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Original Article

Atmospheric pollution as a factor of household expenditures on health, sport, and tourism. Results from the vector error correction model

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Abstract
Introduction: o fully understand the benefits of environmental regulations it is important to quantitate the impact of atmospheric pollutions on economic growth, regional development and society. This work concentrate mainly onthe relations betweenair pollution andsociety in the context ofaveragehousehold income and expenditures.Material and methods:Thestudy examines the causal relationships between expenditures on health, sport, and tourism, household incomes and air pollution across selected polish voivodships in years 2004–2019.A notable feature of this study is that it uses annual data disaggregated into quarterly data to obtain robust empirical results through avoiding a sample size problem.The study applies the vector error correction model (VECM) to analyze the long-term and short-term relationship between six variables, where $PM_{2.5}$(particulate matters) andCO (carbon monoxide) represents atmospheric pollution andhousehold budget is represented by disposable income and expenditures on health, sport, and tourism.Results:Pollution cause direct and indirect pressure on economy, as well as on individual household budget. First, the empirical results shows that air pollution directly affects health, especially when the concentration of harmful dusts and aerosols in the air is high.Second, the air pollution influence the expenses on health indirectly, through the state of health, where the individuals are forced to make expenses to treat the disease caused by air pollution, or for the prevention of potential diseases caused by air pollution.Third, the air pollution also cause the pressure on sport expenses and tourism expenses of household. Conclusion:Atmospheric pollution can impact economic outcomes, as well the atmospheric pollution can be driven by economic activity on different levels of aggregation.Air quality is also an important factor for making decisions about leisure and recreation. Sport activity, as a way of spending free time, has positive effect on health. Physical activity alsoinfluencethe reduction of health expenditure in long term, butalso has a potential to increase the expenditures on sport and recreation.
Keywords: air quality, household budget, disposable income, health, sport and tourism, vector autoregression model

Introduction

Air pollution is one of the most important environmental problems facing humanity. Many research provides the conclusions, that exposure to smog has a negative and severe consequences for humans health. It cause the majordiseasesrelated with respiratory system, cardiovascular system and increases the risk of cancer(Bartman, 2020). In current situation, related with pandemic of COVID-19 disease, the air quality is very important. Early studies shows, that there exists a positive correlation between the air pollution and the spread of virus Sars-Cov-2, which cause the disease (Comunian et al., 2020). Moreover, the air pollution (especially $PM_{2.5}$, NO_2 and SO_2) shows positive relation with COVID-19 cases, hospital admissions and deaths. The researchers presents that increase in PM2.5 increase morbidity to COVID-19, increase the hospital admissions and increase death(Cole et al., 2020). This shows how important for our health is the quality of air we breathe. Also, the pandemic situation is changing daily life habits and has a negative repercussions for physical and sport activity, due to the social restrictions imposed by governments (Raiola & Di Domenico, 2021).

Besides endangering health and shortening lifespan, air pollution adversely affects economic productivity (Pandey et al., 2021). As shows Pandey et al. (2021) the diseases related to air pollution negatively affect the labour supply, which reduce the productivity in economy.Moreover, the economic burden of disease outcomes is visible in public health-care system via health-care expenditures, where the more people suffers from diseases the higher is costs of health care. Chen and Chen (2021) finds that the mechanism of transmission is through diseases occurrence and diseases severity to increase health expenditures(Chen & Chen, 2021).A certain proportion of the economic cost of healthcare can be reduced by promoting and encouraging physical activity, because sport activity is a key contributor for long-term psychological and physiological health (Drenowatz, 2021).

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Air pollution, and more broadly, environmental pollution, affects the economy not only on a macro scale, but is also a significant burden for the budget of every household. Air pollution directly or indirectly shape the expenditure structure of each household through the decision they make. What to buy, where to go on vacation, how to spend a free time. As Wang and Zheng (2020) presented the air pollution and exposure to pollutants lowers travel demand. They highlights the fact that clean air is important factor for travel decision as well as for consumption decision. A deeper understanding of travel effect and consumers' demand at different levels of air pollution exposure can help policymakers, retailers and small business owners for better allocation of public and private money to mitigate the negative impacts of air pollution on travel and consumption decision (Wang & Zheng, 2020).

There is substantial evidence from developed countries, that the ambient air pollution has a significant effects on economy, society and every human being. Searching through the academic papers, we have identifies numerous empirical studies that are relevant to the air pollution-economy nexus. However, it is necessary to distinguish the economic effects of air pollution in the context of general economic development, regional development and individual household budgets of citizens. Several empirical studies showed the negative impact of air pollution to human's health (Kurata et al., 2020; Raju et al., 2020; Tainio et al., 2021), as well as showed the negative impact on health expenditure(Chen & Chen, 2021; Yang & Zhang, 2018). Chen and Chen (2021) implies that air pollution rises health cost in economy, and Yang and Zhang (2018) (Yang & Zhang, 2018)(Yang & Zhang, 2018)(Yang & Zhang, 2018)(Yang & Zhang, 2018)quantitated the effect of air pollution on healthcare expenditure, where 1% increase in yearly exposure of particulate matter ($PM_{2.5}$)cause increase in household healthcare expenditure nearly 3%.Also, Martinez et al., (2018) showed that the long-term exposure to particulate matter causeda significant mortality and illness,as well the decrease in concentrations of $PM_{2.5}$will decrease premature mortality and morbidity.Decrease in concentrations of $PM_{2.5}$will benefits the economy through decreasing related costs(Sanchez Martinez et al., 2018). As Saenz-de-Miera and Rossello (2014) showed that a 1% increase in tourist numbers can increase PM_{10} levels up to a 0,45%. This means the tourist activity is a factor for worsening quality of air (Saenz-de-Miera & Rosselló, 2014). But also, the poor air quality is a important factor in the decision-making process regarding the direction of tourism activity. Wang and Zheng (2020) showed the air pollution and exposure to pollutants lowers travel demand and hence, it lowers expenditures on tourism.Churchill et al. (2020) showed that growth of both air pollutants (CO_2 and $PM_{2.5}$) adversely affects international tourist arrivals(Churchill et al., 2020).Taking into account a physical activity, Lü et al. (2015) showed that worsening air quality causes significant problem for promotion of outdoor physical activity. Physical activity is known to be highly beneficial to health, however exercises in a polluted environment may increase health risk (Lü et al., 2015). As Tainio et al., (2021) showed the physical activity and air pollution are linked through several mechanisms. Air pollution is negative and important health risk factor, but physical activity is a positive important health factor. However, epidemiological studies lead to mixed results interaction between health, air pollution and physical activity(Tainio et al., 2021).

Definitely less empirical work is devoted to the impact of air pollution on household expenditure for physical activity and tourist activity.This paper tries to fill this gap by analyzing the concentration levels of air pollution on household budgets.

Taking into account the multidimensional aspect of air pollution and the impact on each factor of socio-economic life, an attempt was made, to examine the impact of air pollution on household expenses related to sports, health and tourism.The purpose of this research is to investigate the dynamic relationship between household expenditures on sport, recreation and tourism, household incomes and air pollution in six polish regions (Kuyavian-Pomeranian, Łódź, Masovian, Lower Silesian, Subcarpathian and Lublin) between the periods of 2004 to 2019.This study contributes to the literature in several ways. Firstly, it contributes to raising public awareness of the negative impact of air pollution on the health and lifespan. Secondly, it fills the research gap that relates to the impact of air pollution on changes in the structure of household expenditure related to expanses on sports, health and tourism.And last, the selection of regions according to the level of development allows to indicate whether there are differences in the causality between expenditure, income and air pollution due to development of regions. In order to achieve the aim of the paper, the followinghypothesis was formulated: *Air pollution affects the expanses on sport, health and tourism in the long term and short-term, regardless of the level of region's economic development.*

The rest of the paper is organized as follows. Section 2 presents the methods and data description. Section 3 provides the results of the research, including the Granger causality analysis and impulse response analysis in selected regions. Finally, section 4 and 5 presents discussions and conclusions.

Methods and data

Vector autoregression and impulse response analysis

A Vector Error Correction model (VECM) is a restricted Vector Autoregression model (VAR) created to test the co-integration in the system of first ordered time series ($I(1)$). The basic form of VAR model takes the following form(Juselius & MacDonald, 2000):

$$Y_t = A_0 + \sum_{i=1}^{p} A_i Y_{t-i} + \varepsilon_t \quad (1)$$

where Y_t is a column vector with *j* endogenous variables, Y_{t-i} includes *i*-th lagged value of endogenous variables. A_0 denotes a vector of intercept, A_i is a matrix of parameters and ε_t is a vector of disturbance terms.
If all variables are co-integrated, the VAR models can be written as a first-differenced error correction form. Then the model takes the following form(Juselius & MacDonald, 2000):

$$\Delta Y_t = A'_0 + \Pi Y_{t-1} + \sum_{i=1}^{p-1} A'_i \Delta Y_{t-i} + \xi_t \quad (2)$$

where ΔY_t is a column vector of first differenced endogenous variables, Y_{t-i} includes *i*-th lagged value of first differenced endogenous variables. A'_0 denotes a vector of intercept, A'_i is a matrix of short-run parameters in co-integrated system and ξ_t is a vector of disturbance terms. Π is a matrix (with dimension *r* x *j*) of coefficientswith information on long-run relationship between variables, *r* is the number of co-integrating vectors.

The VECM model has been widely used tool in the econometric analysis. Using the VECM model, it is possible to examine the relationships among all endogenous variables, in both, long- and short-term. Also, the model is able to capture the complete dynamic linkages in analyzed system of variables. In context of the research, it allows us to measure the direct or indirect influence of air pollution to household expenditures and incomes per capita.

Based on the estimated VECM model, the Granger causality test was performed. Operational definition of Granger (1969) causality in time domain is formulated for wide sense stationary time series and it is based on forecasting errors. The VAR representation of the time series can be used in forecasting and has the form (Osińska, 2009):

$$\Theta(L) z_t = \varepsilon_t \quad (3)$$
where $z_t = [x_t, y_t]'$ and $\Theta(L) = I - \Theta_1 L - \cdots - \Theta_p L^p$.

Moving average representation takes the form:

$$z_t = \Phi(L)\varepsilon_t = \begin{bmatrix} \Phi_{11}(L) & \Phi_{12}(L) \\ \Phi_{21}(L) & \Phi_{22}(L) \end{bmatrix} \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix} \quad (4)$$

The forecast variance of x_{t+1} conditional on X_t is denoted by $\sigma^2(x_{t+1}|X_t)$. Also the forecast variance is calculated with additional information about Y_t and takes the form $\sigma^2(x_{t+1}|X_t \cup Y_t)$. The above allows to formulate that the variable y_t is Granger cause for x_t if (Osińska, 2011):

$$\sigma^2(x_{t+1}|X_t) > \sigma^2(x_{t+1}|X_t \cup Y_t) \quad (5)$$

The hypothesis that y_t does not cause x_t in time domain implies a linear restriction for the coefficients in the regression equation:

$$x_t = \alpha_1 x_{t-1} + \cdots + \alpha_p x_{t-p} + \beta_1 y_{t-1} + \cdots + \beta_p y_{t-p} + u_t \quad (6)$$

Data description

The main goal of the study is to examine the relationships between householdexpenditures, incomes per capita and air pollution for six regions in Poland.The paper employs six variables in the empirical analysis, four economic indicators and two environmental indicators.
Economic indicators:
Health – household expenditures on health (per capita, in PLN)
Recreation – household expenditures on sport, recreation and culture (per capita, in PLN)
Tourism – household expenditures on tourism (restaurant and hotels) (per capita, in PLN)
Income – household incomes (per capita, in PLN)
Environmental indicators
CO – carbon monoxide – average value [mg/m^3]
PM2.5 – particulate matter with diameter less than 2.5 *μm* – average value [$\mu m/m^3$]

The impact of air pollution on health is an issue that increasingly appears in scientific research. The awareness of society on health consequences of environmental pollution is still improving(Adamkiewicz, 2016). However there is still lack of research that shows how the atmospheric pollutions affects the household budget and how it disrupts the structure of expenses through the spending on health, sport and tourism.

Both, carbon monoxide (*CO*) and particulate matter (*PM2.5*) are a components of smog, where the impact of eachon every human life is harmful and even fatal in the long term. High concentration of particulate matter of less than 2.5 μm in aerodynamic diameter increases the risk of cardiovascular illness and even death (Gładysz et al., 2010). Hence, the above-mentioned environmental factors were selected in the assessment of the impact of air pollution on the structure of households expenses and incomes.

In the analysis the annual data from 2004 to 2019 were used. All data were converted to quarterly observations by means of the Denton-Cholette method(Tahir et al., 2018)to take advantage of larger number of observations when estimating the VECM model.Annual data for income and expenditures were collected from the Local Data Bank (https://bdl.stat.gov.pl/BDL/start). The annual data for air pollution (*CO* and *PM2.5*) were collected from database of Chief Inspectorate of Environmental Protection (https://www.gios.gov.pl/en/).

The regions have been selected based on level of averageincome per capita earned by households. Due to the average per capita income, three groups of region were established: low, medium and high income regions (Table 1). To the group of low-income regions the Subcarpathian and Lublin Voivodeship have been classified. The medium-income group is the Kuyavian-Pomeranian and Łódź Voivodship. The high-income group of regions includes Masovian and Lower Silesian Voivodships.

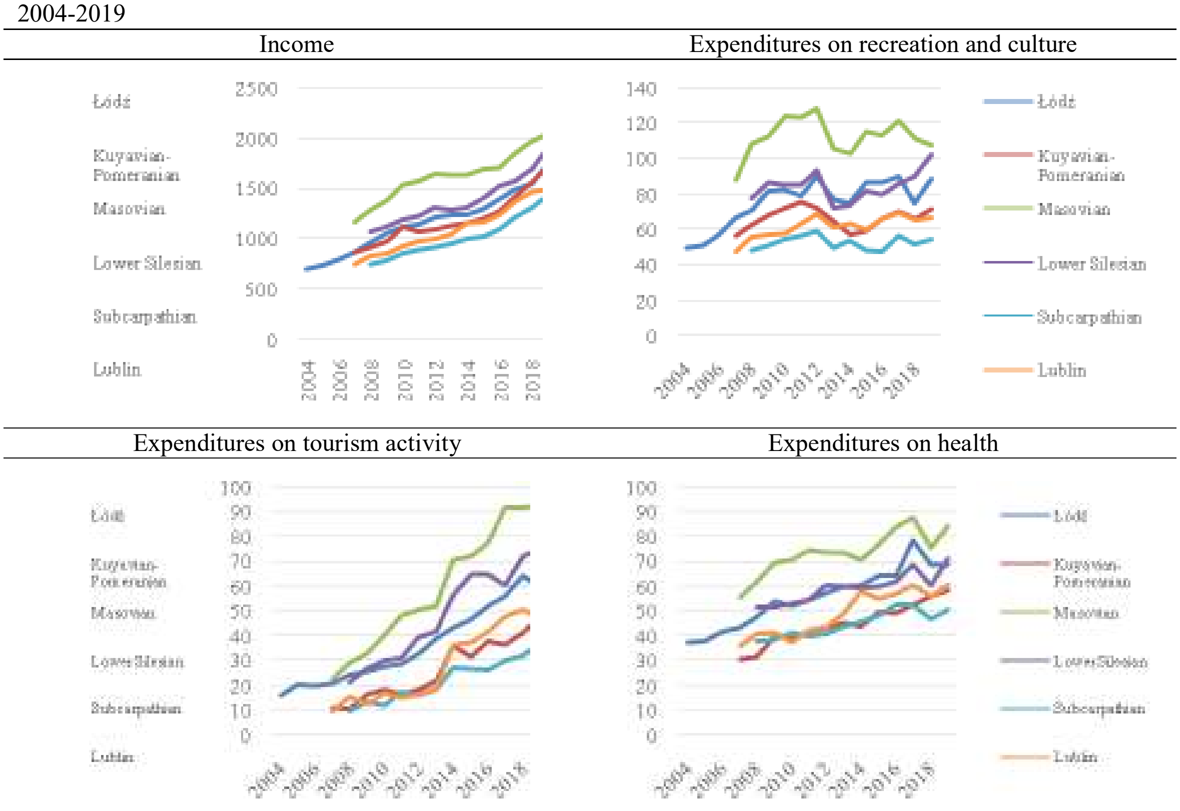
Table 1. Regions used in research

Group of regions	Region	
Low income region	Subcarpathian	Podkarpackie Voivodeship
	Lublin	Lubelskie Voivodeship
Medium income region	Kuyavian-Pomeranian	Kujawsko-Pomorskie Voivodeship
	Łódź	Łódzkie Voivodeship
High income region	Masovian	Mazowieckie Voivodeship
	Lower Silesian	Dolnośląskie Voivodeship

Source: own evaluation.

Fig 1 shows that all regions exhibited similar patterns of income and expenditures evolution, i.e., there has been a substantial increase in earned per capita income in all voivodeships. However the increase of income varies across regions, where the highest increase we can observe in Masovian and the lowest increase in Subcarpathian region. In recent years, the expenses on tourism activity, as well as expenses on health shows the increasing development trends. The levels of expenditures are drawing (quite clearly) the groups of regions with different levels of development. In voivodships with a highlevel of developments (Masovian and Lower Silesian), expendituresare higher than in voivodships classified as regions with a lower level of developments (Subcarpathian and Lublin). In the case of expenditures on sport, recreation and culture, the increases of expanses over the time span are smaller than in other analyzed types of expenditures. Households in high-income regions (Masovian and Lower Silesian) show the highest spending on sports and recreation, and the lowest in low-income regions (Subcarpathian and Lublin) (see Fig 1 - Expenditures on recreation and culture).

Fig 1. Income, Household expenditures (on health, sport and tourism) and air pollution (CO and PM2.5) in years 2004-2019



Air pollution ($PM_{2.5}$ emission)	Air pollution (CO emission)

Source: own evaluation.

Particulate matter ($PM_{2.5}$) concentrations have slightly decreased in recent years. The most improving is Subcarpathian region, where the concentration of $PM_{2.5}$ has decreased from 40 to 20 $\mu m/m^3$. The other analyzed regions showed greater fluctuations in the emission of pollutants (see Fig 1 –$PM_{2.5}$ emission). In 2019 all regions showed a similar value of emission, oscillating around 19-22 $\mu m/m^3$. In the case of emission of carbon monoxide (*CO*) analyzed regions showed a similar – decreasing – path. However, the differences between regions are more visible. In 2019 the region with the highest value of CO emission was Łódź voivodship (medium income group of regions), but the lowest emission of CO has been reported in low-income regions (Subcarpathian and Lublin)(see Fig 1 – CO emission). This description shows that Polish regions are improving, however the amount of emission is still high. This draws the most important air pollution-related problem in polish regions, which is the emission from municipal and household sources and the increased consumption of solid fuels for heating purposes in the heating season(Adamkiewicz et al., 2021).

Research results

Integration and co-integration analysis

Since the data selected in this research are all time series, in order to avoid a spurious regression, it is necessary to conduct a unit root test for each variable in all regions before the main analysis.Table 2 presents the results of the ADF-GLS unit roots test in levels and first differences. The results of test confirms that all variables used in research (health, recreation and tourism expenditures, income per capita and air pollution) in all six regions are integrated of first order $I(1)$. The ADF-GLS test results for Subcarpathian region are inconsistent for recreation spendings and CO-air pollution, wherethe null hypothesis of non-stationarity is rejected for levels (test with constant and trend ($c+t$)), what means that *recreation spendings*and *CO – air pollution* could be a stationary process. However, the KPSS test (where the null hypothesis of stationarity is rejected for levels) suggest the first order of integration ($I(1)$) for variables in Subcarpathian region (see Tab. 2). Because of the inconsistence in ADF test, we diced to take the KPSS test results under consideration. Hence, all variables, in levels are $I(1)$ variablesthen the cointegration analysis were conducted in next step.

Table 2. ADF-GLS unit root test results

	ADF-GLS (Levels)[1]						ADF-GLS (1st differences)[2]					
	M	LS	KP	Ł	S	L	M	LS	KP	Ł	S	L
Health	-1.79	1.07	-1.59	-1.66	-1.75	-2.05	-3.91 ***	-3.08 ***	-3.07 ***	-2.22 ***	-1.75 *	-2.67 ***
Recreation	-1.14	-2.74	-1.65	-1.07	-4.08 ***	-0.89	-1.9 *	-1.69 *	-2.81 ***	-2.81 ***	-2.15 **	-2.21 **
Tourism	-1.35	-1.60	-1.24	-1.46	0.09	-1.58	-1.54	-3.19 ***	-2.02 **	-2.41 **	-2.95 ***	-2.84 ***
Income	-1.65	-1.32	-1.39	-1.43	-1.64	-1.95	-2.90 ***	-3.85 ***	-2.10 **	-1.34	-2.89 *	-4.31 ***
CO	-1.10	-2.22	-2.84	-1.42	-3.74 **	-1.31	-3.08 ***	-3.65 ***	-2.17 **	-4.36 ***	-1.35	-3.19 ***
PM2.5	-1.06	-1.01	-2.71	-0.75	0.37	-2.24	-2.74 ***	-1.62 *	-4.22 ***	-2.30 **	-1.96 **	-4.21 ***
1%	-3.77						-2.62					
5%	-3.19						-1.95					
10%	-2.89						-1.61					

[1] ADF-GLS (version with constant and trend); [2] ADF-GLS – version with constant
M – Masovian, LS – Lower Silesian,KP – Kuyavian-Pomeranian, Ł – Łódź, S – Subcarpathian, L - Lublin
*,**,*** denotes rejection of the hypothesis at the 0.10, 0.05 and 0.01 significance level, respectively
Source: own evaluation.

Before the Johansen co-integration test was performed, the optimal lag length was determined according to AIC (Akaike Information Criterion) criterion. The optimal lag length obtained for all regions used in the research is equal 2.The vector of variables used in cointegration analysis and VECM model construction in all six regions takes the same form:

$$[health_t \quad recreation_t \quad tourism_t \, income_t \quad co_t \quad pm2.5_t]$$

The Johansen methodology involves two test for cointegration analysis:trace test and maximum-eigenvalue cointegration rank (r) test. The null hypothesis in trace test takes the form $H_0: r \leq q$ against alternate hypothesis $H_1: r = q$. The null means that there exist at most *q* linearly independent cointegrating vectors. The maximal eigenvalue test has a null hypothesis $H_0: r = q$ there are *q* cointegrating vectors, against $H_1: r = q + 1$ there are *q*+1 cointegrating vectors (Johansen (1988)). In this paper we present only the results for maximum-eigenvalue test, which are displayed in Table 3.

Table .3 Johansen's cointegration test results

Hypothesized No. of CE(r)	**High income regions**		**Medium income regions**		**Low income regions**	
	Masovian	Lower Silesian	Kuyavian-Pomeranian	Łódź	Subcarpathian	Lublin
None	0.761 *	0.908 *	0.573 *	0.515 *	0.773 *	0.767 *
At most 1	0.548 *	0.801 *	0.553 *	0.481 *	0.619 *	0.637 *
At most 2	0.530 *	0.563 *	0.516 *	0.317	0.601 *	0.505 *
At most 3	0.374 *	0.433 *	0.396 *	0.131	0.526 *	0.419 *
At most 4	0.176	0.329	0.246	0.085	0.390	0.201
At most 5	0.041	0.043	0.079	0.016	0.054	0.122

Source: own evaluation.

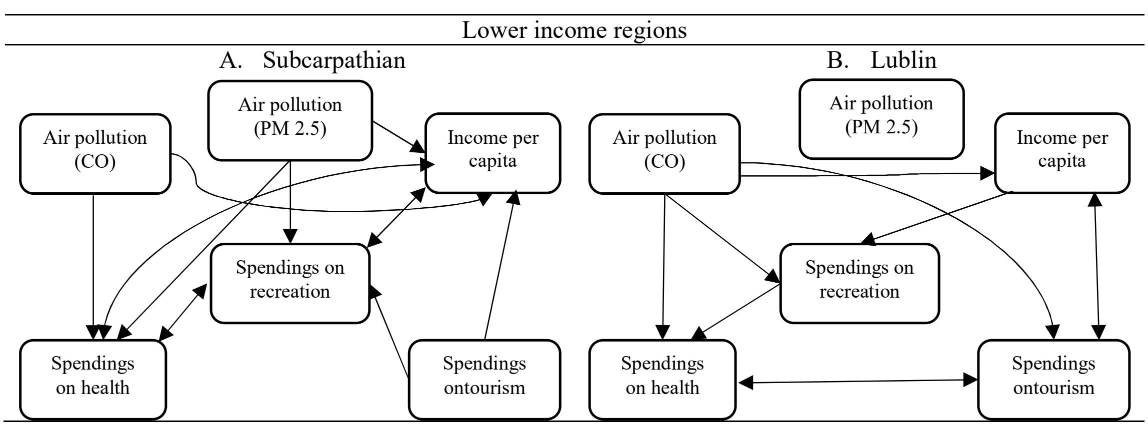
According to the results in Table 3, there are evidence of valid cointegrating relationships in analyzed regions. For high income regions (Masovian and Lower Silesian Voivodeships) a three valid cointegrating relationships were found. In the case of medium income regions the max-eigenvalue test confirms three valid cointegrating relationships for Kuyavian-Pomeranian Voivodeships, and single cointegrating relationship for Łódź Voivodeships. When we consider the low income regions, the max-eigenvalue test shows three valid cointegrating relationships for Lublin and Subcarpathian Voivodeships.

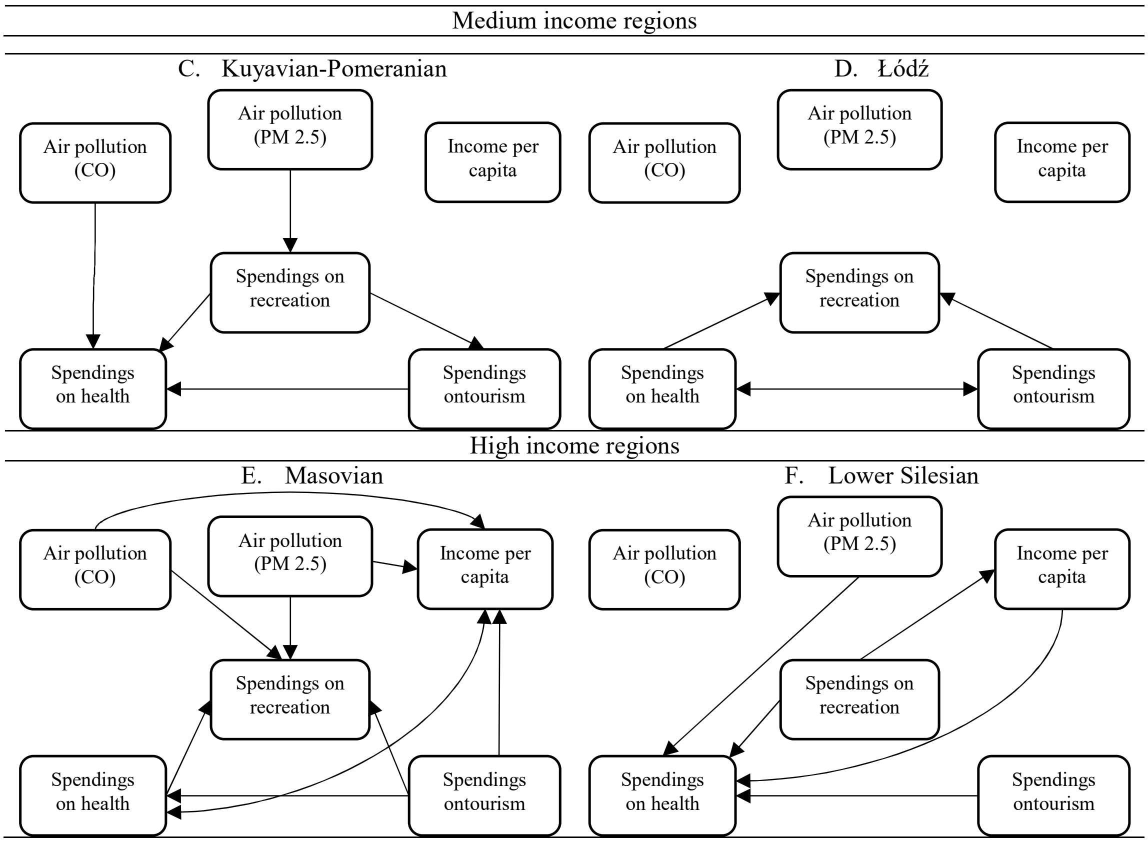
VECM models and Granger causality

Next, the vector error correction models (VECM) for considered regions were calculated.Whole report on the coefficients of the VECM models is available on the request from authors. As we have found a valid long-run relationships between variables in all regions, as well as we estimate the coefficients of VECM models, we can now to run a tests for Granger causality.

Full Granger causality test results are presented in Appendix (**Table A.1**). However, based on causality results we have built a Graner causality pattern graphs, which shows the direction (running form – to) and type (unidirectional or bidirectional) of causality between variables (Scheme 1).

Scheme 1. Short-run causalities among variables in selected regions.





Source: own evaluation.

In lower income regions (Subcarpathian and Lublin) exists a bidirectional causalities between income and different types of spending, for example in case of Subcarpathian region spending on recreation is Granger cause for income, as well as income is a Granger cause for spending on recreation. In Lublin region there is a significant bidirectional relation between income and spending on tourist activity.

This results suggest, that every expenses on higher-order goods or services (such as sport equipment or going to restaurant) is well-thought out. Moreover, in the remaining groups of regions (medium and higher income) such relationships have not been identified (Scheme 1). The neutrality of spending on recreation and tourist activity in relation to income (in groups of medium and higher income) may suggest a greater freedom in disposing of the income that households earned.

Air pollution are the Granger cause for income and spending in polish households. Moreover, we analyzed two types of air pollutant (carbon monoxide (CO) and particulate matters (PM2.5)) and based on Granger causalities we can say that air pollutions have an impact on structure of spending in polish household regardless of the level of development of the region. However, some differences between regions exists, which are related with financial possibilities of households as well as the intensity and concentration of pollutant in the air.

In Masovian (high income region), both, CO and PM2.5 are the Granger cause for spending on recreation. In Lower Silesian region, there is short-run unidirectional causal relationship running from PM2.5 to spending on health. This shows, that the increasing concentration of particulate matter in the air increases the spending on health. Also, the persisting dependence in the long term is affecting negatively the economy of the entire country.

Unidirectional causal relationship is also identified between CO emission and households health spending in Subcarpathian, Lublin and Kuyavian-Pomeranian regions. In the case of Subcarpathian and Kuyavian-Pomeranian regions, there is short-run unidirectional causal relationship running from PM2.5 to spending on recreation. It shows that, air quality is important for making decisions about leisure and recreation. The choice of sports activity as a way of spending free time has positive effects not only on health, but also on the reduction of health expenditure in long term.

Discussion

In high-income regions, there is a causal link between income and health expenditure. In middle income regions, there is a neutrality between income and expenditure. Low-income regions show a contribution between income and expenditure on sport and tourism.The results of the analysis shows that carbon monoxide (CO) as well as particulate matter (PM2.5) are associated with household incomes and expenses. This results imply that the increase in expenses on health and sport are related to an increase in CO emission and concentration of PM2.5 aerosol in air. Air quality is an important factor that determines health directly, but also indirectly affects the amount of health-care costs. Brunekreef and Holgate (2002) shows that exposure to pollutants has been associated with increase in mortality and hospital admissions due to respiratory and cardiovascular disease (Brunekreef & Holgate, 2002). Also the air pollution rises health cost and has heterogeneous effects related with income, insurance or education (Chen & Chen, 2021). However, it is worth to notice that estimating the causal relationship between air pollution and economic outcomes at an aggregate level (for example regional level)is challenging because of the bidirectional causality. Atmospheric pollution can impact economic outcomes(like household disposable incomes, as well as household expenditures which are related to pollution through indirect channels of transmission (health channel or economic status)),but the atmospheric pollution can be driven by economic activity on different levels of aggregation.

Thechanges in distribution of income in terms of household budgets can mean that the households pay more attention to quality of life, health protection and sport activity. A growing percentage of spending on health protection in households may indicate certain tendencies improving the living standard of the Polish society.On the other hand, the increase in health expenses can be caused by deterioratingcondition of the natural environment (most of all the air pollution) which is an important factor for good health.

In health promotion and other fields of prevention the physical activity is one of the key concepts in health improvement and counteraction of risk factors. Healthy value of physical activity is confirmed mainly by epidemiologic investigations(Jethon, 2013).However, as Tainio et. al. (2021) showed the air pollution can adversely impact physical activity on overall level or can reduce outdoor physical activity during high air pollution days.This means, the air pollution have a potential to reduce outdoor physical activity, but also have a potential to increase the expenditures on sport, because as a alternative for outdoor activity we choose a activity in fitness clubs, gyms and other sport facilities, which increase the amount of individual spending on sport activity.

Conclusion

In this paper, the relationship between household expenditures on sport, recreation and tourism, household incomes and air pollution in six polish regions (Kuyavian-Pomeranian, Łódź, Masovian, Lower Silesian, Subcarpathian and Lublin) was studied with a special interest in Granger causality analysis. First, the Johansen procedure provided evidence that expenditures on sport, health and tourism, income, CO emission and $PM_{2.5}$are cointegrated in all regions. Second, based on VECM model, Granger causality test was performed and able to confirm the short-run relationship between household expenses, incomes and air pollution.

In the paper, the followinghypothesis was formulated: *air pollution affects the expanses on sport, health and tourism in the long term and short-term, regardless of the level of region's economic development.* Based on results, the mentioned hypothesis was not rejected. Air pollution affects health, especially when the concentration of harmful dusts and aerosols in the air is high.Then, indirectly, through the state of health, they influence the expenses on health, individual expenses of households as well as governmental healthcare expenses.

Another conclusion from the research is that the level of economic development of the region is not a factor differentiating the negative relationship between expenditure and the level of air pollution. What matters is the amount of income earned by households, as well as the possibility of using certain savings to increase expenditure on health or sports activities, which is a determinant of health.

Conflicts of interest - There is no conflicts of interest to declare.

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