Environment and economic growth in the Russian Arctic

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Abstract: The purpose of this study is to examine the hypothesis of the inverted U-shaped interdependence between environmental damage from air pollutant emissions and economic growth measured by gross regional product (GRP) per capita in the Arctic regions of Russia. Using the panel data for the period of 2000–2014, we apply FM-OLS panel long-run estimates proposed by Pedroni to investigate the existence of environmental Kuznets curve. Various panel data unit root and co-integration tests are also applied. We examine the stationary properties of individual series in panel datasets using different panel unit root tests. According to the concept of the environmental Kuznets curve all regions of the Russian Arctic are on the increasing branch of the curve. The economic growth is found to have no beneficial effect on the environment in the Arctic. We actualise the need of concentrated policies and incentives to reduce air pollutant emissions in the Russian Arctic.

Keywords: Arctic; environmental Kuznets curve; EKC; environment; economic growth; Russia.

1 Introduction

The unique geo-economic and geopolitical potential of the Arctic is attracting an increased attention to the issue of sustainable development of the Russian circumpolar zone, to the need of a balance ensure between economic and technological development of Polar regions and to the improvement of inhabitant's well-being (Giltman, 2016).

As noted by Przybylak (2016) "the Arctic environment has been treated as a pristine place unspoiled by man. The renewed interest in the nature and origin of the 'Arctic haze' was caused by the growing evidence found during this time that air pollution is not only confined to small areas around urban or industrial sources, but can be transported long distances before being removed to the Earth's surface". The issue of preserving and protecting the natural environment of the Arctic in the face of increasing industrial activity is up-to-date. The Arctic trend of nature management acquires a particular significance in the focus of global environment and social-and-economic changes in the modern world. The increasing availability of the Arctic sea water areas draws more and more attention to energy, transport, recreational development of the Arctic zone of our planet. At the same time, there are no unified strategies, policies and approaches to mitigation of pollution problems across Arctic regions. More attention is drawn to issues of ecological safety of human activity in the Arctic which is becoming the cornerstone of the problem and can be an obstacle in development of resources of the Arctic shelf. In this regard, it is necessary to develop methods that could assess environmental risks against adverse impact on the environment. It is also required to develop guidelines for ensuring ecological safety.

The necessity of the scientific substantiation of the Russian Federation's Arctic zone's environmental security is determined by the provisions of the environmental doctrine of the Russian Federation, the climate doctrine of the Russian Federation, a significant climate change in the Arctic (Didenko et al., 2015).

2   Literature review

Empirical studies on the interdependence between economic growth and environmental pollution have been published every year over the past two decades. However, there is no well-defined conclusion on the long-run relationship. This may come from the different economic structures and samples analysed by all studies (Rudenko and Skripnuk, 2016). The main strand of the literature concentrates on the environmental pollution and output nexus, mainly devoted to testing the validity of the environmental Kuznets curve (EKC) hypothesis (Pao et al., 2011). Kuznets (1955) thesis consisted in the fact that there is a certain pattern in the dynamics of inequality – the so-called 'Kuznets curve': the early phase of industrialisation, when the recipients of its benefits is only a tiny minority of large landowners, inequality is growing; but then, as the distribution of these benefits to ever broader sections of the population, it falls back to the original values or even lower.

Since Grossman and Krueger (1995) Kuznets curve has been widely used in an environmental policy. They believe that the economic development of the country when the gross domestic product per capita reaches the level of four to five thousand dollars (in 1991 prices) allows a society to start mitigating the harmful anthropogenic impact on the environment. Evidence of this theory was built on the measurement of soot, sulfur dioxide, particulate matter. However, in subsequent studies, the use of EKC was strongly contested. With economic growth, which begins with low level of development and the low level of income in the country nature-exploiting sectors, extensive use of natural resources in the mining industry, agriculture, forestry farms are at the forefront. This leads to a further depletion of natural resources and environmental pollution. However, as the economy grows the environmental impact is reduced, as its structural and technological basis is changing, diffusion of environmentally friendly technologies takes

place, the country enters the post-industrial stage of development with the priorities of information technology and services. This contributes to the improvement of human welfare in general, and the growth of its requirements for the quality of environmental component of life.

The model of the EKC explains the possibility of combining economic growth and reduction of anthropogenic impacts through effective environmental policy, structural shifts in the economy, changes in the structure of consumption and other factors. Thus, according to the hypothesis of the EKC, economic growth may be the solution, not the source of the problem. The modern theoretical justification of the existence of EKC was deeply reviewed by Taylor and Brock (2005), who focused on three questions:

1   what is the relationship between economic growth and the environment?

2   how can we escape the limits to growth imposed by environmental constraints?

3   where should future research focus its efforts?

Growth of populations revenue is accompanied by increasing demand for services and reduce consumption of manufactured goods, and hence the natural resources. It is also known that in the production of services less energy and natural resources consumed than in the production of industrial goods. As society at a higher level of income is switched to consumption of the products of the tertiary sector of production, negative environmental impacts associated with industrial production decreased. Elasticity of demand for such benefits as clean air, clean water, and pleasant environment for consumers is increasing at a high level of income. For them, these benefits become a kind of luxury. In the country as a whole, the production of such luxuries provided by the more stringent environmental standards, higher environmental taxes, and other administrative measures.

Scientific and technological progress, that accompanying economic development in developed countries, contributes to energy efficiency, i.e., the same amount of product produced at lower resources cost, for example, by recycling. The desire to preserve the environment objectively inherent in countries with high incomes. From a quantitative point of view the EKC may be due to economies of scale as production efficiency becomes a direct consequence of scale. Another explanation is caused by various reasons so-called 'threshold effect'. In this case, a certain threshold value of income creates opportunities to reduce emissions. These features can be directly generated by the advent of new technologies or changes in policy, the emergence of specialised organs of control over the level of contamination.

Kuznets curve has been criticised. One of the arguments is that the reduction of pollution in developed countries is related to the phenomenon of so-called 'ecological discharge' when harmful production moves to less developed countries. Similar scenarios have questioned the belief that economic growth automatically leads to the improvement of the ecological situation in the country, and also allow to doubt that the developing nations today will be able to follow the same path in the future. Paying attention to the question of dirty industries movement to less developed countries is worth noting the hypothesis of 'pollution havens'. This hypothesis tells that more stringent environmental regulations in developed countries makes the company transfer polluting production to countries with less stringent regulations, most of which are developing countries and least developed countries. But a number of empirical studies have failed to confirm the truth of this hypothesis. In practice, it turned out that in the firm's decision to invest in any

country affected by other factors (strategy of the company, the consumer) but not the degree of strictness of environmental legislation.

One of the first in the 'pollution haven' approach is Gallagher (2004). According to his approach, a country with less stringent environmental requirements will have more opportunities to pollute the environment. Therefore, trade liberalisation between developing and developed countries (where more stringent requirements) can lead to an increase in economic activity in the polluting industries in developing countries. Gallagher (2004) also highlights the direct and indirect effects that affect the environmental impact of trade. Direct effects occur in the short term: trade (and pollution) goes through ships, aircraft, and ground transportation.

Grossman and Krueger (1995) described the indirect effects of linking the liberalisation of trade and investment regime with the environment. There are three mechanisms of influence: the scope, structure and technological effects. Within the scale of trade liberalisation leads to an expansion of economic activity, and if the activity is not changed there is an increase in pollution and the reduction of resources. Structure growth in trade leads to specialisation in the country's comparative advantage, and if there are differences in environmental requirements, environmental problems are growing. Technological effects are based on the fact that with the liberalisation of the trade regime multinational corporations export clean technology, the GDP is growing and the population starts to demand a cleaner environment.

The scale effect refers to the impact of economic growth on the environment. Grossman and Krueger (1995) studied data on pollution levels and per capita income in several countries, relying on the following result: the environmental situation deteriorates uniformly with increasing scale of economic activity. However, the results surprised scientists. As expected, the sulfur dioxide pollution level increases with an increase in per capita income at low income levels, but at higher levels of income it falls. This discovery was followed by other researchers studying the impact of economic growth on the environment (Selden and Song, 1994). They came to a similar result reverse U-shaped curve that describes the relationship of per capita income and the various indicators of environmental degradation. Halkos and Tzeremes (2013) show an inverted U-shape form for the relation of US regions' economic growth – environmental efficiency levels. However, using different indicators of environmental damage Halkos and Tsionas (2001) and Halkos (2003) has not proved the existence of EKC in his previous papers.

Day and Crafton (2003) in one of the first papers on the Arctic countries proved no long-term relationship between per capita income and the measures of environmental degradation in Canada suggesting that the country did not have the luxury of being able to grow out of its environmental problems. Pao et al. (2011) analysed the main determinants of CO_2 emissions in Russia employing annual total data over the period between 1990 and 2007. The applied co-integration techniques as well as short and long run causality tests did not support EKC hypothesis. Using an autoregressive distributed lag (ARDL) modelling approach to co-integration Baek (2015) has also provided little evidence of the existence of the EKC hypothesis for the Arctic countries for the period 1960–2010. Meanwhile, applying the same technique Zambrano-Monserrate et al. (2016) confirmed the existence of a long-term relationship among environmental degradation and economic growth in Iceland in line with EKC hypothesis.

Stern (2004) describes the processes behind Kuznets curve as follows. At the lower levels of economic activity impact on the environment is usually small, but with the time the environmental pressure increases (the area of deforestation is increased; exploitation

of natural resources is growing as well as the per capita generation of waste). However, at higher levels of development, structural shifts in the direction of the information-oriented enterprises, concern the environmental situation in the society, the tightening of laws related to the environment, the optimisation technologies result in leveling and a gradual reduction of environmental degradation.

The position of the supporters of the Kuznets hypothesis can be expressed by Beckerman (1992): "the best – and probably the only-way to attain a decent environment in most countries is to become rich".
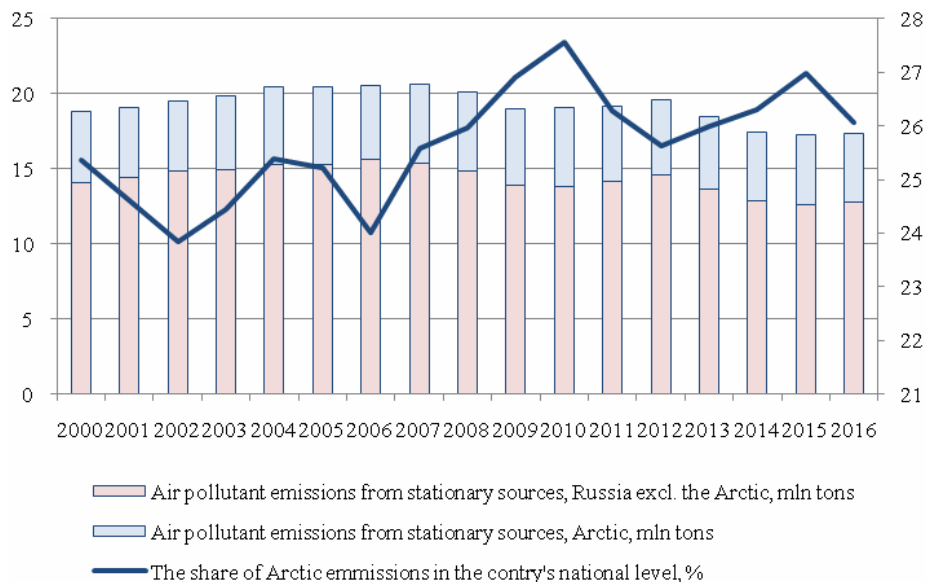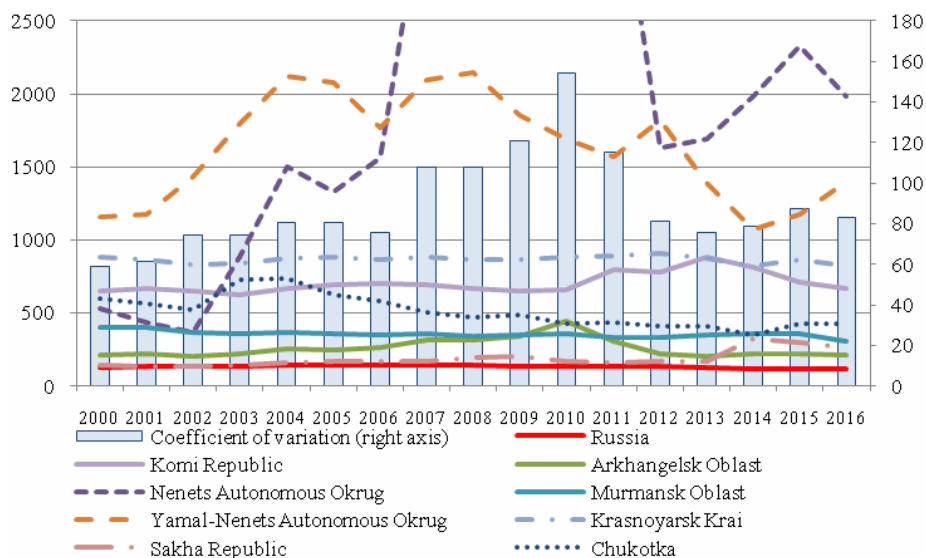
3   The pollution dynamics in the Russian Arctic

The systematic measurements of carbon dioxide and methane concentration in the near surface Arctic air were started in Russia in the late 1980s (long series of observations were obtained at four stations Teriberka, Voyeikovo, New Port and Tiksi). The results of observations at the Teriberka station (Figure 1) reflect a global change in the long-lived greenhouse gases content in the atmosphere.

Figure 1   The dynamics of long-lived greenhouse gases in the Arctic, 1999–2015 (see online version for colours)
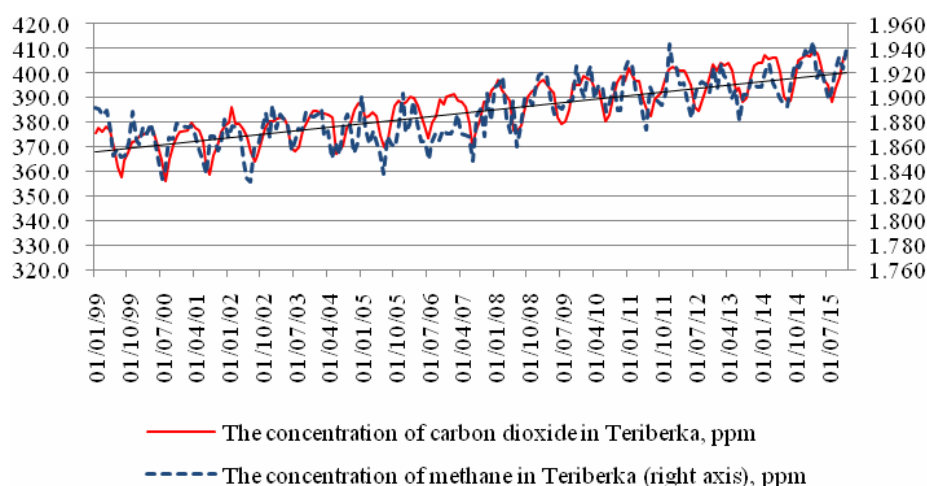
The amount of air pollutant emissions from stationary sources in Russia has decreased from 20.6 in 2007 to 17.3 million tons in 2016. Meanwhile the decrease of air pollutants in the Russian Arctic was not as rapid (Figure 2). Stationary source of emission of contaminants into atmospheric air is a non-moving fixed-site process unit (plant, device, apparatus etc.) polluting the atmospheric air during its work. This category also includes other items (spoil tips, reservoirs, etc.). The slow reduction of emissions of pollutants did not decrease their concentration in the atmosphere since the sharper emission reduction is needed for this purpose. The Arctic regions of Russia with population of 2.4 million people or just 1.7% of the country's total produce about 26% of all air pollutant emissions in Russia. Taking it into account the per capita emissions in all the regions is considerably above Russia's average.

Figure 2   Air pollutant emissions in Russia and the Arctic, 2000–2016 (see online version for colours)

Figure 3   Emissions of air pollutants per capita in the Arctic regions, kg (see online version for colours)

The dynamics of air pollutant emissions from stationary sources per capita in the Russian Arctic regions over the period from 2000 to 2016 is presented in Figure 3. The regions are characterised by high differentiation in the level of development, which is linked to the fact that they are sector specific, largely defined by their historical and geographical background (Romashkina et al., 2017). Regional differences in air pollutions have been

rapidly increasing after 2006 due to a start of oil and gas exploration in the area. The highest volume of emissions per capita is observed in the Nenets Autonomous Okrug and the Yamalo-Nenets Autonomous Okrug. The main factor behind the poor performance of Arctic regions is the significant depletion of extractable resources, owing to the dominance of the mining sector in the economy. The role of resource mining in the structure of gross regional product (GRP) in the Nenets Autonomous Okrug and the Yamalo-Nenets Autonomous Okrug is the highest in Russia, at over 70% and 50% respectively. As noted by Gilmundinov et al. (2014) the industrial impacts on the environment in both regions lead to significant pollution and the elimination of reindeer pastures and hunting grounds, which form the basis of the lives and activities of the indigenous people in the region. The major sources of pollution in the Murmansk and Arkhangelsk oblast are mining companies, nonferrous metallurgy, energy production, the chemical industry, and housing. The significant negative impacts of environmental factors are more evident in the Arctic than in the southern regions, since the restoration of ecosystems that have been disturbed by external impact takes decades there.

4   Data, methodology and results

Following the empirical literature in environmental economics, it is plausible to form a long-run relationship between emissions and its factors in a linear logarithm form Baek (2015). We estimate the Kuznets curve in Arctic regions of Russia using a time series dataset covering the period from 2000 to 2014. We explore four regions of Russia, which, according to presidential decree number 296 of 2nd May 2014 wholly relate to the Arctic zone of the Russian Federation: Murmansk Oblast, Nenets Autonomous Okrug, Yamal-Nenets Autonomous Okrug and Chukotka. Due to the lack of municipal statistics, research is being conducted at the level of subjects of the Russian Federation without detailed consideration of municipalities of the Komi Republic, Republic of Sakha (Yakutia), Krasnoyarsk Krai and Arkhangelsk Oblast. We use official data published by the Federal State Statistics Service of the Russian Federation.

The baseline regression is represented by equation (1).

$$\ln E_{it} = \beta_{0i} + \beta_{1i} \ln y_{it} + \beta_{2i} \ln y_{it}^2 + \rho_i t + \varepsilon_{it} \tag{1}$$

Where E_{it} is environmental damage measured by air pollutant emissions from stationary sources in kg per capita, y_{it} is GRP per capita in constant 2010 prices, $i = 1, \ldots, 4$ and $t = 2000, \ldots, 2014$ indicate the region and time, respectively. β_{0i} and ρ_i denote the region specific fixed effect and deterministic trends corresponding to each panel, respectively. ε_{it} indicates the estimated errors representing other causes of environmental damage. The parameters β_{1i} and β_{2i} are the long-run elasticities corresponding to each explanatory variable of the panel. With respect to the inverted U-shaped EKC hypothesis, the sign of β_{1i} is expected to be positive, whereas the sign of β_{2i} is expected to be negative.

As noted in Halkos and Managi (2016) different variables have been used so far in empirical modelling to approximate environmental damage like air pollutants (SO_X, NO_X, CO_2, etc.), water pollutants (e.g., toxic chemicals discharged in water, etc.) and other environmental indicators (e.g., deforestation, municipal waste, urban sanitation and access to safe drinking water). Due to lack of reliable regional data in Russia we use only

harmful emissions in the air in kg per capita as an indicator of environmental damage. We employ panel co-integration techniques presented in Jebli et al. (2016) to construct a Kuznets curve for a panel of four Russian Arctic regions during the period 2000–2014. Our empirical analysis consists in the following stages:

1   examination of the stationary proprieties using traditional panel unit root tests

2   testing the existence of long-run relationship among variables using Pedroni co-integration tests

3   estimation of the long-run coefficients by using the fully modified ordinary least squares (FM-OLS) and dynamic ordinary least squares (DOLS) panel techniques.

Table 1 presents some descriptive statistics of the selected variables over the period. The summary common statistics contain the means, median, maximum and minimum of each series after transformation in logarithm form. We have also examined the correlation between our analysis variables.

Table 1   Descriptive statistics

Variables	E_{it}	y_{it}	y_{it}^2
Mean	6.476441	13.67879	187.8177
Median	6.259648	13.78589	190.0547
Maximum	8.809684	15.10315	228.1053
Minimum	5.794591	12.41521	154.1374
Std. dev.	0.723675	0.849354	23.21835
Skewness	1.602610	–0.037172	0.036279
Kurtosis	4.841962	1.788385	1.821016
Jarque-Bera	31.88794	3.438257	3.255627
Probability	0.000000	0.179222	0.196358
Sum	362.6807	766.0121	10,517.79
Sum sq. dev.	28.80380	39.67710	29,650.04
Observations	56	56	56
Correlations			
E_{it}	1		
y_{it}	0.7899	1	
y_{it}^2	0.8024	0.9996	1

The first step is to run the unit root tests. We use five unit root tests to check for the integration order of each variable. All unit root statistics reported in Table 2 are calculated at level and after first difference. The results from these integration tests indicate that, for the harmful emissions variable, four tests among five cannot reject the null hypothesis of non-stationary at level, while after taking the first difference, the five tests reject the null hypothesis of non-stationary at the 1% level of significance.

Table 2 Panel unit root tests

Variables	E_{it}	ΔE_{it}	y_{it}
Method/statistics	*Level*	*First diff.*	*Level*
Null Unit root (assumes common unit root process)			
Levin, Lin and Chu	–3.056**	–6.698***	–2.164**
Breitung t-stat	0.434	–1.303*	0.657
Null Unit root (assumes individual unit root process)			
Im, Pesaran and Shin W-stat	–0.375	–3.629***	–0.451
ADF – fisher chi-square	9.749	27.719***	13.119
PP – fisher chi-square	4.208	40.456***	23.663**
Variables	Δy_{it}	y_{it}^2	y_{it}^2
Method/statistics	*First diff.*	*Level*	*First diff.*
Null Unit root (assumes common unit root process)			
Levin, Lin and Chu	–4.722***	–2.110**	–4.705***
Breitung t-stat	–2.495***	0.622	–2.5621***
Null Unit root (assumes individual unit root process)			
Im, Pesaran and Shin W-stat	–1.947**	–0.406	–1.894**
ADF – fisher chi-square	17.583**	12.939	17.248**
PP – fisher chi-square	32.602***	22.710***	32.692***

Notes: ***, **, * indicate 1%, 5% and 10% significance levels, respectively. All
variables are tested with intercept and trend. Automatically lag length selection
based on the Schwarz information criterion (SIC).

In line with Jebli et al. (2016) the existence of long-run dynamic relationship between variables is tested by using Pedroni panel co-integration tests. Co-integration implies that albeit series may be non-stationary there is as a systemic co-movement among variables over the long run. For all these tests, the null hypothesis is that there is no co-integration. The results are reported in Table 3. These tests confirm that the null hypothesis of no co-integration can be rejected at the 1% significance level because two tests of the within dimension (panel PP-statistic and panel ADF-statistic) and two tests of the between dimension (group PP-statistic and group ADF-statistic) approve this rejection. Thus, four tests among seven reveal that the variables move together in the long-run equilibrium.

We employ the fully modified least squares (FM-OLS) and the dynamic least squares (DOLS) techniques to analyse the long run impact of selected variables on environmental damage. As mentioned in Adom (2015) "the co-integration approach is known to be more robust to serial correlation and endogeneity compared to the Johansen and ARDL approach. Hence the estimates are more consistent and robust".

Models in Table 4 show the estimate of equation (1). The long-run coefficients estimated using the two techniques are similar. The result is robust in all two regression models.

The FM-OLS panel estimate shows that the long-run elasticity of harmful emissions with respect to GRP is approximately equal to 0.78 y – 20.38 y. For the DOLS model the long-run elasticity is approximately equal to 2.37 y – 64.03 y. The EKC hypothesis that

assumes an inverted U-shaped relationship between per capita emissions and per capita GRP is not verified for both models. The same result was obtained by Pao et al. (2011) using co-integration technique and causality test during the period between 1990 and 2007 for Russia.

Table 3   Pedroni co-integration tests

Alternative hypothesis: common AR coefs. (within-dimension)		
	Statistic	*Weighted statistic*
Panel v-statistic	–2.014186	–1.586214
Panel rho-statistic	–1.184533	1.095541
Panel PP-statistic	–2.856556***	–2.739382***
Panel ADF-statistic	–2.531726***	–2.924744***
Alternative hypothesis: individual AR coefs. (between-dimension)		
	Statistic	
Group rho-statistic	1.737204	
Group PP-statistic	–4.065012***	
Group ADF-statistic	–3.520918***	

Notes: ***, **, * indicate 1%, 5% and 10% significance levels, respectively. The null
        hypothesis is that there is no cointegration among variables.

Table 4   Long-run estimates

Dependent variable: E_{it} (ln)		
Sample (adjusted): 2001–2014		
Co-integrating equation deterministics: C		
Additional regressor deterministics: trend, trend^2		
Long-run covariance estimate (Bartlett Kernel, Newey-West fixed bandwidth = 6.0000)		
Variable	FM-OLS	DOLS
y_{it}	–20.38048***	(4.219527)
	–64.03483**	(17.80937)
y_{it}^2	0.788814***	(0.150119)
	2.376145**	(0.640482)
Adjusted R-squared	0.932811	0.983034
Lon-run variance	0.032133	0.000525

Note: ***, **, *indicate 1%, 5% and 10% significance levels, respectively.

5   Conclusions

In this paper, we have tested the EKC hypothesis for harmful emissions from quadratic function. The primary contribution of the paper is to address the very important topic for the Arctic regions of Russia. For this purpose, FMOLS and DOLS panel long-run approach to co-integration is applied to the four Arctic regions of Russia – Murmansk

Oblast, Nenets Autonomous Okrug, Yamal-Nenets Autonomous Okrug and Chukotka – for the period 2000 to 2014. Our empirical analysis consisted in the following stages:

1   examination of the stationary proprieties using traditional panel unit root tests

2   testing the existence of long-run relationship among variables using Pedroni co-integration tests

3   estimation of the long-run coefficients by using the FM-OLS and DOLS panel techniques.

According to the concept all regions of the Arctic zone of the Russian Federation are on the increasing branch of the curve. In other words our results provide little evidence to support the existence of the EKC hypothesis for the Russian Arctic regions. The same result was obtained by Baek (2015) for the Arctic countries: Canada, Finland, Denmark, Iceland, Norway, Sweden and USA for the period 1960 to 2010, by Pao et al. (2011) for Russia. The Russian Arctic requires concerted policies and incentives to reduce air pollutant emissions taking into account its enormous potential for the rational use of natural resources, including renewable sources of energy.

Acknowledgements

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