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Monitoring and forecasting waste generation and emissions of harmful substances

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SUMMARY

The study objective was to determine sustainable development conditions according to the criteria of emissions of harmful substances and waste generation when modelling impact factors of the parameters and general environmental situation in Ukraine.

It has been proved that the EKC model should be used not only to model parameters of emissions of harmful substances, but also for waste generation. Besides, it has been proved that it is necessary to take into account not only national level indicators, but also the contribution of the leading sectors driving national economy. Modelling has been carried out for the following industries: processing; mining and quarry development; agriculture, forestry and fisheries; supply of electricity, gas, steam and conditioned air; transport, warehousing, post and courier services. The models are based on correlation between GDP, average nominal income per capita, environmental costs, waste generation and emissions of harmful substances at the national level and by its leading industries. It has been determined that reaching the "turning point" on sectoral EKCs correlates waste generation and emissions with industry`s rate of remuneration, value added (sectoral GDP) and sectoral investment in environmental protection in the context of industry`s specifics.

Introduction

Taking into consideration that higher waste generation poses threat to the country`s sustainable growth, this problem needs special attention. Waste is becoming perhaps the most acute environmental problem of the humanity as a whole and Ukrainian society in particular. Significant resource consumption, energy and raw material specialization of Ukraine's economy together with outdated technological base cause serious annual quantities of waste generation and accumulation. Man-caused load on the environment in Ukraine is 4-5 times higher than similar indicators of the developed countries. The difference between Ukrainian and developed countries` case of waste lies in the larger quantities of waste generation and lack of waste management infrastructure, which is the integral part of these economies.

Method

In the analysis, general-scientific methods (analysis and synthesis, induction and deduction) and special methods of phenomena and processes analysis (abstraction, econometric and econometric-mathematical modelling) have been used.

Results

Most scholars believe that correlation between income (economic growth) and pollution is non-linear and has the form of the inverted parabolic curve. Simon S. Kuznets is the author of the model.

The environmental Kuznets curve (EKC) is usually built to illustrate correlation between income per capita (GDP per capita) and pollutant emissions (or by their specific types). In our opinion, there is similar relationship between waste generation and household income or GDP, because as in the case of pollutants, if incomes surge, one can expect not only emission contraction but also waste generation shortening.

Fig. 1 - 3 illustrate the dynamics of correlation between average nominal income per employee in Ukraine, GDP, environmental expenditures and pollutant emissions, and waste generation during 2010-2019, respectively.

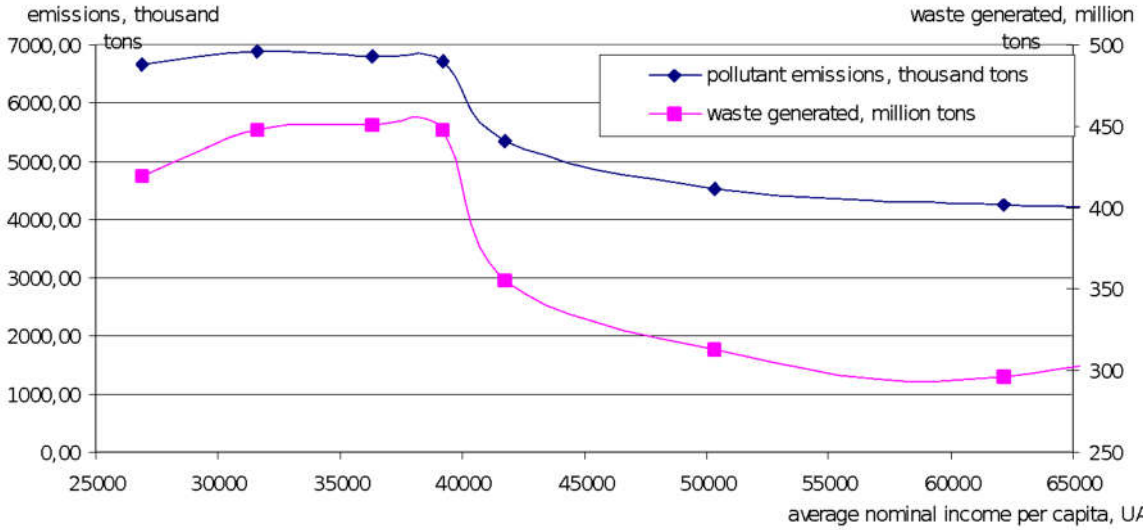

Figure 1 *Dynamics of correlation between average nominal income per capita in Ukraine, masses of emissions and waste generation during 2010 – 2019.*

As one can see, the maximum growth of emissions and waste generation coincide and correspond to the level of nominal income of UAH 39180 (average monthly nominal income per employee UAH 3265), GDP of 1,522.7 billion UAH in 2013. After that, emissions and waste generation began to decline. Comparison with the EKC allows us to conclude that the average nominal income per employee and GDP is the "turning point" that ensures environmental change in the country in terms of emissions and

waste. Regarding the corresponding correlation for consolidated budget`s environmental expenditures, only in 2016-2017 there were low quantities of emissions and waste generation alongside increasing expenditures.

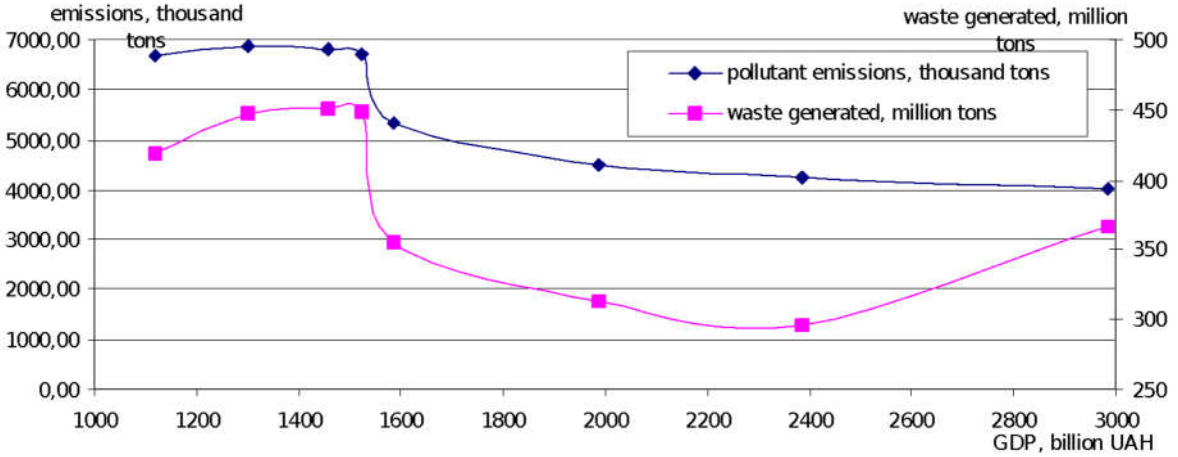

Figure 2 *Dynamics of correlation between GDP in Ukraine, masses of emissions and waste generation during 2010 – 2019.*

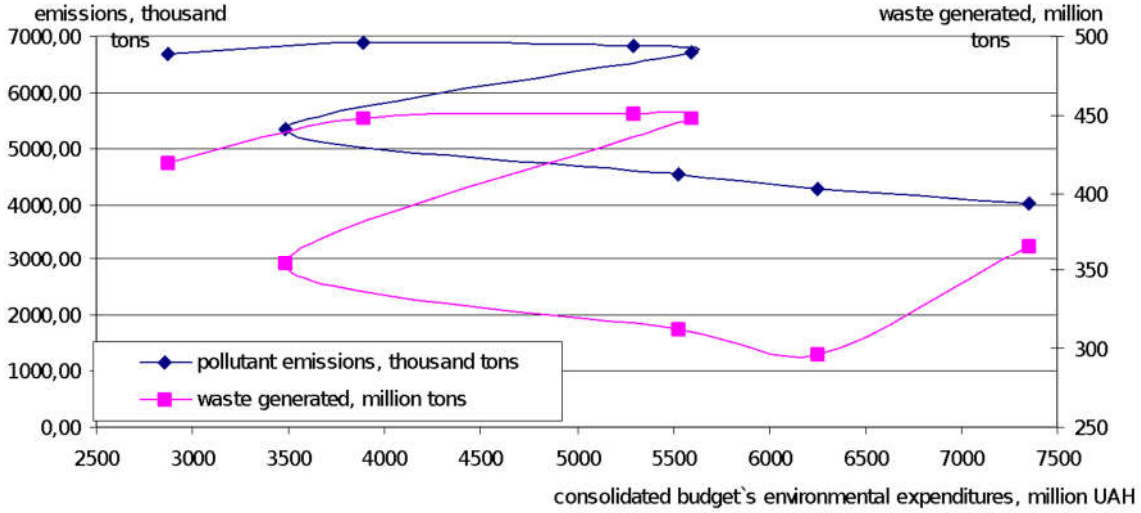

Figure 3 *Dynamics of correlation between consolidated budget`s environmental expenditures in Ukraine, masses of emissions and waste generation during 2010 – 2019.*

Taking into account that these dependencies for Ukraine have been formed by the leading sectors of its national economy, the "turning points" analysis in the following sectors have been proved: mining and quarry development; processing; electricity, gas, steam and conditioned air supply; transport, warehousing, post and courier service; agriculture, forestry and fisheries.

Fig. 4 -5 demonstrate interdependencies between pollutant emissions, waste generation and average monthly nominal income per capita in the mining, sectoral GDP and environmental expenditures.

It has been found out that the maximums of emission growth and waste generation in the mining coincide and correspond to the level of nominal income of UAH 63468 (UAH 5289 / month) in 2013. After that emissions and waste generation began to decline.

GDP during 2012-2014 fluctuated between UAH 79,12-82,52 billion; shortening of pollutant emissions and waste generation began with GDP of UAH 82,52 billion. The following years there was growth in pollutant emissions alongside with waste generation contraction. This can be explained by the fact that

the obtained level of GDP does not ensure the EKC consistent trend in terms of mining emissions. At the same time, one can associate sustainable reduction of waste generation with technical innovations that have led to lower inefficiency in the mining industry. The conclusion confirms the relationship between emissions and waste generation and sectoral environmental expenditures. The turning point was the expenditures at UAH 4394,67 million, further boost in environmental expenditures in the industry ensuring the contraction of waste generation. Nevertheless, it did not fully lead to the pollutant emissions shortening.

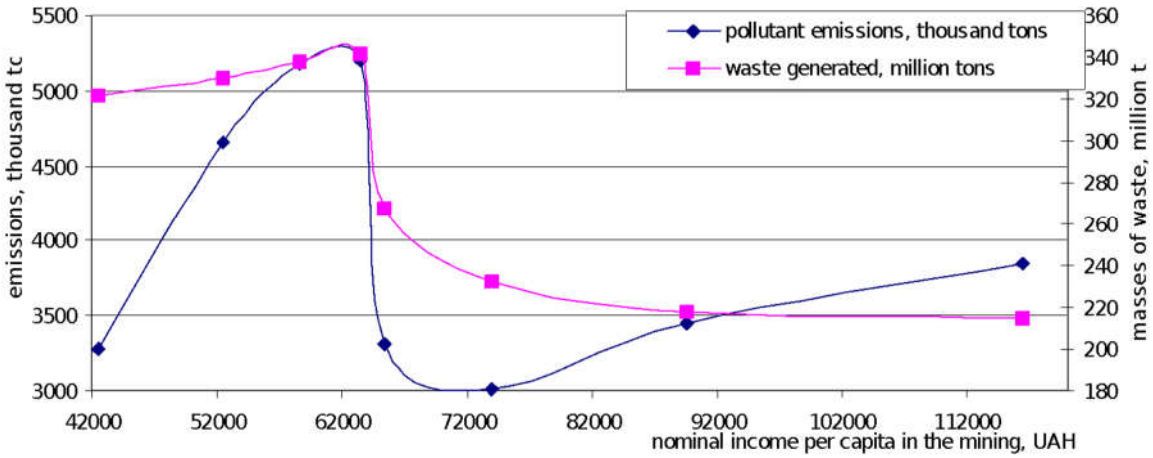

Figure 4 *Dynamics of correlation between average nominal income in the mining in Ukraine, masses of emissions and waste generation during 2010-2019.*

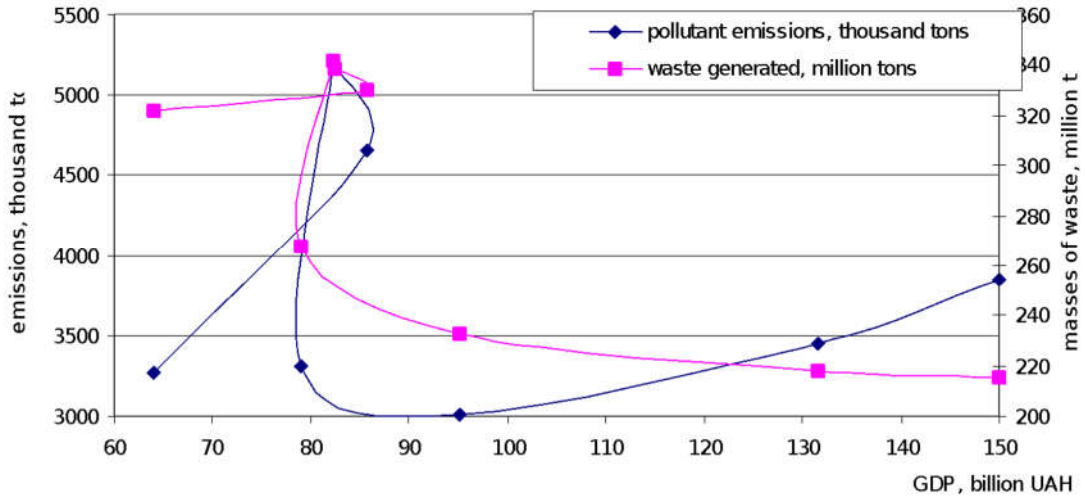

Figure 5 *Dynamics of correlation between GDP in the mining in Ukraine, masses of emissions and waste generation during 2010-2019.*

Similar dependencies were obtained for other leading sectors of the national economy. It has been found out for the processing industry that there are "turning points", but not as clear as in the previous case: the first point was reached with the average nominal income in the field at UAH 33252 (UAH 2771 / month) in 2011, the next - at UAH 39732 (UAH 3311 / month) in 2013. The income level in 2011 was sufficient to reach the "turning point" for waste generation.

GDP in the processing industry during 2012-2013 at the level of UAH 169,73 – 178,44 billion was sufficient to set the consistent trends on the EKC curve. In the same period (2013), sectoral

environmental expenditures amounted to UAH 6402,47 million, their growth in the following years included positive trends, and the level of UAH 774670 million additionally stimulated contraction of both emissions and waste generation. This can be explained by the notable growth in environmental expenditures by the main pollutant – metallurgy during the period – from UAH 3575,00 million in 2015 to UAH 501,05 million in 2016.

The obtained correlations for the electricity, gas, steam and air conditioning supply in Ukraine of the average nominal income per capita and sectoral GDP can be considered as the EKC for the electricity, gas, steam and air conditioning supply. They have two "turning points" for pollutant emissions. Initially, the decline in emissions began at the average nominal income in the field at UAH 58620 (UAH 4885 / month) and sectoral GDP of UAH 44836 billion (2014). The next decline was observed at 83016 UAH (UAH 6,918 / month) and GDP of UAH 73809 billion in 2016. Thus, in 2016 the average nominal income and GDP in the electricity, gas, steam and air conditioning supply were sufficient to reach the firm "turning point". This result, in our opinion, was also achieved due to substantial growth of sectoral environmental expenditures. Thus, if in 2013 their value was UAH 1388,53 million, then in 2014 it surged by UAH 5312,20 million, in 2016 – by UAH 9605,10 million. Therefore, industry expenditure is considered to be additional positive determinant to reach the EKC "turning point".

The obtained EKC for transport, warehousing, postal and courier services has two "turning points": the first for the average nominal income in the field at UAH 32508 (UAH 2709 / month) and GDP at UAH 103,179 billion in 2011; the second for the average nominal income in the field at UAH 39180 and GDP at of UAH 104,483 million in 2013. Unfortunately, since 2016 there has been the EKC deviation on emissions due to the considerable environmental expenditure contraction in the field from UAH 1367,30 million in 2013 to UAH 576,30 million in 2017.

The EKCs for agriculture, forestry and fisheries have been obtained only since 2014 because of low income level in the industry. The "turning point" was reached for the average nominal income in the field at UAH 37680 (UAH 3140 / month). The EKC on pollutant emissions by GDP in agriculture was achieved earlier in 2012 at GDP of UAH 113,245 billion, on waste generation – in 2011 at GDP of UAH 109,961 billion. We believe that the results are caused by the growth of sectoral environmental expenditures in the period from UAH 96,167 million in 2010 to UAH 147,15 million in 2011; UAH 200,11 million in 2012 and UAH 544,17 million in 2013. Increasing pollution in the following period was due to the shortening of environmental expenditures to UAH 172,12 million in 2014 and UAH 192,38 million in 2015 despite the GDP growth.

Conclusions

It has been proved that the EKC model should be used not only for the pollutant emissions parameters, but also for the masses of waste generation. Moreover, it is necessary to take into account not only national indicators, but the contribution of the leading sectors of national economy. The EKC modelling for waste has been made for the following industries: processing; mining and quarrying; agriculture, forestry and fisheries; electricity, gas, steam and air conditioning supply; transport, warehousing, post office and courier service. The models are based on correlation between GDP, average nominal income per employee, environmental expenditures and waste generation at the national level and for the leading industries of national economy.

It has been found out that to reach the "turning point" in sectoral EKCs for waste generation, one has to consider the remuneration rate in the industry, the value added (sectoral GDP) and total sectoral environmental investment by the field specifics.

It has been determined that the key factor to ensure country`s sustainable development is environmental investment both at the national level and by its driving economic sectors. Thus, the sectoral EKC reflects the progress towards industries` sustainable development that form main revenue receipts of the government and determine the rate of remuneration in the real sector. Modelling of the EKC parameters for waste and emissions of harmful substances fully corresponds to the trends of sustainable economic growth and its transition to the innovative type of development.