INTRODUCTION

One of the indicators that characterize social policy efficiency is the health of the population; the last heavily depends on the state of the environment. Environmental pollution influences health quality and resulted in increased incidence of diseases and mortality among the population. Prolonged exposure to air pollution may lead to irritation, headache, bronchitis, asthma, heart disease, cancer and mortality (Brunekreef et al., 1995; Hammitt et al., 2006; Neidell, 2004; Pope, 2007).

Hammitt and Zhou (2006) stated that there are numerous studies estimating reducing risks of mortality and other health effects in the industrialized countries, yet there are relatively few such estimates for transition and developing countries (mainly due to the shortages of data). As a result, economic estimations and values of pollution reduction in industrialized counties are transferred to developing ones. However, in the last case economic benefits of pollution reduction are highly overestimated and cannot be used in policy regulation. In general, it is some sort a dilemma for developing and transition countries to combine economic growth and high quality of environment. The cost-benefit analysis has to be used to estimate proper costs of pollution and expected benefits of its reduction.

Objectives: the objective of the study is to estimate environmental health relationships based on aggregated data for Ukraine; second objective is to estimate economic values of health damages from outdoor air pollution.

Practical contribution of the research: It is expected to estimate health damages from outdoor pollution and provide relevant policy recommendations for charging payments on emissions. Also it is expected to provide specific recommendations for health care system
improvement in Ukraine basing on results from ecologically caused diseases. That is out of total number of specific diseases it will be calculated the environmentally caused ones and attributed proper economic values.

HYPOTHESES TO BE TESTED

1. The higher levels of outdoor air pollution do cause higher levels of endocrine, respiratory and circulatory diseases. The hypothesis is tested through the parametric regressions to prove that higher outdoor pollution cause higher levels of diseases.

2. Regions which suffered high radiation levels in 1986 (due to Chernobyl incident) do have higher relative endocrine illness today. That is necessary to estimate endocrine health model (basing on aggregate data for different territories) using the variation in radiation pollution and controlling for other factors.

3. It is expected that total environmental health damage as percentage of regional product (RGP) is higher in Ukraine than in developed and majority of developing countries, while the health expenditures from state are much smaller.

LITERATURE REVIEW

In this study we address only socio-economic damage from pollution, which results in deterioration of human health and do not analyze the reduction of the natural resource potential (crop or fishery production, etc.). There are several problems in analyzing the influence of outdoor air pollution on health. First of all, it is difficult to state real cause-effect of the relationships. Additionally, placing monetary values on those effects, either health or productivity is often not easy work and special approaches have to be used.

Bellow we analyze several policy papers considering health effects from pollution. Also we provide available information on healthcare costs from outdoor pollution as a percentage of GDP in analyzed countries or regions in order to compare them with Ukrainian ones.
Department of Ecology of Washington State (Ecology, 2009) basing on Environmental Benefits Mapping and Analysis Program (BenMAP) estimated that approximately 1,100 people die each year in Washington due to Fine Particle Pollution. Also it was found that particles smaller than 2.5 microns in size (PM2.5) contributes to approximately: 1,500 nonfatal heart attacks, 100 cases of chronic lung disease, 250 incidents of pneumonia, about 2000 incidents of bronchitis, thousands incidents of worsened asthma and others. According to Quaha and Boon (2003) research on air pollution in Singapore outdoor emissions (especially PM10 exposition) are the most life-shortening factors and cause respiratory symptoms, cardiovascular disease, damage to lung tissue, carcinogenesis and premature death. Using the values of statistical life approach it was found that the total economic cost of air pollution was US $3662 million or about 4.31% of Singapore’s GDP in 1999. Laura Perez at al. (2009) estimated economic benefits of reducing the mean PM10 in municipality of Barcelona with a total population of 3.9 million inhabitants. The paper stated that annual mean health exposure reduction to the recommended levels of World Health Organization would bring annual benefits in 6,400 million euros per year.

Seethaler at al. (2003) have estimated economic costs of air pollution-related health impacts in tri-national study of Austria, France and Switzerland. It was found that across the three countries the health costs due to traffic-related air pollution were approximately 1.7% of GDP.

Sydney (Australia) Department of Environment and Conservation (Department, 2005) has estimated economic loses in Greater Sydney Metropolitan Region (GMR) caused by ambient particulate pollution from 2000 to 2002. Thus the total health per capita costs from ambient air pollutants in the GMR were estimated in three base scenarios Low cost - $192; midpoint cost $893; high cost $1,594; Which were about 0.4% and 3.4% of gross state product (table 1.).

<table>
<thead>
<tr>
<th></th>
<th>% of GDP (or GSP)</th>
<th>Per capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMR (Australia)</td>
<td>0.4% to 3.4%</td>
<td>$192 to $1,594</td>
</tr>
<tr>
<td>Austria</td>
<td>1.6% to 4.8%</td>
<td>$694 to $2,042</td>
</tr>
<tr>
<td>France</td>
<td>1.4% to 4.0%</td>
<td>$562 to $1,641</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0.7% to 2.2%</td>
<td>$485 to $1,458</td>
</tr>
</tbody>
</table>

Source: Department (2005), Seethaler at al. (2003)
Thus, Chanel and Luchini (2008) using contingent valuation approach estimated the monetary values for mortality risk associated with air pollution. In their paper basing on France data, the value of a Prevented Fatality for different ages were at level 2.15 million euros. Hammitt and Zhou (2006) using contingent valuation in three diverse locations in China (Beijing, Anqing (Anhui province) and the rural areas near Anqing) have estimated preventing adverse health effects related to air pollution. In order to prevent case of chronic bronchitis there were received estimates in ranges between US$500 and US$1,000 and the value per statistical life ranges were between US$4,000 and US$17,000. Those estimates were 100 times smaller than estimates for the US and Taiwan.

Naveen (2012) found that annual welfare gain from reducing pollution to safe levels in Kathmandu and Lalitpur (Nepal) was about USD 4.37 million per year per region. Devi (2007), estimated average health costs from pesticide exposure at Kuttanad (India) at level US $0.86 per day or about a quarter of the average daily earnings of the applicator. That is the costs in developing countries from pollution exposition are too small comparing with value of one statistical life in industrialized countries.

**METHODOLOGY**

In this section we discuss several model specifications related to the health effects estimation and provide the description of the model used for own research. We use, like Naveen (2012), a simplified version of the general health production function:

\[
H = H(Q, M, A; E)
\]

Where, 
H - indicates the health status measured in level of illness per 1000 of population 
Q - Level of air (radioactive) pollution; 
M- Refers to mitigating activities number and visits to doctors, laboratory tests, etc.; 
A - is averting activities extra miles traveled per day to avoid polluted areas in the city, living in parks or near sea zones, etc; 
E - is a vector of economic parameters.
A current study on valuing the health costs due to air pollution in the Ukrainian regions has some limitations because of methodological issues and data problems. *Our study differs from the previous studies in several respects.* Firstly, it is based on aggregated regional panel data which covers ecological, social and economic variables, while individual level data would provide more proper estimates. That is we work with regional panel data on diseases, pollution, social and economic indicators. Secondly, while many other studies have used time series secondary data and the benefit transfer approach to value human health costs (mainly contingent valuation), this study uses the parametric function approach to explain relationship between environmental pollution and health. On the other hand, our results could be interesting for policy implications (since all individual fluctuations are smoothed) and net effect of pollution on health is analyzed.

Developing the relationship between environmental pollution and health, we propose the following regression equation, which determines the degree of influence of individual factors on public health:

\[
H_t = \beta_0 + \beta_1 T_t + \beta_2 S_t + \beta_3 R_t + \beta_4 D_t + \beta_5 P_t + \beta_6 I_t + \epsilon_{it} \tag{2}
\]

\(H_t\) – level of illness in population by type of disease;
\(T_t\) – Square of forest plantations by region in %;
\(S_t\) – Access to sea by region (dummy variable takes the value 0 or 1);
\(R_t\) – The average real wages of employees (in basic prices of 1999);
\(D_t\) – Number of people per one medical officer;
\(P_t\) – Air pollution (concentration, emission);
\(I_t\) – Level ionization (radiation) by cesium-137;
\(y_{it}\) – Year dummies.

Based on the analysis of theoretical and empirical works which researched the issue of human health, we can predict the effect of some environmental factors on the health. In particular, it is expected that *more doctors* in the region per 1000 persons positively correlate with health of population in the region. The *growth of pollution* in the region as well as *higher radiations levels* due to Chernobyl accident are associated with worse health indicators. It is also expected that regions with *larger forest area* do experience fewer respiratory diseases. Annual dummy variables
are introduced into the model to control the factors that had the same impact on the entire territory of Ukraine (solar radiation, the rate of inflation in the country and other factors). The parameters $\beta_5$ – $\beta_6$ in (2) are reflecting the level of environmentally caused diseases (among the current number of cases) for each additional unit of pollution. Indicators $\beta_1$ – $\beta_4$ characterize the level of socio-economic and natural factors that affect the health of the population.

To determine the economic damage from ecologically caused diseases it is needed to find the coefficients $\beta_4$, $\beta_5$, multiply those on averages contamination in regions to get the increment at ecologically caused diseases per 1000 people. The methodology to estimate health impacts is not new and was already published many times; for example (Ostro, 1994). Thus the estimated health impact can be presented by the following relationship (Ostro, 1994):

$$dHi = b_i \times POP_i \times dA$$

(3)

where: $dHi$ - change in population risk of health effect $i$;
$b_i$ - slope from the dose-response curve for health impact $i$;
$POP_i$ - population at risk of health effect $i$;
$dA$ - change in ambient air pollutant under consideration.

Using (3) it is possible to calculate the number of ecologically caused diseases and estimate the health costs as percentage of GDP (RGP)

**DATA DESCRIPTION**

To achieve the goal we have to collect and process the information from state regional statistical committees of Ukraine and medical statistics. Currently we have obtained unbalanced data for 16 regions in Ukraine from 2000 to 2006 for the following diseases: endocrine, circulatory, respiratory, cancer, skin, which gives us 112 observations (112 are 16*7 years, not big but enough to satisfy normality criteria). All of these diseases are related to the state of the environment. Limitation of more complete data covering all regions in Ukraine is explained by the necessity to purchase more complete and updated data from the Statistical department at Ukrainian Health
Ministry. It is expected that final data base will be at least 2 times bigger (about 300 observations) due to the span of time period and regions considered.

From the available data we have estimated coefficients of illness (per 1000 people) for such diseases: endocrine system – 12 people, blood (circulatory) – 49 people, lung diseases (respiratory) – 288 people, skin – 41 people, chromosomal abnormalities – 1 person. The general health of the population can be classified as critical, since only the above mentioned diseases affect about 40% of the Ukrainian population.

Among the other factors that affect population health (all the data is available) are: the number of physicians per 1000 population, the percentage of regional area under the forests, the real wages of the population, and concentration of pollutants in the air. It is expected that the level of pollution, including radioactive contamination will be positively correlated with the number of illnesses per 1000 population. Researches on endocrine system should consider factors of radioactive contamination; in our case we use radiation maps for cesium-137 pollution, and level of exposure of the thyroid gland in children at the time of the Chernobyl disaster. The data on emissions is taken from the statistical yearbooks “Environment of Ukraine”.

PRELIMINARY RESULTS

The analysis of panel data on health involves usage of fixed effects or random effect estimations, however there was found the presence of autocorrelation and generalized method of least squares was used. Bellow we provide results only for endocrine diseases on 2000-2006. Also considering the availability of data some preliminary results could be calculated for respiratory, circulatory, cancer and skin diseases.

Our results indicate that the increase in radiation of thyroid gland on 30 cGy (radioactivity level) causes an increase of endocrine system illness by 30%. Also emissions do positively affect the number of endocrine diseases (increased pollution correlated with growing incidence). Relatively richer regions suffer from diseases of the endocrine system less than the economically weaker regions. Annual dummy variables in the endocrine system are significant and each year
diseases of the endocrine system are increasing compared to the baseline in 2000. More estimation of endocrine diseases in Ukrainian regions see Appendix A.

The average number of endocrine diseases in Ukraine is 13 people per 1000 population; the coastal regions suffer 6 people less per 1000 population. It requires deeper research (omitted variable bias, etc.) but still regions with sea access do suffer average 40% fewer endocrine diseases than average in Ukraine. Also the average wage growth in 100 USD (in prices, base 1999), were associated with a decrease in endocrine system by 16%. Also using (3) we estimated the health impact of pollution (table 2)

Table 2. The estimated health impact due to the ecological factors

<table>
<thead>
<tr>
<th>1 endocrine diseases</th>
<th>Economic interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 due to air pollution</td>
<td>That is an increase in average regional emissions of air pollution on 100 thousand tons does increase endocrine diseases on 5.5%. Some cites (like Kryvyi Rih) polluts 300-500 thousand tons into atmosphere annually.</td>
</tr>
</tbody>
</table>
| Average regression coefficient of **air pollution** impact on **endocrine diseases** (slope from the dose-response curve for health impact, Appendix A) is 0,000007. Average illness among population is – 0,01267 (per 1000 of population). The endocrine diseases estimated health impact due air pollution is as follows: 
\[dH_{endocrine(air)} = \frac{0,000007}{0,01267} = 0,00055 \text{ or } 0,055\% \] | |
| 1.2. due to radiation | Also an increase in average regional radiation on thyroid due to Chernobyl disaster on 10 cGy in 1986 do increase endocrine diseases on 7% in analyzed period 2000-2006 . |
| Average regression coefficient of **radiation** impact on **endocrine diseases** (slope from the dose-response curve for health impact Appendix A) is 0,000087. Average illness among population is– 0,01267 (per 1000 of population) 
\[dH_{endocrine(radiat)} = \frac{0,000087}{0,01267} = 0,007 \text{ or } 0,7\% \] | |

**CONCLUSIONS**

It was found that ecological factors do influence health of population in Ukraine. The following results were received: first, the level of radiations is statistically significant and positively affect the number of endocrine diseases. Secondly, wages and other economic indicators, together with the social (e.g., the number of doctors) were statistically significant and correlated with endocrine diseases. Thus, an increase in air pollution emissions on 100 thousand tons do increase illness among population: endocrine diseases on 5,5%. An increase in average regional radiation on thyroid due to Chernobyl disaster on 10 cGy do increase endocrine diseases by 7%.
REFERENCES


3. Brunkreerf B; Dockery DW; Krzyzanowski M (1995). ‘Epidemiologic studies on short term effects of low levels of major ambient air pollution’. Environmental Health Prospective, 103(2)


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Research experience in grant activities (grant titles and registration numbers):

2) Methodologies of economic damage estimation and greening policy forming for the Sustainable developments implementation (No 0109U004805)

PARTICIPANTS:

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Research experience in grant activities (grant titles and registration numbers):

2) Methodologies of economic damage estimation and greening policy forming for the Sustainable developments implementation (No 0109U004805)

ALTERNATIVE/ADDITIONAL SOURCES OF FUNDING

There is no alternative source of project financing. Consortium covers 80% of value added in the researches on economic estimates of ecological health relationship; the other part is due to authors’ increment.

PROJECTS TIME TABLE

<table>
<thead>
<tr>
<th>dates</th>
<th>Progress on project</th>
</tr>
</thead>
<tbody>
<tr>
<td>September–November 2013</td>
<td>data collection for the research; consultations on Econometrics analysis with EERC/KSE researchers</td>
</tr>
<tr>
<td>November –December 2013</td>
<td>statistical analysis and obtaining of the research results (Stata analysis)</td>
</tr>
<tr>
<td>January–February 2014</td>
<td>preparation of the first draft report on ecological health relationships in Ukraine</td>
</tr>
<tr>
<td>February–March 2014</td>
<td>discussions of the obtained results in scientific community</td>
</tr>
<tr>
<td>March–May 2014</td>
<td>preparation of the final version of the research report in English</td>
</tr>
<tr>
<td>May–July 2014</td>
<td>application of the article to one of the referred journal (probably with coauthors, with remarks on supporting grant by Consortium)</td>
</tr>
</tbody>
</table>
Appendix A.

Results of regression analysis of economic and ecological factors on endocrine systems

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>endocrine</td>
<td>endocrine</td>
<td>endocrine</td>
<td>endocrine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>diseases</td>
<td>diseases</td>
<td>diseases</td>
<td>diseases</td>
</tr>
<tr>
<td>Forest areas (% of territory)</td>
<td></td>
<td>0.0002109</td>
<td>0.0002002</td>
<td>0.0002002</td>
<td>0.0002002</td>
</tr>
<tr>
<td>Access to sea</td>
<td></td>
<td>-0.006 (0.000)**</td>
<td>0.001 (0.386)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population per one doctor</td>
<td></td>
<td>-0.0000375 (0.017)**</td>
<td>-0.0000304 (0.025)**</td>
<td>-0.0000607 (0.000)**</td>
<td></td>
</tr>
<tr>
<td>Overall air pollution</td>
<td></td>
<td>8.22e-06 (0.001)**</td>
<td>6.95e-06 (0.000)**</td>
<td>5.81e-06 (0.009)**</td>
<td></td>
</tr>
<tr>
<td>radiation on thyroid</td>
<td></td>
<td>0.0001 (0.000)**</td>
<td>0.0000634 (0.001)**</td>
<td>0.0000591 (0.001)**</td>
<td>0.0001244 (0.000)**</td>
</tr>
<tr>
<td>Real wage</td>
<td></td>
<td>0.00002 (0.11)</td>
<td>-0.0000504 (0.000)**</td>
<td>-0.0000427 (0.000)**</td>
<td>-0.0000502 (0.000)**</td>
</tr>
<tr>
<td>Year dummies</td>
<td></td>
<td></td>
<td>2000-2006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td>0.007 (0.003)**</td>
<td>0.022 (0.000)**</td>
<td>0.020 (0.000)**</td>
<td>0.030 (0.000)**</td>
</tr>
<tr>
<td>Number of population</td>
<td></td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
</tr>
</tbody>
</table>

Statistical significance of the results: *significant at 90% confidence interval; **significant at 95% confidence interval; ***significant at 99% confidence interval;