Awareness of climate change (focus on the Russian Arctic zone)

Stefanie Lösch
TU Dresden
Dresden, Germany
stefanie.loesch@tu-dresden.de

Ostap Okhrin
TU Dresden
Dresden, Germany
ostap.okhrin@tu-dresden.de

Hans Wiesmeth
TU Dresden
Dresden, Germany,
Ural Federal University
Yekaterinburg, Russia
hans.wiesmeth@urfu.ru

Abstract

Global climate change is likely to affect the wellbeing of citizens of the Russian Federation, with many regions in permafrost areas and the Arctic Zone, with large forested areas, and with an agriculture adjusted to the current climatic conditions. The question is, whether citizens are sufficiently aware of these challenges in order provide necessary support for related activities of the public administration. In the paper, awareness is introduced by means of a "Multiple-Indicator-Multiple-Causes" (MIMIC) model with "indicators" derived from regional search entries in ©Yandex, whereas "causes" result from economic and socio-economic factors. The empirical study investigates dependence of awareness on characteristics of regions with arctic and subarctic zones, the dependence on the devaluation of the Russian Rouble end of 2014, and the influence of the UN Climate Change Conference in Paris 2015.

Keywords: Regional economics, Climate change, Environmental awareness, Kyoto Protocol, Multiple-Indicator-Multiple-Causes (MIMIC) model.

1 Introduction

Are Russians concerned of climate change, which is likely to affect the country in a variety of ways? A decreasing permafrost area in the arctic zone will require adaptations in urban and industry planning, and global warming might have serious effects on agriculture (cf. [Lehmann et al., 2013]). Individuals, who are "aware of climate change", tend to be susceptible to local and global efforts to building "resilience to climate change" ([Wilson and Stevenson, 2016]).

Among the possibilities to conceptualize environmental awareness in order to make stringent use of it in academic research, [Lin, 2015], by applying Ajzen's "Theory of Planned Behavior" (cf. [Ajzen, 1991]), developed the model of "efficiency action toward climate change" (ECC). Structural equation modeling (cf. [Bollen, 1989])

In: M.Yu. Filimonov, S.V. Kruglikov M.S. Blizorukova (eds.): Proceedings of the International Workshop on Information Technologies and Mathematical Modeling for Efficient Development of Arctic Zone (IT&MathAZ2018), Yekaterinburg, Russia, 19-21-April-2018, published at http://ceur-ws.org

is then applied to confirm the model's applicability. Similarly, [Halady and Rao, 2009] use structural equation modeling to validate different approaches.

This paper is based on a special case of structural equation modeling, the "Multiple Indicators-Multiple Causes" (MIMIC) model that was introduced originally by [Jöreskog and Goldberger, 1975]. It uses well defined indicators to measure a latent construct and regresses them against certain causes. Along these lines, [Khakimova et al., 2017] use this approach to analyze regional aspects of awareness, whereas [Lösch et al., 2017] investigate the geographical diffusion of awareness in a time-dependent context.

Regionally stratified search entries in ©Yandex, collected over a period of 28 months (January 2014 – April 2016) are serving as indicators for awareness of climate change, thus revealing interesting differences among Russian regions. End of 2014 started the significant decline of world market prices of oil and gas, and end of 2015 many countries assembled in Paris for the Climate Change Conference. Did these events leave their footprints on awareness, in particular in the vulnerable regions with arctic or subarctic zones?

The paper is structured as follows: the next section addresses the methodology including relevant aspects of the MIMIC model and the data. Thereafter, some empirical results will be discussed with a focus on the arctic and subarctic zone. Some final remarks conclude the paper.

2 Research Methodology, and Data

2.1 Research Methodology: The MIMIC Model

As mentioned, the index of awareness of climate change is derived as a latent variable from search entries in ©Yandex. Economic and socio-economic factors, likely to affect this index, are integrated as "causes". The MIMIC model with seasonal and trend components is used to estimate the proposed index.

The measurement part includes the indicators y, "the pillars" ([Halady and Rao, 2009]) of awareness of climate change, given by the latent variable $\tilde{\eta}$ with random errors ε:

$$y = \lambda\,\tilde{\eta} + \varepsilon.$$

The structural part includes the exogenous causes variables $x = (x_1, x_2 \ldots, x_k)^\top$, and the model parameters β and γ. The random errors ζ are assumed to be independent from the other random factors ε. Moreover, the matrix z includes three binary variables for the quarters (reference is the 4th quarter) and two binary variables for the years (reference is the year 2016):

$$\tilde{\eta} = \beta^\top x + \gamma^\top z + \zeta.$$

The parameters as well as the variances of the error terms are then estimated using a ML approach (cf. [Jöreskog and Goldberger, 1975]).

Relative numbers of queries from ©Yandex, filtered according to approximately 200 climate-related phrases in Russian or English, constitute the indicator variables y. These phrases, and subsequently also the queries, are clustered into the following categories: [Y1] Climate Change Queries, [Y2] Endangered Environment Queries, [Y3] Political Queries, [Y4] Science Queries, [Y5] Renewable Energies and Technologies Queries.

Following the data collection, the numbers of compatible requests in each region and in each category are summarized and divided by the number of all search requests from ©Yandex in these regions. This yields the indicator variables y:

$$y_{in} = \frac{\text{number of queries of category } i \text{ in region } n}{\text{number of all queries in region } n},$$

where $i = 1, \ldots, p$ with $p = 5$ refers to the categories, and $n = 1, \ldots, N$ with $N = 81$ to the regions of the Russian Federation.

2.2 Identification and Data Considerations

As already mentioned, ©Yandex filtered the Internet queries from January 2014 to April 2016 (28 months) according to the environmental phrases provided and according to the Russian regions. Table 1 provides the descriptive statistics.

The data for the regional cause variables are on year level available and provided by the Federal Statistics Service of Russia ([RFSSS, 2016]).

Table 1: Descriptive statistics regarding the number of queries

	mean	sd	median	min	max	obs
Climate Change Queries	9096	20614	4628	20	240957	2268
Endang. Environm. Queries	20658	41374	11191	54	479940	2268
Political Queries	340	899	172	0	11296	2268
Science Queries	408	1398	155	0	34483	2268
Renewable Energies Queries	703	1853	282	0	22611	2268
Number of all Queries	5.45E+07	1.3.E+08	3.E+07	1.6.E+05	1.3.E+09	2268
$y_{\text{Climate Change}}$	1.73E-04	5.20E-05	1.7E-04	0	4.80E-04	2268
$y_{\text{Endangered Environment}}$	4.09E-04	1.56E-04	3.9E-04	0	4.16E-03	2268
y_{Politic}	6.78E-06	4.37E-06	5.7E-06	0	5.19E-05	2268
y_{Science}	7.66E-06	8.14E-06	5.6E-06	0	1.95E-04	2268
$y_{\text{Renewable Energies}}$	1.30E-05	7.37E-06	1.1E-05	0	7.75E-05	2268

3 Awareness of Climate Change in the Arctic and Subarctic Zone

We investigate the dependence of awareness of climate change in the regions of the Russian Federation on certain regional characteristics. Additionally, effects of the Rouble devaluation end of 2014 and the Paris Climate Change Conference end of 2015 are of interest. A special focus is on regions with arctic and subarctic zones.

Russian regions differ substantially with respect to GRP per capita, the share of manufacturing, level of air pollution, and other variables. Thus, with estimation results from the MIMIC model, Figure 1 shows that a higher GRP per capita tends to induce a higher level of this awareness. Some regions with arctic and subarctic zones reveal a particularly high level of awareness.

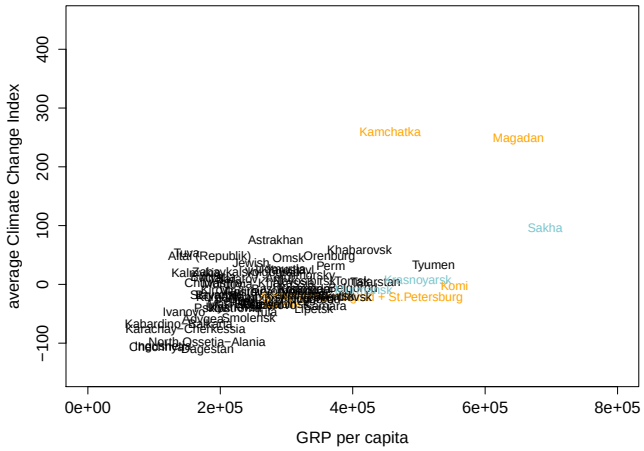

Figure 1: Estimated average awareness index depending on GRP per capita for most of the regions assembled in three clusters: with arctic zone (blue), with subarctic zone (orange), and remaining regions (black).

End of 2014 is marked by the substantial fall of the world market prices of natural oil and gas, leading to the decline of the Rouble-Dollar exchange rate and to other negative consequences for the Russian economy, which is dependent on the export of oil and gas. Whereas this development might adversely affect efforts to mitigate climate change, the Climate Change Conference in Paris end of 2015 inspired many countries to increase efforts to fight climate change and its consequences. Did these milestones leave any footprints in the levels of awareness, particularly in regions with arctic and subarctic zones?

Figure 2 shows the development of awareness (with a 90% confidence interval) in the arctic and subarctic zones in comparison to that in the other regions. The regions with arctic zones comprise Arkhangelsk, Nenets AO, Yamalo-Nenets AO, Chukotka AO, Murmansk, Sakha, and Krasnoyarsk. Moreover, Khanty-Mansi AO, Karelia, Komi, Magadan, Kamachatka, and Leningrad with St. Petersburg are included in the regions with subarctic zones. Interestingly, awareness tends to be higher in these regions in comparison to the rest of the country.

Moreover, both the Rouble devaluation and the climate change conference are followed by a temporary, but at first stronger decline of awareness, also in the regions with arctic and subarctic zones. Whether this decline is a consequence of other developments, remains to be seen and has to be left to a further, more detailed investigation. Nonetheless, the largest differences between the climate change index of the arctic regions and all others are in February and March 2015 as well as, especially, in the same month in 2016.

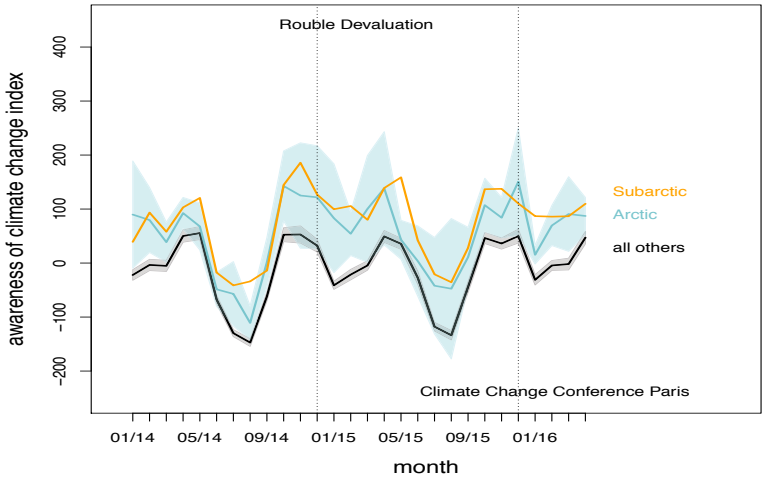

Figure 2: Estimated average awareness index for 10 quarters for the regions assembled in the clusters with arctic, resp. subarctic zones and all others.

Figure 3 details the regions with arctic (blue) and subarctic zones (orange) as well as all others (grey). Actually the region Krasnoyarsk extends from the north to the south of Siberia, which could strongly influence the variability of the arctic climate change index. But if we exclude this region as an arctic area, the results hardly change from Figure 2. [Lösch et al., 2017] provide more information on the "diffusion" of awareness of climate change, which seems to spread from the eastern parts of the country to the western parts.

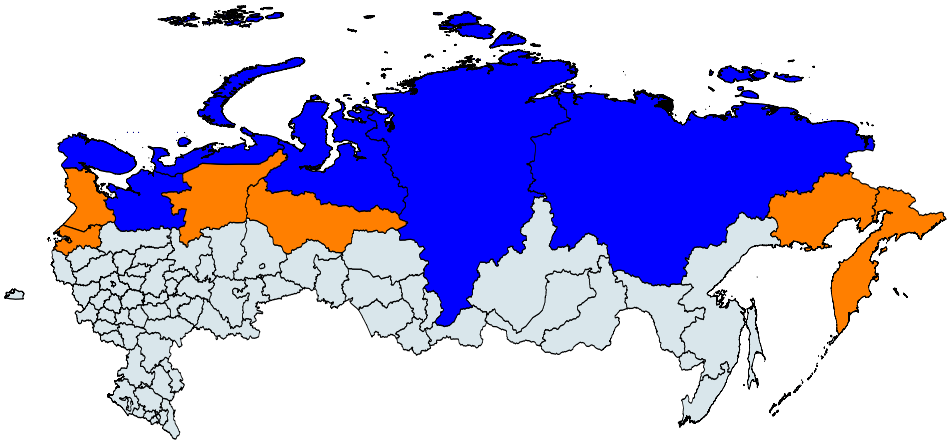

Figure 3: Map of the Russian Federation with the regions with arctic (blue) and subarctic (orange) zones.

4 Concluding Remarks

The paper demonstrates how search requests submitted to ©Yandex can be filtered, structured and used to get some idea on the level and the development of awareness of climate change, depending on the specific situation in the various regions of the Russian Federation.

The focus on regions with arctic and subarctic zones reveals a higher level of awareness, especially in the vulnerable northern parts of the country. This is a signal for accommodating public policies for mitigating climate change and adapting to its consequences.

4.0.1 Acknowledgements

We are very grateful to ©Yandex, which provided us with the necessary empirical data from Russian regions. Research was supported by RSF grant Nr. 15-18-20029 "Projection of optimal socio-economic systems in turbulence of external and internal environment".

References

[Ajzen, 1991] I. Ajzen. The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, 50(2):179–211, 1991.

[Bollen, 1989] K. A. Bollen. *Structural Equations with Latent Variables.* John Wiley & Sons, Inc., New York, 1989.

[RFSSS, 2016] Federal Statistics Service of Russia. *RFSSS public database*, http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru (Access January, 2016).

[Halady and Rao, 2009] I. R. Halady, P. H. Rao. Does awareness to climate change lead to behavioral change? *International Journal of Climate Change Strategies and Management*, 2(1):6–22, 2009.

[Jöreskog and Goldberger, 1975] K. G. Jöreskog, A. S. Goldberger. Estimation of a model with multiple indicators and multiple causes of a single latent variable. *Journal of the American Statistical Association*, 70(315a):631–639, 1975.

[Khakimova et al., 2017] D. Khakimova, S. Lösch, D. Wende, H. Wiesmeth, O. Okhrin. Index of Environmental Awareness in Russia MIMIC Approaches for Different Economic Situations. https://arxiv.org/abs/1703.09472. 2017.

[Lehmann et al., 2013] N. Lehmann, R. Finger, T. Klein, P. Calanca, A. Walter. Adapting crop management practices to climate change: modeling optimal solutions at the field scale. *Agricultural Systems*, 117:55–65, 2013.

[Lin, 2015] S.-P. Lin. Raising public awareness: the role of the household sector in mitigating climate change. *International Journal of Environmental Research and Public Health*, 12:13162–13178, 2015.

[Lösch et al., 2017] S. Lösch, O. Okhrin, H. Wiesmeth. Diffusion of Environmental Awareness. *Diffusion Fundamentals*, 30:1-16, 2017.

[Wilson and Stevenson, 2016] L. Wilson, C. Stevenson. *Promoting Climate Change Awareness through Environmental Education.* IGI Global, 2016.