Value and Economic Significance of the Cold for Human Life and Activities in the Arctic

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Abstract. The natural resource of the Cold is often overlooked. The Arctic has its own characteristic features: cold climate, glaciers and permafrost. What is the cost of the Cold, and how can we calculate it? Many problems are associated with the attempts to identify the cost characteristics of the Cold using the methods that are employed to establish the cost of production material resources. The current approach to the evaluation of the natural resources does not allow to adequately assess the significance of the Cold as a natural resource in the society’s life, in particular, in the Arctic. The cost of the Cold can be considered from the point of view of the concepts of the total economic value (TEV). The Cold cost assessment methods cases for the cost calculation of direct and indirect use of the Cold are presented.

1. Introduction

Government agencies, researchers, and various businessmen now more and more often focus on the Arctic, underscoring its role as a whole in the national and international economy. However, the natural resource of the Cold is often overlooked. Unfortunately, low temperature, the cold, is still considered not from the point of view of its usefulness and use for the purposes of the humanity, but more in terms of the costs of its alleviation, for example, the negative impact of the temperature on economic activities, uncomfortable conditions and low economic efficiency. However, the Arctic territories have their specific features, in particular, the following three aspects: cold climate, glaciers and permafrost [1].

What is the potential of the cold and low temperatures? What is the cost of the Cold and how can we calculate it? These are only a few questions that we try to answer in this article, in a very general and methodological way.

No one has ever tried before to really search and study significant comparative advantages of the Cold. We believe that the Cold is the resource of the future. Such a natural resource, even given the ability to generate new technologies, is becoming more important, in particular, in the Arctic.

2. Methods for assessing the cost of cold

It is clear that in order to really be seen as a natural resource in a certain industry both in short and long term, from a strategic point of view and given the current economy development state, the Cold must be scientifically studied, researched, experiments must be conducted, and this is a complex and lengthy process that requires significant material, financial and labour costs. Also, the methodological foundation needs to be improved that assesses the Cold as a natural resource on the basis of the social
and economic and ecosystem approaches that would take into account all the range of the advantages of the Cold for the development of the society.

Many problems are associated with the attempts to identify the cost characteristics of the Cold using our methods to establish the cost of material resources production. Russian scientists do not provide any relevant breakthrough research. However, there have been some attempts, for example Suslov N.I., Buzulutskova V. [2, 3] assess the Cold as a natural product that is manufactured using alternative technologies (technological methods that are material-efficient (consumption of raw materials, fuel and power), labour and capital intensive (technology incremental cost)), and also as a cost element of financial costs in other national industries that characterizes their cold-intensity (similar to heat and electric capacity).

The calculation of the cost of the Cold was considered by the scientists from the Center of social and economic development (CSED) in the Brookings Institution and at the economy department of the Pennsylvania State University (USA). For example, they proposed the indicator "Temperature per capita (TPC)" [4]. As the basis for the TPC, the average temperatures in January, being the coldest month, and the population size were considered. The TPC allows to economically compare temperatures in different countries and monitor the evolution of the temperature in a country in time. The TPC also allows to identify specific regions of countries that are especially temperature intensive. However, the American scientists only consider the costs of the negative impact of the Cold on human activities, e.g. direct costs, for example, when the Cold reduces the labour productivity of people and machines, and adaptation costs, in particular, expenditures on power, heating, additional (special) materials, that are used in construction of buildings and infrastructure to protect it from the Cold.

The approach of the "Cold Economy" partisans (mainly scientists from the US and the UK) is partially determined by the fact that there is no demand for the Cold in itself, but there is a demand for the services that it can provide, like cooled food, comfortable air conditioning of buildings in hot climates and cooling large server rooms. Cold Economy scientists are more concerned with the fact that by the end of the century the global demand for air conditioning can account for the equivalent of half of the global power production today with developing markets accounting for the majority of that increase [5].

At the same time, the cost of the Cold can be considered based on the concept of total economic value (TEV) of natural resources (Figure 1) (it is now a priority scientific innovation in the field of economic evaluation of natural resources) and using the methods and approaches developed by Pearce and Turner (see the monograph translated into Russian [6, 7]), J. Pascual, Mark D. Davidson [8], the Russian expertise in the evaluation of natural resources [9,10,11,12], the evaluation plan for natural capital developed by the World Bank [13].

![Figure 1. The Cold cost assessment plan under the concept of TEV.](image-url)
As a result, the total economic value of the Cold (TEV\(_{C}\)) amounts to:

\[
TEV_{C} = Bn + Bh,
\]

where Bh stands for benefits for humans; Bn represents the support for natural resilience.

The support for the natural resilience with the Cold cannot be economically evaluated, however, the benefits to humans can be assessed in the following way:

\[
Bh = U + NU,
\]

where U is the value of usage; NU is the value of non-using.

The value of usage (U) is calculated in the following way:

\[
U = Ud + Ui + Av,
\]

where Ud is the value of direct usage; Ui is the value of indirect usage; Av is the additional value.

\[
Uc = R + C,
\]

where R is the regulating environmental services; C stands for cultural environmental services.

The cost of non-using (NU) is calculated using the following formula:

\[
H = H_1,
\]

where the cost of living H\(_1\) is determined by the willingness of the society to pay (WTP) for natural resources as part of ecosystems.

*Direct use* of the Cold is associated with the implementation of resource functions of the Cold and can be assessed according to the methodological recommendations for the economic evaluation of natural resources [14]. The methods of assessing the value of direct use of the Cold are relatively simple and accurate, which stand for the evaluation of the resource element of the Cold as natural capital. Its usage can be measured quantitatively in quite an accurate way, and the level of sustainable consumption of the potential benefits of the Cold can also be assessed. All these indicators are absolutely "tangible" and have their costs, that, when summed up, can show the direct cost.

*Indirect usage value* corresponds to the environmental concepts concerning the value of environmental functions and services.

The establishment of the value of natural resources can be done for the present moment and for the long-term. So, the need for the *additional value measurement* is associated only with the long-term assessment, as it concerns potential applications. Thus, the additional value is the sum that individuals are prepared to pay to protect natural resources for their future use. Between the current and long-term period, something might happen that would increase the value of the Cold, for example, scientific discoveries, and the society would decide whether to involve the Cold into the economic turn-out.

"The value of non-use" is based on the "value of existence". "Value of existence" is the satisfaction of a person at the existence of nature, for example, at the Cold, with the reference to altruism toward the nature itself without any intention to use it. The concept of the existence value was first developed by John Krutilla (1967) [15] who believed that people could value the nature not only because of the practical applications of its resources or the possibility to use the nature in the future [16], but just for its very existence.

Let us consider the methods of evaluating the Cold using the methodological structure of the evaluation of natural resources that are shown in the publication by Bobylev S. [17]. We propose the following structure for the assessment of the value of the Cold, see Table 1. The method of the cost assessment of the Cold under the concept of total economic value can be divided into the methods for the evaluation of market values and methods for the evaluation of non-market values. Thus, market values are assessed with economic methods, while the non-market ones are studied with sociological methods.

To assess the values of the *direct use* of the Cold, the traditional assessment methods can be used, e.g. profit, cost and comparison ones.
Table 1. Structure of the Cold cost assessment methods.

| Cold cost assessment methods |
|------------------------------|
| **Economic methods**         |
| **Profit methods**           |
| Roster method                |
| Method of substituting costs |
| **Cost methods**             |
| Method of substituting goods |
| **Comparative methods**      |
| Method of production functions |
| Method of reconstruction costs |
| **Sociological methods**     |
| Method of subjective preferences (willingness to pay) |
| **Methods of relative evaluation** |
| Method of transport and distance costs |

Let us consider the examples using the proposed types and methods for the evaluation of the Cold. Let us start with the **indirect value**. The definition of indirect value of the use of the Cold is slightly more difficult in comparison with the direct one. The most important element here is the environment forming role of the Cold. It is associated with the functions of ice, snow, permafrost and the cold as a whole, that provides living conditions for traditional communities. Lack of any of these resources can destroy the traditional life system. Indirect value of the Cold also concerns the following: CO2 binding by permafrost (alleviation of the greenhouse effect); water regulating functions (including permafrost ensuring the best possible soil humidity). Also, for example, the Arctic ice cap plays an essential part in the climate system of Earth, by reflecting the sunlight and preventing the planet from overheating. What is more, the Arctic ice cap fulfills important functions within the ocean water circulation system [1]. A large scale epidemic outbreak of anthrax in Yamal in the summer of 2016 demonstrates another environmental forming function of the permafrost that has not been sufficiently studied. According to experts, the cause of the epidemic could be a temperature anomaly that led to a deeper seasonal melting of permafrost and anthrax germs moving to the surface with intrapermafrost water [18]. This situation makes us think more about the underexplored protection functions of the Cold that protects us against a number of biological dangers.

3. **As for the direct value of the cold**
1. American economists William Masters from Purdue University and Margaret McMillan from Tufts University analysed, how cold climate influenced the economic growth rate [19]. According to their research published in Journal of Economic Growth, the Cold positively affects the economy because of two reasons. First, cold regions historically have had a more developed and diversified agriculture. The authors explain that in the following way: frosts regulate the populations of agricultural pests, insects in particular; they also promote the formation of more fertile soils (it is curious that many agricultural plants, like potatoes and wheat were first introduced in warm climates, but produce higher yields in moderate climates). What is more, ice and snow that appear in winter reduce the risk of draught. Second, in cold climates pathogenic micro-organisms do not spread so fast thus curbing epidemics. These two factors have created a reliable foundation for the successful development of other industries. Here the value of the Cold can be calculated using the profit method (production function method) or the comparative method.
2. One of the mechanisms for the implementation of the Paris agreement in Russia is the introduction of a carbon tax and the creation of a system for selling greenhouse gas quotas. This would help countries to sell or buy additional emission quotas. The established emission volume is
respectively added or deducted from the total volume. Carbon tax should in theory increase the attractiveness of more environmentally friendly power. However, the financial burden for the economy grows significantly. Today one ton of carbon dioxide equivalent costs 15 USD. If the rate is going to grow as has been planned up to 35 USD, the costs for Russia can grow up to 42 billion USD per year. The research also confirms a large amount of carbon in permafrost [20]. This is why the role of permafrost for forests that absorb greenhouse gases and the absorbing capacity of permafrost itself, must become part of the new strategy for the development of regions with permafrost and a part of a new model for their economic growth, providing for the possibility of selling quotas under the system of greenhouse gases quota trade. The calculation can be made using the profit method.

3. Experiment-based research established that as a result of climate cooling and lower layer temperatures, common gases can form gas-hydrate deposits, the so-called clathrates, solid compounds of natural gas (natural formations with the concentration of gas of more than 10 m3 per 1 m3 of rock). The gas-hydrate deposits can be found in permafrost. At the temperature lower than 0°C, a solid gas-hydrate deposit isolates itself from its surroundings by a thin film of ice that prevents it from further decomposition. After that the hydrate can be stored for a long time under atmospheric pressure (it also depends on the temperature, humidity and other parameters of the environment), it can be stored and transported [21]. The cost effect can be measured by the comparative method.

4. Transport ground communication with individual remote communities in the Arctic is only possible through winter roads that have the road surface made of ice that is frozen layer by layer or are made from pressed snow and ice, or by frozen ice-covered rivers and lakes. How economic is that? We can measure it with the help of the comparative assessment method.

5. Every state is concerned with the food safety of its population with a view to ensure its livelihood. In the opinion of international experts, massive deficit of food and drinking water can in the next 50 years lead to regional and even global conflicts for natural resources. It is essential now to use the mechanism for reducing losses and preserving food with the help of the Cold as the most accessible, environmentally friendly and economic resource.

Natural and climate conditions in Siberia and Far East helped the local peoples to develop skills in cool storage of food. However, even after WWII, the interest to the use of natural cold in the economy started to decrease as refrigerating equipment that worked from the electric grid became easier to afford. Despite that, lately a number of countries have shown a renewed interest in the natural cold as industrial cooling agent. This is caused by the fact that electric power consumed by modern refrigerating equipment becomes more expensive, and this is a significant factor that increases the initial cost of food and therefore reduces their competitiveness in the modern market. This is why the study of traditional environmental knowledge of various peoples that dates back centuries ago and concerns cool storage of food, can become pertinent in the view of creating innovative energy-saving technologies. For example, food naturally cooled down to 0 degrees is easier to freeze in a freezer and thus electric power is saved. Using both natural and artificial cold, we can calculate the money saved using the profit method.

6. Significant power resources are consumed to produce artificial Cold. Artificial chlorine agents destroy the ozone layer and increase the amount of ultraviolet radiation from the sun that reaches Earth, and, as a result, the climate parameters of regions, continents and the planet as whole change. This makes us fundamentally rethink the development of refrigerating industry and the associated sectors. For example, in the Arctic regions with permafrost, standard storage facilities for global information and communication systems, biological materials, etc. that are cooled by underground cold can be more economically efficient. Here calculations can also be based on the profit and comparative methods.

7. Using ice and snow as a basic construction material or an element of construction structures is characteristic for regions with the coldest climates. When technologies are well-developed, it is much cheaper to use local materials in construction, for example snow and ice. The savings can be easily calculated by the profit and comparative methods.
8. Natural cold was widely used as a means of sanitary protection. Its main principle is based on the impact of low temperatures on the indoor space, clothes that destroys pests and parasites. Many indigenous peoples in the North used to freeze clothes outdoors. For example, the Chukchi people cleaned clothes by brushing it in snow and long drying in the cold wind [22]. Russians living in Siberia froze their houses to fight pests [23]. The cost of artificial means of fighting these pests can be calculated and compared.

9. Though the role of the cold in folk medicine today have not been studied enough, folk beliefs say that brief exposure to the cold can have a mobilizing effect for the body. Snow and ice in the folk culture of indigenous peoples of the North are often used for their medicinal properties. Here we can also calculate the cost of the alternative to the folk approach by the comparative method.

10. Traditional livelihood systems of peoples who live in the Arctic, in the subarctic region (everywhere in Yakutia), and in mountains, snow and ice play an important part as a source of drinking water. The calculation is made using the method of substituting goods (comparative method).

11. The Cold as a recreation and tourism resource can be assessed with the method of transport and travelling costs (the method of conditional assessment). Here, the most important thing is how attractive the Cold is for the population that has never or rarely seen the elements of the Cold, such as snow, ice, permafrost.

4. Conclusion
The above mentioned applications of the Cold as a natural resource in the traditional livelihood systems in the Arctic are not the only ones. Today there are some other areas for their use, and the potential of the Cold is far from being sufficiently studied. For example, it can help to find solutions to innovative challenges associated with the rational management of natural and energy resources. Taking into account the crisis trends in energy consumption, natural Cold can be highly financially efficient. Modern innovations in the creation of new materials with unprecedented insulation and thermo-electrical qualities, allow to develop innovative systems that sustainably operate consuming only natural cold.

We also hope that the dynamically developing assessment methodology today will allow in the nearest future to accurately calculate the value of the Cold, so that both economically efficient and environmentally friendly solutions could be developed at different levels of nature management regulation. This is very important for the development of the Arctic territories.

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