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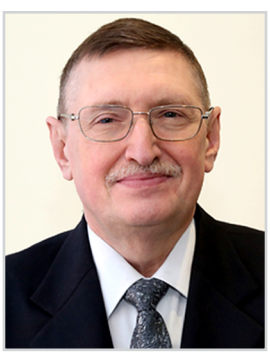

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Economic growth, pollution, and quality of environment: estimation of problems and solutions

Abstract
Faced with the dilemma of industrial economic growth and improved environmental quality, the government must formulate a sound environmental regulatory policy to accelerate the tipping point of improving environmental quality. In our opinion, the issues of measuring the effectiveness and rationality of economic policies and environmental regulation tools will be at the centre of scientists' upcoming research.
Production with a high level of pollution limits the further development of the economy of any country. It is necessary to radically change the mode of development of the industrial economy, which requires a constant increase in the overall productivity of «green» factors of production, which contribute to improving the quality of economic growth in industry. In the process of accelerating the «green» transformation of the economy, the important role of the productivity of «green» factors in the transformation of the economic growth regime should be fully realized.
The authors examine environmental factors that directly affect the country's economy in the context of the selected indicators.
Improving the quality of the environment is not an inevitable endogenous result in the process of economic growth, that is why, we cannot continue the current extensive economic growth regime and expect automatic improvement in the quality of the environment. There is a certain threshold for the quality of the environment. As soon as environmental pollution exceeds the capacity of the ecosystem, it will lead to irreversible environmental losses. Therefore, we must first correct the concept of pollution, and then control it, taking into account the improvement of environmental quality and economic growth.
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Економічне зростання, забруднення та якість навколишнього середовища: оцінка проблем і шляхи їх подолання

Анотація
Зіткнувшись із дилемою промислового економічного зростання й поліпшення якості навколишнього середовища, уряд повинен сформулювати розумну політику екологічного регулювання для прискорення переломного моменту в поліпшенні якості навколишнього середовища. На наш погляд, питання вимірювання ефективності та раціональності економічної політики й інструментів екологічного регулювання будуть знаходитися в центрі уваги вчених у майбутній науково-дослідній роботі.
Виробництво з високим рівнем забруднення обмежує подальший розвиток економіки будь-якої країни. Необхідно кардинально змінити режим розвитку індустріальної економіки, що вимагає постійного підвищення загальної продуктивності «зелених» факторів виробництва, які сприяють підвищенню якості економічного зростання в промисловості. В процесі прискорення «зеленої» трансформації економіки повинна бути повністю усвідомлена важлива роль продуктивності «зелених» чинників у трансформації режиму економічного зростання.
У рамках статті авторами досліджуються екологічні фактори, що безпосередньо впливають на економіку країни в розрізі обраних індикаторів.
Поліпшення якості навколишнього середовища не є неминучим ендогенним результатом у процесі економічного зростання, тому ми не можемо продовжувати нинішній режим екстенсивного економічного зростання й очікувати автоматичного поліпшення якості навколишнього середовища. Існує певний поріг якості навколишнього середовища. Як тільки забруднення навколишнього середовища перевищить можливості екосистеми, це призведе до незворотних екологічних втрат. Тому ми повинні спочатку скорегувати концепцію забруднення, а потім вже контролювати його, враховуючи поліпшення якості навколишнього середовища та економічне зростання.
Ключові слова: промислові забруднювачі; емісія; навколишнє середовище; сталий розвиток; крива Кузнеця; економічне зростання; зелене виробництво; фактори виробництва; ВВП на душу населення.

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Экономический рост, загрязнение и качество окружающей среды: оценка проблем и пути их преодоления

Аннотация
Столкнувшись с дилеммой промышленного экономического роста и улучшения качества окружающей среды, правительство должно сформулировать разумную политику экологического регулирования для ускорения переломного момента в улучшении качества окружающей среды. На наш взгляд, вопросы измерения эффективности и рациональности экономической политики и инструментов экологического регулирования будут находиться в центре внимания ученых в предстоящей научно-исследовательской работе.
Производство с высоким уровнем загрязнения ограничивает дальнейшее развитие экономики любой страны. Необходимо кардинально изменить режим развития индустриальной экономики, что

требует постоянного повышения общей производительности «зеленых» факторов производства, которые способствуют повышению качества экономического роста в промышленности. В процессе ускорения «зеленой» трансформации экономики должна быть полностью осознана важная роль продуктивности «зеленых» факторов в трансформации режима экономического роста.
В рамках статьи авторами исследуются экологические факторы, напрямую влияющие на экономику страны в разрезе выбранных индикаторов.
Улучшение качества окружающей среды не является неизбежным эндогенным результатом в процессе экономического роста, поэтому мы не можем продолжать нынешний режим экстенсивного экономического роста и ожидать автоматического улучшения качества окружающей среды. Существует определенный порог качества окружающей среды. Как только загрязнение окружающей среды превысит возможности экосистемы, это приведет к необратимым экологическим потерям. Поэтому мы должны сначала скорректировать концепцию загрязнения, а затем уже контролировать его, учитывая улучшение качества окружающей среды и экономический рост.
Ключевые слова: промышленные загрязнители; эмиссия; окружающая среда; устойчивое развитие; кривая Кузнеца; экономический рост; зеленое производство; факторы производства; ВВП на душу населения.

1. Introduction

Improving the quality of the environment, in our deep conviction, cannot be solved by slowing down the pace of economic growth. In our view, it is possible to achieve a win-win situation between economic growth and environmental quality by changing the current economic development regime and achieving «green» transformations.

Due to the rapid economic development of various countries and the growing problems of environmental pollution, many scientists have focused on the impact of economic growth on the quality of the environment, and some scientists have focused on the mechanism of environmental regulation for economic growth. However, from the existing literature on the subject, there are few studies on the two-way mechanism of impact on the resources of the state of the environment and economic growth.

Researchers tend to think about how to turn the current mutually restrictive relationship between the economy and the environment into a favourable relationship that promotes each other's development. In many modern literary sources, the relationship between resources, the environment and economic growth is considered by scientists from different perspectives, but ways to promote economic growth by increasing the «green economy» they are not yet universal.

The research methodology is based on a systematic interdisciplinary research approach. Theoretical constructions are based on the results of analysis of economic literature and empirical research on resources, environment and sustainable economic development in existing theories of economic growth.

The theoretical basis of the research was the works of modern scientists who described the idea of transferring part of social functions to business.

2. Brief Literature Review

During the rapid development of the world economy, the material living conditions of people have improved significantly, but the quality of the environmental environment has suffered unprecedented damage (Brock, 2004). As a result, people began to face economic growth (Mishan, 1967). An overview of surveys at home and abroad (Meadows, 1972). Numerous studies of scientists on the relationship between environmental qualities at different stages of economic development have been published (Cialani, 2007; Kaika & Zervas, 2013 a, b). During this period, many literary studies appeared, and the most relevant topic of research by domestic authors is currently sustainable development (Shkiperova, 2013; Zhao, 2015).

This task is largely solved through environmental regulation, which is playing an increasingly important role in transforming Russia's economic development regime (Wang, 2016). The main goal of environmental regulation is not to completely eliminate environmental pollution or completely slow down the pace of economic growth (Baek, 2016), but to promote a development model that is compatible with economic growth and environmental quality (Panayotou, 1993). Originally, environmental regulation was the direct intervention of governments in market-based economic activities to protect resources and the environment, including a licensing system and production bans (Cole, 2013). Subsequently, with the introduction of more environmental

regulations (Webber, 2010), the content of environmental regulations was expanded, and environmental regulations became a direct and indirect intervention in market economic activity (Grossman, 1991).

3. Materials and Methods

In this work, we used materials from scientific articles and dissertations of domestic and foreign scientists, data from monographs, as well as information from the state statistics service Rosstat. The econometric modelling has been applied to check the hypothesis.

4. Results

Environmental problems caused by the energy crisis and the accelerated depletion of non-renewable resources since the 1970s have forced environmentalists and economists to study the question of sustainable economic growth in greater depth. The most representative of them is the study «Limits of growth», published by the representative of the club of Rome, D. Meadows in 1972 (Meadows, 1972). After constructing a growth model that includes population, energy, environmental pollution, and other factors, the author concluded that economic growth has limitations.

The classical regression model of panel data for hypothesis testing, using the Environmental Kuznets Curve (EKC) can be represented as follows (Niesten, 2017):

$$Y_{it} = a_i + B_1 X_{it} + B_2 X_{it}^2 + B_2 X_{it}^3 + B_3 Z_{it} + e_{it}\ , \quad (1)$$

where:

Y is a dependent variable describing the degree of degradation and the surrounding environment;
X is an explanatory variable on the obtained;
Z is a vector of variables responsible for factors that can potential affect Y;
a_i (const) and B_k (K = 1; 2, 3) are coefficients for the explanatory variables. Depending on the significance and signs at coefficients B_k, the nature of the relationship between economic growth and environmental qualities will be determined as follows (Michalides, 2016):
a) the expression $B_j = B_2 = B_3 = 0$ means that there is no difference between Y and X;
b) expression $B_j > 0$, $a > B_2 = B_3 = 0$ indicates the presence of a linearly increasing interconnectedness;
c) the expression $B_j < 0$, and $B_2 = B_3 = 0$ indicates the presence of a linearly decreasing relationship;
d) the expressions $B_j > 0$, $a > B_2 < 0$ and $B_3 = 0$ indicate the presence of a t inverted U-shaped relationship;
e) expression $B_j < 0$, and $B_2 > 0$ and $> B_3 =$ indicates the presence of a U-shaped connection;
f) the expression $B_j > 0$, $a > B_2 < 0$ and $B_3 > 0 >$ indicates the presence of an N-shaped relationship;
g) the expression $B_j < 0$, and $B_2 > 0$ and $> B_3 < 0$ indicates the presence of an inverted N-shaped relationship between the dependent and explanatory variables Y and X.

The hypothesis of the existence of EKC will be confirmed when the signs and significance of the coefficients of the algorithm shown above were identical with the case «d». In the variants of the algorithm «f» and «g», changes in the quality of the environment will also be observed in the areas of economic growth, corresponding to the EKC theory.

The state of environmental pollution in Russia

By the end of 2018, the total volume of industrial production in all sectors in Russia reached EUR 1.02 trillion (Kharlamov, 2019), the aggregate growth rate at current prices was 1.22%, and the share of GDP in the industrial sector increased from 44.6% in 2016 up to 47.3% in 2018. However, the current model of extensive development has led to an accelerated depletion of resources and serious environmental pollution. According to data released by the Federal State Statistics Service of Russia (2018), Russia has become the fourth largest energy consumer in the world, accounting for 2% of total energy consumption in the world. At the same time, China's carbon dioxide emissions surpassed the United States in 2007, becoming the country with the highest carbon dioxide emissions in the world.

In Russia has, since 2010, for a decrease of the weight of emissions from 59.1% to 54.9% in 2017, the amount emitted into the atmosphere pollutants are consistently growing: 31.3 thousand tons in 2015, 31.6 thousand tons in 2016 and, accordingly, to 32.1 thousand tons in 2017.

The largest share in the emissions of air pollutants is carbon oxides, the amount of which has not changed since 2010 (15.4 thousand tons - 2010, 15.5 thousand tons - 2014 and 2015, 15.8 thousand tons - 2016 and 16.2 thousand tons in 2017).

The data of the Federal State Statistics Service of Russia (2018) on environmental protection is information basis for conducting our study.

It should be noted that Rosstat does not provide data on carbon dioxide (CO_2) emissions, which is one of the most intense anthropogenic pollutants in the environment. Factors reflecting environmental pollution, in our opinion, could be the volume of emissions of sulphur dioxide (SO_2), nitrogen oxide (NO_2), carbon monoxide (CO) and volatile organic compounds (VVOCs). The Gini coefficient is used to determine economic inequality. To assess the impact of structural changes in the Russian economy on the studied dependence, data on the contribution of various industries to GRP are used (Table 1).

The sample consists of 29 cities (municipalities) of the regions for the period 1997-2015. Based on available data, the study analyzes the relationship between emissions of five types of industrial pollutants and per capita income. The following pollutants were studied: industrial wastewater (CB), solid industrial waste (PV), industrial emissions of sulphur dioxide (SO_2), industrial dust (ID) and industrial soot (IS). As an indicator of state environmental regulation, we used the proportion of pollutants that were removed from the natural environment and - in the case of solid waste - recycled (Table 2).

Empirical results for data for 29 provinces are shown in Table 3. As can be seen from Table 3, the relationship between different pollutants and GDP per capita at the national level is ambiguous. From the results, it is obvious that if we use panel data for the period 1997-2018, the hypothesis of the existence of EKC does not come true. The relationship between industrial SO_2/soot/dust/solid waste emissions and GDP per capita can be described by a cubic parabola (N-shaped curve), while the relationship between industrial wastewater emissions and GDP per capita can be described as a regular parabola (U-shaped curve).

Table 1:
List of variables used in empirical analysis

Designation	GRPp Indicator
GRPp (X)	GRP per capita in constant prices, rubles
$GRPp^2$ (X2)	InRP in sq. ad rate per capita in constant prices, rubles
$GRPp^3$ (X3)	GRP in per capita in constant prices, rubles
SO_2	Sulphur dioxide, tons
No	Nitrogen oxides, tons
WITH	Carbon monoxide, tons
VOS	Volatile organic compounds, tons
GINI	Gini Coefficient (%)

Source: Compiled by the authors

Table 2:
Statistical description of variables in the Russian tax system

Variable	Units of measurement	Number of observations	Average value	The median	Standard deviation	At least	Maximum
SV (industrial wastewater)	10000 tons	406	76065.96	61713.00	57784.76	4093.00	296318.00
PV (solid industrial waste)	10000 tons	384	50568.09	40.63	402306.00	0.00	6288789.00
SO_2 (industrial emissions of sulphur dioxide)	10000 tons	406	55.65	48.44	38.96	1.67	182.42
ID (industrial dust)	10000 tons	406	29.31	22.88	22.36	1.06	100.58
IS (industrial soot)	10000 tons	406	31.50	26.60	22.67	1.00	156.19
Y_{it} (real GDP per capita)	10000 yuan	406	4766.41	3649.48	3576.01	951.70	26290.43
ind_{it} (share industry in GDP)	%	406	43.43	42.74	6.91	20.92	60.79
ex_{it} (share of exports in GDP)	%	406	14.60	6.42	17.53	2.07	93.67
im_{it} (share of imports in GDP)	%	406	13.75	4.48	22.70	0.49	157.52
FDI_{it} (received inflow of foreign direct investment)	10000 USD US	405	154581.6	52340.00	252863.00	0.00	1318020.00
POP_{it} (population)	10000 people	406	4440.75	3966.00	2731.17	461.00	11847.00
R (ratio) SV	%	406	66.42	65.53	19.59	27.04	99.84
R PV	%	384	17.64	12.82	20.69	0.12	82.46
R SO_2	%	398	22.02	15.57	16.42	0.00	68.36
R PP	%	406	80.60	82.46	10.78	23.11	99.51
R PS	%	406	91.89	93.06	5.33	62.30	99.30

Source: Compiled by the authors according to Rosstat data of 2019

Table 3:
The results of calculations in Russia

Variables	SV	PV	SO_2	Inventory items	PS
C	19.4442	214.3910	82.9334	76.6555	150.2739
	(3.0704)*	(1.1364)	(3.3333)*	(1.8837)***	(5.4285)*
lnY_{it}	-3.8009	-119.9141	-31.5505	-30.1168	-46.2946
	(-3.3711)*	(-1.6145)****	(-3.5116)*	(-2.0289)**	(-4.8111)*
$(lnY_{it})^2$	0.2419	15.1057	3.8025	4.0161	5.6374
	(3.7462)*	(1.7092)***	(3.6251)*	(2.2978)**	(5.0558)*
$(lnY_{it})^3$		-0.6297	-0.1502	-0.1739	-0.2272
		(-1.7949)***	(-3.6837)*	(-2.5392)**	(-5.2837)*
ind_{it}			0.0146	0.01499	0.0147
			(4.0113)*	(2.4432)**	(3.4364)*
ex_{it}		-0.0447	0.0065		0.0042
		(-1.8455)***	(2.7154)*		(1.9869)**
im_{it}			-0.0030		
			(-2.3635)**		
$lnFDI_{it}$		-0.4693			
		(-2.6178)*			
$lnPOP_{it}$	0.7626	13.4528	0.7702	1.1392	
	(1.8794)***	(2.7998)*	(2.33.7)**	(1.8671)***	
lnR_{it}	-0.1803		-0.1554	-2.4481	-4.8766
	(-4.2131)*		(-7.8914)*	(-19.3156)*	(-17.8574)*
AR(1)	0.9673	-0.2667	0.5796	0.5152	0.5499
	(44.5595)*	(-5.5688)*	(12.2835)*	(11.2847)*	(13.3662)*
Adjusted R-squared	0.9917	0.8676	0.9856	0.9568	0.9721
F statistic	1360.536	65.7803	684.0447	238.6831	375.7000
Hausman	111.5277	13.2003	13.9630	7.7371	16.1747
Extremum (P)	-	6361	13900	7601	7841
Extremum (L)	2578	1420	1543	639	1947
Number of observations	406	384	398	406	406
Number of cities	29	29	29	29	29
shape of the curve	Parabola (U -shaped curve)	Inverse cubic parabola (N -shaped curve)	Inverse cubic parabola (N -shaped curve)	Inverse cubic parabola (N -shaped curve)	Inverse cubic parabola (N-shaped curve)

Note: * significance at 1% confidence level; ** significance at 5% confidence level;
*** significance at 10% confidence level; **** significance at 15% confidence level.

Source: Compiled by the authors

Please note that the study analyzes data only for 18 years - this may also affect the reliability of the results. In addition, the model does not take into account the possible reverse impact of the environment on economic growth. Therefore, for further research, it is worth using a system of equations that will also take into account this relationship.

Methods for the industrial economic growth measuring

According to the second method, the production function Y_{it} of the I-th sub-sector in the t-th period can be expressed as:

$$Y_{it} = A_{it} \times K_{it}^{\propto} \times L_{it}^{\beta} \times E_{it}^{\gamma}, \quad (2)$$

where:
Y_{it} - total productivity of production factors;
A_{it} - a constant term in the model, or shift;
$K_{it}^{\propto}$ - capital;
L_{it}^{β} - labour costs;
E_{it}^{γ} - total energy consumption.

Then, it is necessary to find the logarithm of both sides of the formula, differentiating the time:

$$g_{Y_{it}} = g_{A_{it}} + g_{K_{it}} + g_{L_{it}} + g_{E_{it}}, \quad (3)$$

where:
$g_{Yit} = \Delta YitlYit$ represents the rate of change in the volume of industrial production;
$g_{Ait} = \Delta AitlAit$ sets the rate of change in the «green» output common factor;
$g_{Kit} = \Delta KitlKit$ represents the rate of change in capital investment;
$g_{Lit} = \Delta LitlLit$ represents the rate of change in labour input;

$g_{Eit} = \Delta Eit/Eit$ represents the rate of change in energy consumption.

Dividing both parts of equation (3) by g_{Yit}, we obtain the expression:

$$1 = \frac{g_{A_{it}}}{g_{Y_{it}}} + \frac{\alpha g_{AK_{it}}}{g_{Y_{it}}} + \frac{\beta g_{L_{it}}}{g_{Y_{it}}} + \frac{\gamma\alpha g_{E_{it}}}{g_{Y_{it}}} \cdot \quad (4)$$

The right-hand side of the above equation represents the coefficients of the contribution of total «green» productivity to economic growth by factors of production, capital investment, labour input, and total energy consumption of industry. Let ATY_{it} be a share of the contribution of «green» total factor productivity of the I-th subsector in the t-th period in the growth of industrial production of the subsector:

$$ATY_{it} = \frac{g_{A_{it}}}{g_{Y_{it}}} = \frac{(A_{it}-A_{it-1})/A_{it-1}}{(Y_{it}-Y_{it-1})/Y_{it-1}} = \left(1 + \frac{\alpha g_{K_{it}}}{g_{A_{it}}} + \frac{\beta g_{L_{it}}}{g_{A_{it}}} + \frac{\gamma g_{E_{it}}}{g_{A_{it}}}\right). \quad (5)$$

From the above formula it follows that, when $g_{Ait} > 0$, $\alpha g_{kit} + \beta g_{Lit} + \gamma g_{Eit} > 0$, and $g_{Ait} > \alpha g_{kit} + \beta g_{Lit} + \gamma g_{Eit}$, then:

$$0 < \frac{\alpha g_{kit}+\beta g_{Lit}+\gamma g_{Eit}}{g_{A_{it}}} < 1 \Rightarrow 0.5 < ATY_{it} < 1 . \quad (6)$$

This indicates that if the overall productivity growth is «green» if and the number of factors exceeds the weighted average of capital, labour and energy growth rates, then industrial economic growth can be characterized as «green» and intense.

$$\text{If, } g_{Ait} < \alpha g_{kit} + \beta g_{Lit} + \gamma g_{Eit} \Rightarrow \frac{\alpha g_{kit}+\beta g_{Lit}+\gamma g_{Eit}}{g_{Ait}} > 1 > \Rightarrow 0 < ATY_{it} < 0.5 , \quad (7)$$

then it indicates that the growth of the overall «green» this factor is less than the weighted average of capital, labour, and energy growth rates, which means that industrial economic growth tends to grow extensively. The quality of industrial economic development will also decline, provided that ATY_{it} = 0.5. The resulting value of ≤ 0 indicates that the overall productivity of the industrial environmental factor has decreased compared to the previous period, which can be caused by a decrease in production efficiency or technological regression.

Discussion on the achieved results

Studying the restrictive impact of resources and the environment on economic growth in the context of the increasing role of technological progress, first, there is a two-way relationship between economic growth and environmental quality. In addition, resources and the environment not only participate in the process of economic growth as factors, but also improve economic quality, as well as provide the necessary material conditions for improving the state of the environment.

5. Conclusion

Due to the increase in environmental pollution, the current model of extensive development of Russia, which relies on traditional factors to stimulate economic growth, is no longer sustainable. Production with a high level of pollution limits the further development of the Russian economy. Therefore, it is necessary to radically change the mode of development of the industrial economy, which requires constant improvement in the overall productivity of «green» factors of production, which contribute to improving the quality of economic growth in industry. Therefore, first of all, Russia should abandon the ideology of «first pollute, and then manage» and «everything is only for the benefit of GDP». Secondly, in the process of accelerating the «green» transformation of the domestic economy, the important role of the productivity of «green» factors in transforming the economic growth regime should be fully realized. It is necessary to encourage the development of knowledge-intensive industries, while accelerating the elimination of backward production capacities.

It is necessary to accelerate the creation of a reliable industrial production system based on the principles of reuse and recycling, significantly improving the efficiency of resource use, implementing such industry functions as production, energy conversion, waste disposal and recycling, as well as strengthening horizontal links between production sectors.

References

1. Baek, J. (2016). Do nuclear and renewable energy improve the environment? Empirical evidence from the United States. *Ecological Indicator*, *66,* 352-356. doi: https://doi.org/10.1016/j.ecolind.2016.01.059
2. Bhattarai, M., & Hammig, M. (2001). Institution and the environmental Kuznets curve for deforestation: a crosscountry analysis for Latin America, Africa and Asia. *World Development*, *29*(6), 995-1010. doi: https://doi.org/10.1016/S0305-750X(01)00019-5
3. Brock, W., & Taylor, M. S. (2004). Economic growth and the environment: a review of theory and empirics. *National Bureau of Economic Research, 10854,* 1-59. doi: https://doi.org/10.3386/w10854
4. Cialani, C. (2007). Economic growth and environmental quality: an econometric and a decomposition analysis. *Management of Environmental Quality, 18*(5), 568-577. doi: https://doi.org/10.1108/14777830710778328
5. Cole, M. A., & Elliott, R. (2003). Do environmental regulations influence trade patters? Testing old and new trade theories. *World Economy*, *26*(8), 1163-1186. doi: https://doi.org/10.1111/1467-9701.00567
6. Daly, H. E. (1990). Toward some operational principles of sustainable development. *Ecological Economics*, *2*(1), 1-6. doi: https://doi.org/10.1016/0921-8009(90)90010-R
7. Federal State Statistics Service of Russia. (2018). *Environmental protection in Russia.* Retrieved from https://www.gks.ru/free_doc/doc_2018/ohrana_2018.pdf (in Russ.)
8. Forster, B. A. (1972). A note on economic growth and environmental quality. *The Swedish Journal of Economics*, *74*(2), 281-285. doi: https://doi.org/10.2307/3439237
9. Grimaud, A. (1999). Pollution permits and sustainable growth in a schumpeterian mode. *Journal of Environmental Economics and Management*, *38*(3), 249-266. Retrieved from https://econpapers.repec.org/article/eeejeeman/v_3a38_3ay_3a1999_3ai_3a3_3ap_3a249-266.htm
10. Grossman, G. M., & Krueger, A. B. (1991). *Environmental impacts of a North American free trade agreement.* National Bureau of Economic Research, Cambridge: MA 02138. Retrieved from https://papers.ssrn.com/sol3/Delivery.cfm/nber_w3914.pdf?abstractid=232073&mirid=1
11. Hueting, R. (1980). *New scarcity and economic growth: more welfare through less production*. Amsterdam: North Holland.
12. Kaika, D., & Zervas, E. (2013a). The Environmental Kuznets Curve (EKC) theory - Part A: Concept, causes and the CO_2 emissions case. *Energy Policy*, *62*, 1392-1402. doi: https://doi.org/10.1016/j.enpol.2013.07.131
13. Kaika, D., & Zervas, E. (2013b). The Environmental Kuznets Curve (EKC) theory. Part B: Critical issues. *Energy Policy*, *62*, 1403-1411. doi: https://doi.org/10.1016/j.enpol.2013.07.130
14. Kharlamov, M., Sernyk, V., & Zabaykin, V. (2019). *Socio-ecological and economic conditions of development and formation of subsurface use enterprises: monograph*. Research. Retrieved from https://nationalresearch.ru/index.php/nr/catalog/book/17
15. Meadows, D. H., Meadows, D. L., & Randers, J. (1972). *Limits to growth. Earthscan*. Retrieved from http://cima.ibs.pw.edu.pl/wp-content/uploads/limits-to-growth-updated.pdf
16. Michalides, S. G., & Ruskin, J. V. (2016). Kuznets curve: the case of Russia. *Business & Finance, 1,* 17-39. Retrieved from http://businessandfinance.com/magarchive/2016/FDI100
17. Mishan, E. J. (1967). *The costs of economic growth*. London: Staples Press.
18. Niesten, E., Jolink, A., Jabbour, A. B. L., Chappin, M., & Lozano, R. (2017). Sustainable collaboration: the impact of governance and institutions on sustainable performance. *Journal of Cleaner Production*, *155*, 1-6. doi: https://doi.org/10.1016/j.jclepro.2016.12.085
19. Opschoor, J. B. (1998). Sustainability, economic growth and development theory. *Journal of Social and Economic Development*, *1*(1), 24-43. Retrieved from https://ideas.repec.org/a/sch/journl/v1y1998i1p24-43.html
20. Panayotou, T. (1993). *Empirical tests and policy analysis of environmental degradation at different stages of economic development.* International Laborur Office, Geneva: WEP 2-22/WP. 238. Retrieved from http://www.ilo.org/public/libdoc/ilo/1993/93B09_31_engl.pdf
21. Pearce, D. W., & Turner, R. K. (1990). *Economics and natural resources and the environmental in the third world.* New York: Harvester Wheatsheaf.
22. Pezzey, J. C. V. (1992). Sustainability: an interdisciplinary guide. *Environmental Values*, *1*(4), 321-362. doi: https://doi.org/10.3197/096327192776680034
23. Shkiperova, G. T. (2013). Environmental Kuznets curve as tool of regional development studies. *Economic analysis: theory and practice, 12*(19), 8-16. Retrieved from https://www.fin-izdat.com/journal/analiz/detail.php?ID=56722
24. Wang, Y., & Shen, N. (2016). Environmental regulation and environmental productivity: the case of China. *Renewable and Sustainable Energy Reviews*, *62*, 758-766. doi: https://doi.org/10.1016/j.rser.2016.05.048
25. Webber, D. J., & Allen, D. O. (2010). Environmental Kuznets curves: mess or meaning? *International Journal of Sustainable Development and World Ecology*, *17*(3), 198-207. doi: https://doi.org/10.1080/13504501003787638
26. Zhao, X., Zhao, Y., & Zeng, S. (2015). Corporate behavior and competitiveness: impact of environmental regulation on Chinese firms. *Journal of Cleaner Production*, *86*(1), 311-322. doi: https://doi.org/10.1016/j.jclepro.2014.08.074

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