000
Akaike crit. (AIC)	394.189	Bayesian crit. (BIC)	419.181

Table 6: Regression outcome for female under fixed effect model

Regression results							
lifeexp_female	**Coef.**	**St.Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**	**Sig**
air_pollution	.001	.002	0.50	.62	-.004	.006	
ln_real_inc	-2.92	1.209	-2.42	.017	-5.309	-.532	**
water_supply	.015	.009	1.78	.077	-.002	.032	*
gdp_share	-30.638	14.235	-2.15	.033	-58.769	-2.506	**
ln_gdppc	3.403	1.005	3.39	.001	1.418	5.389	***
hospitals	.007	.007	1.11	.268	-.006	.021	
schools	-.019	.005	-3.51	.001	-.03	-.008	***
Constant	84.429	3.154	26.77	0	78.196	90.662	***

Mean dependent var	76.006	SD dependent var	1.706
R-squared	0.336	Number of obs	168
F-test	10.611	Prob > F	0.000
Akaike crit. (AIC)	394.189	Bayesian crit. (BIC)	419.181

Based on fixed effect model, the obtained results, no significant relationship has been observed between life expectancy and air pollution emittance in both estimations for male and female. Instead, GDP per capita and number of schools are supposed to positively and negatively affect the life expectancy respectively. In a similar way, the random effect model indicates the following relationship level in the following manner:

Table 7: Regression outcome for female under random effect model

Regression results							
lifeexp_female	**Coef.**	**St.Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**	**Sig**
air_pollution	.001	.002	0.54	.592	-.003	.006	
ln_real_inc	-3.867	1.011	-3.83	0	-5.848	-1.886	***
water_supply	.013	.009	1.47	.143	-.004	.03	
gdp_share	-20.513	11.85	-1.73	.083	-43.74	2.713	*
ln_gdppc	3.934	.861	4.57	0	2.245	5.622	***
hospitals	.004	.006	0.63	.527	-.009	.017	
schools	-.001	.002	-0.65	.518	-.005	.002	
Constant	75.328	2.273	33.14	0	70.873	79.784	***

Mean dependent var	76.006	SD dependent var	1.706
Overall r-squared	0.007	Number of obs	168
Chi-square	54.248	Prob > chi2	0.000
R-squared within	0.279	R-squared between	0.007

Table 8: Regression outcome for female under random effect model

Regression results							
Lifeexp_female	**Coef.**	**St.Err.**	**t-value**	**p-value**	**[95% Conf**	**Interval]**	**Sig**
air_pollution	.001	.002	0.54	.592	-.003	.006	
ln_real_inc	-3.867	1.011	-3.83	0	-5.848	-1.886	***
water_supply	.013	.009	1.47	.143	-.004	.03	
gdp_share	-20.513	11.85	-1.73	.083	-43.74	2.713	*
ln_gdppc	3.934	.861	4.57	0	2.245	5.622	***
hospitals	.004	.006	0.63	.527	-.009	.017	
schools	-.001	.002	-0.65	.518	-.005	.002	
Constant	75.328	2.273	33.14	0	70.873	79.784	***

Mean dependent var	76.006	SD dependent var	1.706
Overall r-squared	0.007	Number of obs	168
Chi-square	54.248	Prob > chi2	0.000
R-squared within	0.279	R-squared between	0.007

Based on the results from the estimations under random effect model, we can confidently refer to the fact that real income and number of schools have negative statistically significant effect on life expectancy for both male and female while GDP per capita affects positively on the dependent variable. However, insignificant coefficient of air pollution emittance does not necessarily mean to neglect this factor as it might have joint significance no matter it is individually insignificant.

Furthermore, we can conduct Hausman test for model selection. According to Hausman test results in Table 9 below, fixed effect model is consistent.

Table 9: Hausman test for fixed effect and random effect models

```
                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random        Difference          S.E.
-------------+----------------------------------------------------------------
air_pollut~n |    .0012312     .0012312        5.01e-17               .
 ln_real_inc |   -3.867141    -3.867141        1.07e-12               .
water_supply |    .0127578     .0127578        7.98e-16               .
   gdp_share |   -20.51315    -20.51315        7.47e-12               .
    ln_gdppc |    3.933598     3.933598       -8.92e-13               .
   hospitals |    .0041076     .0041076       -2.01e-15               .
     schools |    -.001158     -.001158       -4.28e-16        1.11e-10
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        0.00
                Prob>chi2 =      1.0000
                (V_b-V_B is not positive definite)
```

Now we can extend the scope of the results to the possibilities of implementing the empirical results in the form of policy recommendations. First of all, the government should focus more on investing in the construction of schools since it has positive effect on the life expectancy. However, insignificant coefficient of air pollution emittance does not mean neglecting the projects in green economy in order to decrease air pollution emittance. Because the impact air pollution emittance could be significant in joint with other factors and this stimulates the government to accelerate to green the economy by taking measures to reduce air pollution emittances. For example, water supply rate might have joint significance with air pollution emittance that requires investment in water supply management projects by the government. Furthermore, negative effect of real income can be explained in a way that a person with higher real income is expected to have higher rate of spending which might cause to marginal air pollution emittances in forms of garbage.

Limitations

In this research analysis, we have to highlight some limitations as well since these limitations could be further evaluated and models could also be modified. Regarding the data limitations, we have faced a challenging case to find annual spending to decrease air pollution emittance by region. Moreover, we also experienced a methodological constraint that the methodology leaves behind the implementation of advanced comparison of the models used in this research. In fact, we have applied Hausman test for model selection but, indeed, we could have chosen even more advanced approach for this purpose. Finally, external validity can be the admittance of the country to green economy in later periods compared to the range of our data. In simple words, we used the data from 2011 to 2022 but the country started to focus more on green economy later during the second part of the period included in our dataset.

Conclusion

In this research study, we have conducted the estimation of air pollution emittance and other demographic and economic factors on the life expectancy in Uzbekistan. In order to provide better comparison, we have conducted this estimation for male and female separately. First of all, we have explained the main motivation for the selection of this topic. In fact, the importance of controlling air pollution emittance in the economy is considered as one of the major factors in transition to green economy. Moreover, relevant academic papers have been reviewed and appropriate research studied have been cited. Furthermore, we have explained the data and methodology implemented in the empirical part and empirical findings have also been explained in detailed way. Finally, policy recommendations based on findings have been proposed and limitations incurred in this research have also been stated. However, we could have obtained better and more sophisticated outcome if broader dataset with wide range of factors had been collected.

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