

Environmental Kuznets curve: national economy of sustainable development

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Nowadays globalization causes on the one hand new development conditions, on the other hand – new threats. That is why the problem of parameters', conditions' and mechanisms' formation of sustainable development in Ukraine in the context of deepening ecological crisis and taking into account national economy specifics needs to be solved. Accordingly, the degree of environmental risks and threats now is largely determined by the political efficiency in the field of both emissions contraction, waste generation and its management. This requires environmental policy adjustment, taking into account the need to develop and implement comprehensive strategies aimed at lower pollutant emissions while identifying impact factors of the level of environmentally friendly manufacturing. Therefore, the study objective is to determine sustainable development conditions by the criteria of pollutant emissions including impact factors modelling of the parameters' and environmental situation in Ukraine.

Most researchers believe that the correlation between income (economic growth) and environmental pollution is nonlinear and has the form of inverse parabolic curve. Simon S. Kuznets is the author of the - environmental Kuznets curve (EKC). Figure 1 shows the dynamics of the relationship between the per capita income in Ukraine and sulfur dioxide, nitrogen dioxide, carbon oxide and dioxide emissions volumes (EKC).model.

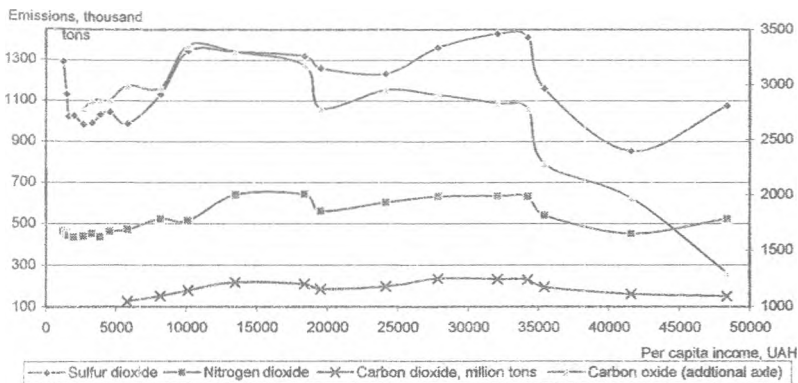


Figure 1 Dynamics of the relationship between the per capita income in Ukraine and sulfur dioxide (from 1990), nitrogen dioxide (from 1990), carbon oxide (from 2000), carbon dioxide (from 2004) emissions volumes till 2017

We have proved that these dependencies for Ukraine have been formed by the leading branches of its national economy: mining and quarrying; processing industry; supply of electricity, gas, steam and air conditioning; transport, warehousing, postal and courier services; agriculture, forestry and fisheries.

Share and dynamics of pollutant emissions and carbon dioxide emissions in these industries during 2010-2017 are defined in Table 1. As one can see, the lowest degree of emissions is in agriculture, the highest – in energy. Metallurgy occupies significant share of processing industry emissions, so special attention will be paid to its analysis.

The ratio of the average monthly nominal wage in the industries with the corresponding mean values for Ukraine have been determined the same way (Table 2). Thus, the highest wages are in mining, the lowest – in agriculture. In 2017 the employment rate in the analyzed industries was about 40% of all employed persons in Ukraine (Table 3). The largest rate was in agriculture, the smallest – in mining.

Table 1 Shares of pollutant emissions, total (pollutant emissions / carbon dioxide emissions) of point sources by fields of economic activity in total emissions in Ukraine, %

Years	Agriculture, forestry and fisheries	Transport, warehousing, postal and courier services	Mining and quarrying	Processing industry	Supply of electricity, gas, steam and air conditioning
2010	0,47 (1,7/0,4)	3,42 (4,7/3,4)	1,93 (20,6/1,5)	35,75 (32,6/35,8)	57,56 (38,8/58,0)
2011	0,42 (1,7/0,4)	2,86 (4,5/2,8)	2,25 (19,6/1,9)	43,99 (31,7/44,3)	49,54 (41,3/49,7)
2012	0,98 (1,8/0,4)	2,00 (3,8/1,2)	2,56 (20,4/2,2)	41,07 (29,4/41,3)	53,15 (43,4/53,4)
2013	0,53 (2,1/0,5)	2,23 (3,9/2,2)	2,58 (21,4/2,2)	41,26 (28,7/41,5)	52,62 (42,8/52,8)
2014	0,55 (2,4/0,5)	2,15 (3,9/2,1)	2,12 (17,5/1,8)	39,11 (30,4/39,3)	54,62 (43,8/54,7)
2015	0,84 (2,7/0,8)	1,76 (2,7/1,7)	2,12 (17,2/1,8)	41,17 (32,9/41,3)	51,78 (41,1/52,0)
2016	0,62 (2,7/0,6)	2,44 (2,0/2,4)	2,24 (15,1/2,0)	40,39 (31,7/40,6)	52,38 (46,0/52,5)
2017	0,93 (3,1/0,9)	3,51 (2,4/3,6)	3,03 (18,5/2,7)	39,40 (33,8/39,5)	51,16 (39,1/51,4)

Table 2 Ratio of the average monthly nominal wage in the industries with the corresponding mean values for Ukraine, %

Years	Agriculture, forestry and fisheries	Mining and quarrying	Transport, warehousing, postal and courier services	Processing industry	Supply of electricity, gas, steam and air conditioning
2010	63,87	158,06	118,71	102,19	135,24
2011	70,38	165,97	102,89	105,24	127,35
2012	68,27	161,30	96,63	102,35	126,27
2013	69,59	161,99	109,92	101,41	137,83
2014	71,15	156,47	108,28	102,59	140,37
2015	74,85	146,94	110,92	106,72	130,20
2016	75,55	143,97	112,10	106,95	133,47
2017	81,10	136,60	108,22	102,74	119,55

Table 3 Employment rate in the field to all employed persons in Ukraine, %

Years	Agriculture, forestry and fisheries	Mining and quarrying	Transport, warehousing, postal and courier services	Processing industry	Supply of electricity, gas, steam and air conditioning
2010	15,26	2,21	5,97	9,47	2,81
2011	16,72	2,21	6,01	9,26	2,84
2012	17,18	2,16	5,94	11,41	2,87
2013	17,53	2,10	5,99	11,15	2,79
2014	17,10	1,99	6,16	11,19	2,86
2015	17,46	1,59	6,07	11,19	2,88
2016	17,61	1,47	6,13	11,01	2,85
2017	17,71	1,36	6,14	10,99	2,76

We have also compared the share of gross value added (GDP by sector) of the analyzed industries in 2017 with the total GDP of the country (Table 4).

Table 4 Share of gross value added by types of economic activity to GDP of Ukraine, %

Years	Agriculture, forestry and fisheries	Mining and quarrying	Transport, warehousing, postal and courier services	Processing industry	Supply of electricity, gas, steam and air conditioning
2010	7,4	5,7	7,8	13,0	2,8
2011	8,1	6,3	8,0	11,8	3,1
2012	7,9	5,7	7,1	12,2	3,1
2013	8,7	5,4	7,2	11,2	2,9
2014	10,2	5,0	6,4	12,2	2,8
2015	12,1	4,8	6,8	11,9	2,7
2016	11,7	5,5	6,6	12,2	3,1
2017	12,1	5,6	6,7	12,1	2,9

The largest share of GDP was generated in the processing industry, the smallest – in the field of electricity, gas, steam and air conditioning supply. In 2017 agriculture's, forestry and fisheries', and the processing industry's shares in GDP were equal.

Thus, agriculture having the lowest degree of emissions and waste generation, generates the same value added (GDP by sector) as the processing industry, which is the leader in pollution (metallurgy gives the biggest part of pollution). At the same time, the industry that accounts for the largest share of pollution – energy, generates the smallest share of GDP in the country.

The obtained results reveal that the «turning point» for Ukraine on the EKC was reached in 2013 (income –UAH 34264, average nominal income per employee –UAH 39180). Industries that reached the final «turning point» in 2013 accumulated 46.07% of pollutant emissions and 20% of the employed population of Ukraine. Among 20% of employed persons, 2.1% worked in the mining characterized by 1.61 times higher wages than the average; 11.5% – in the processing industry having the average income; 5.9% worked in the transport industry with slightly higher income than the average in Ukraine.

However, energy and agriculture, reaching the turning point in 2014 – 2016, employed the same 20% and formed almost the same amount of 53% of pollutant emissions. Among 20% of employed persons, 2.8% worked in the energy sector

characterized by 1.5 times higher wages than the average; 17.1% – in agriculture, having the average income.

Thus, comparison of the obtained results shows that 20% of the working population in Ukraine being employed by industries that generate 46% of pollutant emissions ensure the «turning point» on the EKC, if national average nominal income per worker and steady growth of environmental costs for at least two years are reached.

The analysis demonstrated that the industries like mining and quarrying, agriculture, fisheries and forestry have one «turning point», others – two. We believe that these sectoral features may be related to the environmental costs. Table 5 illustrates the results of pollutant emissions` and sectoral environmental costs` growth rates analysis. Their analysis allows us to conclude that in Ukraine, not only average nominal income per employee, but sectoral environmental costs matter.

Table 5 Dynamics of chain weighted growth rate of pollutant emissions and sectoral environmental costs

Years	Growth rates, %									
	Mining and quarrying		Processing industry (metallurgy)		Supply of electricity, gas, steam and air conditioning		Transport, warehousing, postal and courier services		Agriculture, forestry and fisheries	
	Emissions	Environmental costs	Emissions	Environmental costs	Emissions	Environmental costs	Emissions	Environmental costs	Emissions	Environmental costs
2011	<u>142,11</u>	<u>157,11</u>	<u>150,28</u> <i>(161,68)</i>	<u>127,04</u> <i>(126,61)</i>	105,10	97,95	<u>102,12</u>	<u>346,67</u>	<u>109,39</u>	<u>153,02</u>
2012	<u>111,34</u>	<u>106,65</u>	<u>91,52</u> <i>(92,37)</i>	<u>106,65</u> <i>(119,95)</i>	105,17	114,88	<u>68,58</u>	<u>122,96</u>	<u>230,93</u>	<u>135,99</u>
2013	<u>100,47</u>	<u>89,62</u>	<u>100,16</u> <i>(102,19)</i>	<u>97,04</u> <i>(106,85)</i>	98,72	38,48	<u>111,07</u>	<u>41,07</u>	<u>53,37</u>	<u>271,94</u>
2014	63,62	127,82	73,38 <i>(70,33)</i>	95,78 <i>(102,92)</i>	<u>80,36</u>	<u>382,58</u>	74,57	59,63	<u>80,17</u>	<u>31,63</u>
2015	90,94	103,73	95,47 <i>(95,54)</i>	100,39 <i>(97,25)</i>	<u>86,00</u>	<u>102,10</u>	74,37	90,64	139,30	111,77
2016	114,39	99,44	106,33 <i>(109,93)</i>	125,84 <i>(140,29)</i>	<u>109,62</u>	<u>177,10</u>	149,98	264,21	80,81	190,87
2017	111,64	114,93	80,50 <i>(74,19)</i>	103,33 <i>(94,13)</i>	80,60	64,01	118,99	70,31	122,91	116,83

As one can see, to achieve the «turning point» in the mining, it was necessary to increase environmental costs` growth rate during two years. Having high level of

wages in the industry, the result was achieved in 2013. The processing industry has similar pattern: as the required income per employee was achieved in 2013, it has two «turning points». Transport, warehousing, postal and courier services industries had two «turning points» as well; the upsurge of environmental costs also lasted for two years. In addition, as one can see, after a two-year growth of environmental costs and «turning point» reached by all industries, pollutant emissions contracted. If environmental costs dropped off, emissions rose.

In the energy sector despite high average nominal income per employee (UAH 40236 in 2011), the dynamics of sectoral environmental costs constantly increased or decreased, then during 2014-2015 they were rising and therefore, in 2016 the «turning point» was reached.

Agriculture, forestry and fisheries had positive environmental costs growth; the «turning point» was reached only in 2014 due to low wages in the industry.

Parameters of national economy's sustainable development by pollutant emissions have been modelled in the paper. It has been proposed to apply sectoral approach and the model of the environmental Kuznets curve (EKC). Modelling has been made for the following industries: processing; mining and quarrying; agriculture, forestry and fisheries; supply of electricity, gas, steam and air conditioning; transport, warehousing, post office and courier service.

It has been proved that the sectoral EKC reflects the progress towards industries' sustainable development that form the main budget incomes and determine wages in the real sector of the economy. The EKC parameters' modelling for waste and emissions fully corresponds to the trends of sustainable economic growth and its transition to the innovative development pattern.

The study of sectoral EKC revealed close correlation between environmental investment, investment activity and skilled labour force. Sectoral environmentally friendly investments can induce significant effect without drastic changes in the production structure. It has been confirmed that stable sectoral investments in environmental protection together with sufficient income of employees, form the conditions for national economy's sustainable development. Environmental investments

allow to modernize production, surge R&D intensity and profitability of the applied technologies. This will reduce emissions and increase wages. Indeed, higher R&D intensity of production will induce the need for highly qualified personnel with wages bigger than average. The second important outcome of environmental investments will be more qualitative and competitive products, their effective market promotion.

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