Climate Change as a Challenge for the Economy

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Abstract
According to historical climatology, climate and climate change have always had an impact on human society. Anthropological climate change is happening fast and will indisputably affect the global economy for decades to come. This paper provides a review of the expectations of leading economists and organisations on the magnitude of this effect. It clarifies the different approaches used to quantify the future economic loss attributed to climate change. Despite the different approaches used, all the authors examined in the paper foresee a negative impact of the climate change on the global economy. The different approaches result in different predictions about the magnitude of the impact. The authors express similar positions about the geography of the damages that will be caused by the climate change. The most affected countries will be most likely those in Sub-Saharan Africa and South Asia. A moral paradox arises that the least developed countries that are not at fault for anthropogenic climate change will have to carry the economic burden of its consequences. The paper also suggests and compares a variety of measures that could be taken in order to adapt to and mitigate the negative impacts of climate change on the economies.

Keywords: climate change, social changes, economic policies, mitigation, and adaptation.

Introduction
Climate change has become an increasingly important issue in business and politics. This article has the goal to review and analyse the propositions of leading economists on the issue of climate change impacts on the economy and some of the measures that may be applied. The thesis of the paper is that the climate change will have a significant negative impact on the global economy and this was proved through a variety of research methods. It suggests that the cost of implementing mitigation and adaptation measures would be lower than the cost of the damages that climate change would cause.

According to the Encyclopedia Britannica, climate is defined as:

“Conditions of the atmosphere at a particular location over a long period of time; it is the long-term summation of the atmospheric elements (and their variations) that, over short time periods, constitute weather. These elements are solar radiation, temperature, humidity, precipitation (type, frequency, and volume), atmospheric pressure and wind (speed and direction)” (Gentilli, 2020).

The emphasis of the definition is on the long period of astronomical time, which distinguishes climate from weather. The Earth’s climate has changed many times, potential reasons for this being solar radiation cycles, Earth’s volcanic activity, changes in ocean flows, etc. The last ice age ended approximately 11,500 years ago, followed by the creation of the first settlements with developed agriculture that we know of, in Mesopotamia and the lands of the Fertile Crescent (nowadays Lebanon, Palestine, Israel and Iraq). For the past 2,500 years there is evidence of climate change, alternating between periods of warmer and colder climate,
such as: The Roman Climatic Optimum - from approximately 250 BC to approximately AD 400; The Medieval Climate Optimum – from approximately AD 950 to approximately SD 1250 and the Little Ice Age – from approximately AD 1550 to approximately AD 1850.

The industrial development of humanity since the start of the XIX century until now and the emission of large volumes of greenhouse gases related thereto has resulted in the gradual increase of the average temperature and accompanying changes in global climate. Concentration of carbon dioxide in the atmosphere has increased, from approximately 280 ppm (parts per million) in the preindustrial age, to approximately 420 ppm in 2021, where it has reached its peak for the last 14 million years. Earth’s geological history has periods with significantly higher atmospheric concentration of CO2. According to Mulhern (2020), the highest known levels of concentration ranging from 3,000 ppm to 9,000 ppm have been reached 450 million years ago during the Ordovician Period, with average temperatures being 10 degrees centigrade higher than current temperature levels. According to the author, the reason these concentrations had not resulted in a complete ecological disaster is the colder temperature of the Sun and the difference in the Earth’s orbital cycles during that period. According to the National Aeronautics and Space Administration (2021a), human activity is the underlying reason for temperature rising by 1 degree centigrade compared to the preindustrial age, whereas the current rate of temperature rise is approximately 0.2 degrees centigrade per decade, which would lead to unprecedented anthropogenic climate change. According to the NASA, rising temperatures will impact climate in the following manner:

- More droughts and heat waves;
- Changes in the precipitation model;
- Hurricanes will be stronger and more intensive;
- The expected global sea level rise by the year 2100 ranges from 0.3 m to 2.5 m;
- The Arctic will most likely lose all of its glaciers;

- Climate change will continue over the course of this century and thereafter.

Climate and climate change have always had strong impact over human activity. Historical climatology is a branch of science that studies climate change and its effect on human civilization. According to Brown (2001), the roots of historical climatology can be found in the works of Aristotle, Tit Lucretius Car and Pliny the Elder. In contemporary works, the existence of precise paleoclimate data has been the leading cause for diverse studies that examine the correlation between certain climate and social events. In an extensive study, Zhang et al (2007) analysed the history of Europe and China using high-resolution paleoclimate data and reached the conclusion of strong correlation existing between climate change and the frequency of fighting wars, as well as changes to the human population in preindustrial history. The reason for this relationship is the adverse impact of climate change (predominantly cold spells in recent history) on agriculture and economy and the capacity to provide food to the population. With climate change, the options to adapt include migration, cultural and technological changes, innovations, trade, peaceful reallocation of resources, or war. In preindustrial societies, as the appropriate institutions for it did not exist, and as society was not ready for the rapid social change experienced, possibilities for peaceful adaptation often did not work, so the outcome of climate change had been war. War, in turn, contributed to reducing human population, which increased the output of agricultural produce per capita, resulting in lowering of prices for this produce, and once again this resulted in the increase of human population.

According to NASA (2021b) the current warming is taking place ten times faster than the ice-age-recovery warming. This unprecedented speed would limit the possibilities of the humankind to adopt. That is why the possible impact of the climate change on global and regional economies should be carefully examined.
Material and methods

Over the course of the last twenty years, the impact of climate change on the global economy has become an increasingly popular topic, with a number of scientists and organizations attempting to forecast this effect in varied climate scenarios and employing varying methods to do it. One of the most frequently used methods is the consensus method, wherein a certain number of scientists are interviewed, and they provide their forecasts for the effect, then calculating the average values and the median of their projections. Another method used is the enumerative method, wherein the expected material effect from climate change is determined first, an example would be changes in precipitation and land productivity or global sea level rising, and subsequently value is assigned to each of these material effects. According to Tol, a third method is the statistical method:

“It is based on direct estimates of the welfare impacts, using observed variations (across space within a single country) in prices and expenditures to discern the effect of climate” (Tol, 2012).

This article makes a literary overview of the opinions of some of the leading economists on the matter for impact of climate change on the global and regional economies.

Results and discussion

One of the first attempts to forecast the impact of climate change on the global economy is the forecast of the Nobel Prize economist William Nordhaus. In the beginning of 1994, he published his article Expert opinion on climatic change (Nordhaus, 1994a), wherein he interviews 19 experts in the area of climate change, among which 10 economists, 4 social scientists, and 5 natural scientists. In the article, Nordhaus outlines the major differences in the opinions of the interviewed scientists, as well as various scenarios for climate developments. In the scenario where Earth’s temperature is increased by 3 degrees centigrade until 2090, the median expected reduction in the Gross World Product is 1.9%, and the expected average value of the forecasted reduction in GWP is 3.6%.

In his book, Managing the global commons (Nordhaus, 1994b) published in October the same year, Nordhaus used a different approach, namely Dynamic Integrated Model of Climate and the Economy or DICE model, which is the first dynamic model that includes carbon emissions and their concentrations, expected climate change, as well as emissions damage and emissions control. The model represents a limited, non-linear, dynamic optimization model with an endless horizon. The basic structure of the model could be represented through the following diagram:

\[ \max c(t) W = \max c(t) \left[ \int_0^\infty U(c(t)) e^{-\rho t} dt \right] \]

subject to:

\[ c(t) = M(y(t); z(t), \alpha; e(t)), \]

where \( c(t) \) means consumption; \( y(t) \) are other endogenous variables (such as global

The economic growth led to CO₂ emissions (driving, heating and cooking, airplane travel, ...)

Rising CO₂ concentrations and other forces lead to climate change (temperature, precipitation, sea-level rise, ...)

Climate change policies reduce emissions (cap-and-trade, carbon taxes, regulations...)

Climate-change imposes ecological and economic impacts (lower corn yields, coastal flooding, ocean acidification, ...)

**Figure – 1 DICE model**

Source: Nordhaus 1994b

Slightly simplified, the mathematical representation of the model looks like this:

\[ \max c(t) W = \max c(t) \left[ \int_0^\infty U(c(t)) e^{-\rho t} dt \right] \]

subject to:

\[ c(t) = M(y(t); z(t); \alpha; e(t)), \]

where \( c(t) \) means consumption; \( y(t) \) are other endogenous variables (such as global...
temperature); \( z (t) \) are exogenous variables (such as population); \( \alpha \) means parameters (such as climate sensitivity); \( p \) is a pure rate of time preference; and \( \varepsilon (t) \) are random variables in stochastic versions (Nordhaus, 2019, p. 1995).

Using the DICE model, the author views various climate change scenarios, and for the scenario where Earth temperature is increased by 3 degrees, the expected decline of the world Gross Domestic Product is 1.3%.

In 1995, Frankhauser (1995) compared the costs for reducing greenhouse gas emissions with the costs that would have been caused by these emissions on a regional and global level. His assessment, in case of a scenario where temperature has been increased by 2.5 degrees centigrade, is a decline of GDP by 1.4%.

The same year Tol (1995) uses cost functions and incorporates uncertainties in his analysis in order to assess damage caused by climate change. Square functions have been used predominantly for nine regions and nine categories of damage. According to the calculations of the author, if global temperature rises by 2.5 degrees centigrade, the decline of GDP would be 1.9%.

Mendelsohn, Morisson, Andronova and Sclesinger (2000) propose a Global Impact Model, attempting to use it to forecast the impact of climate change on the economies of different countries. They assume a temperature increase of 2 degrees by 2060 and examine the possible climate and precipitation changes in 184 countries. In their opinion, the net effect for the world as a whole would be a decline of GDP by about 0.3%.

In 2007, Nicholas Stern (2007) published his emblematic report Stern Review on Economics of Climate Change after an assignment of the government of the United Kingdom. In it, the former chief economist of the World Bank provided a thorough analysis of the expected effects on climate change. Stern used a production function that includes environmental status of the following type:

\[
Y(t) = F (K, L, E),
\]

where:

- \( Y(t) \) is the output of the economy for the year \( t \);
- \( K \) – capital;
- \( L \) – labour;
- \( E \) - environmental quality.

This function makes it clear that GDP is dependent on the environmental conditions, or as the author calls it - natural capital. One of the main conclusions of Stern's report is that the benefit of humanity's rapid response in reducing carbon emissions far exceed the costs we would have to pay, had such rapid actions not been taken. According to Stern, lack of action would result in decline of GDP by a minimum of 5% per year (and in case a wider range of risks is considered, the decline may reach 20%), while costs that would have been accrued, had humanity attempted to limit carbon emissions, would approximately be 1% of GDP per year. According to the author, four methods exist for decreasing carbon dioxide emissions, namely: attempting to reduce the demand for goods and services involved in the intensive output of emissions; improving energy efficiency; transitioning to lower emission technologies; limiting non-fossil fuels emissions (Stern, 2007).

In his recent book How to Avoid a Climate Disaster Bill Gates identifies in a similar manner five major sources of greenhouse gas emissions, namely: how we plug in, make things, grow things, get around, and keep cool and warm (Gates, 2021, p. 158).

Expectations about the economic impact of climate change of Bosello, Eboli, and Pierfederici (2012) are more moderate. Assuming average global temperature by the year 2050 would increase by 1.92 degrees centigrade compared to preindustrial age, and using a recursive dynamic calculation model of total equilibrium, the authors have reached the conclusion that global GDP would decline by approximately 0.5%.

Maddison and Rehdanz (2011) have proposed an interesting study on the topic of the impacts of climate change on the level of life satisfaction in 79 countries. They measure climate as “degree-months”, which represents...
cumulative monthly deviations from a base temperature of 18.3 degrees centigrade. According to the conclusions of the study, in countries with high “degree-months” values, the life satisfaction level is relatively lower.

According to the global reinsurance company Swiss Re (2021), the expected impact on global GDP until 2050 for various scenarios, compared to a world without climate change, would be:

A decrease by 18%, if no mitigation actions are taken, which would result in a temperature rise by 3.2°C.

A decrease by 14%, if some mitigation actions are taken, which would result in a temperature rise by 2.6°C.

A decrease by 11%, if additional mitigations actions are taken, which would result in a temperature rise by 2°C.

A decrease by 4%, if the targets of the Paris Climate Agreement are reached, which would result in increase of temperature by a level below 2°C.

In one of the most recent studies in 2021 by the University of New York (Howard & Sylvan, 2021), which includes the opinion of 738 leading climate change economists, economic damage caused by climate change would reach 1.7 trillion dollars per year until 2025, and 30 trillion dollars per year until 2050.

Regardless of the methodology used, the projected values for the reference studies are negative. According to Nordhaus, other main conclusions from the use of all Integrated Assessment Models (or models used for assessment of economic impact of climate change, integrating knowledge derived from various disciplines) are:

• “One major finding of integrated assessment models is that policies to slow emissions should be introduced as soon as possible.

• A second finding is uniformity of price—that the most effective policies are ones that equalise the incremental or marginal costs of reducing emissions.

Equivalently, in a market context, that means that the carbon prices should be equalised in every sector and in every country.

- Effective policies should have the highest possible participation; that is, the maximum number of countries and sectors should be on board as soon as possible.

Free-riding should be discouraged.

- Finally, an effective policy is one that ramps up over time—both to give people time to adapt to a high-carbon-price world and to tighten the screws increasingly on carbon emissions” (Nordhaus, 2019, p. 2002).

2. Regardless of the model used and the result for the global economy, all studies reach the conclusion that damage caused by climate change will not be evenly distributed between different world regions. Tol (2011) projects the effect of climate change for different countries around the world and reaches the conclusion that the countries which would suffer the worst economic impacts will be countries in Africa, Southern Asia, and Latin America, while for countries in Europe and North America, climate change could even have a positive effect. A similar proposition is also made by Gates (2021), who claims that it is the developing countries that will suffer most from climate change if greenhouse emissions are not reduced by 2050 and they are also the ones that will have to pay the highest Green Premiums in order to introduce innovations to achieve the 2050 emissions goals.

According to Mendelson at al. (2000) the countries in Africa, Asia, Latin America, and Oceania will be adversely affected by climate change, while countries in Europe and North America could benefit. Authors have found that the economies of OECD countries would add approximately 69 billion dollars to their GDP, while countries outside of OECD would lose approximately 348 billion dollars.

Stern reaches similar conclusions in the second part of his report. In his opinion, developing countries will suffer more adverse economic effects due to climate change compared to the developed countries, because of their geographic location, low-income levels that predicate reduced opportunities for realization of adaptation measures and higher
level of dependency on the climate sensitive sectors of the economy, such as agriculture. According to the author, the regions that would suffer the most would be Sub-Saharan Africa and South Asia. Unlike developing countries, some developed northern countries, such as Canada and the Nordic countries, would stand to gain economic benefits from climate change, but only if temperature rise is limited to up to 2 degrees centigrade compared to preindustrial age. In case of a temperature rise by 3 or more degrees – no region in the world would benefit. Stern makes the conclusion that economic effects for states with larger territories, such as the USA or Russia, will be diverse, and the socially disadvantaged people in developed countries will have a harder time dealing with the effect of climate change.

Furthermore, climate change will have an uneven impact, not just on global regions, but also on the different economic sectors. The following sectors are expected to be among the affected ones:

- **Agriculture** – agricultural production is directly dependent on temperature, sunshine, and precipitation. In many regions, climate change is expected to result in droughts, which will have an adverse effect over the output volume of production.

- **Fishing** – higher carbon emissions directly correlate with increased acidity of the oceans, which in turn has an adverse impact on biodiversity.

- **Insurance** – climate change results in increasing losses from natural disasters, which has a major impact on the bottom line of insurance companies. According to the reinsurance company Munich Re (2020), the number of catastrophic natural disasters has increased, from 249 in 1980 to 820 in 2019, with the growth rate steadily increasing over the whole period. According to the company’s evaluation, losses caused by natural disasters between 1980 and 2019 amount to 5,200 billion dollars.

- **Banks** – banks have some serious credit exposure to sectors that would be directly affected by climate change. Turning these exposures into problematic exposures would have a serious effect over the financial results of the banking sector.

- **Capital markets** – the decrease of prices for shares of companies affected by climate change would have an adverse impact on the profitability of investments by institutional investors.

- **Tourism** – there are many reasons why the tourist sector would be one of the most affected sectors. According to the calculations of the organization Sustainable Travel International (2021), tourism is responsible for approximately 8% of the global carbon dioxide emissions. Amelung, Nicholls and Viner (2011) consider that climate conditions are among the main motivators in the tourism sector, whereas global sea level rising has the potential of changing coastal areas in many regions.

- **Infrastructure** – global sea level rising, and the accompanying floods of coastal areas would have an adverse effect on streets, coastal highways, power lines, pipelines, and communication infrastructure, situated in these areas.

Climate change is expected to also cause global trends affecting the global economy, such as reduction of work productivity. According to a report of the International Labor Organization (2019), rise of global temperature by 1.5 degrees centigrade would result in a loss of 2.2%-3.8% of work hours globally in 2030, which is the equivalent of 80 - 130 million workplaces at full work hours. According to the same report at 33–34° C, a worker, who works at moderate labour intensity, loses 50 percent of his or her work capacity.

At the same time, climate change could have positive impact over certain sectors of the economy, such as:

- **Construction** – global sea level rise would require construction of facilities protecting coastal areas from floods, as well as consolidation and maintenance of the existing infrastructure in multiple places all over the world.
• Renewable energy output – because the energy sector is among the biggest carbon emission sources, the installation of renewable energy sources has gone through turbulent development over recent years, which is expected to continue in the future.

• Healthcare – climate change would result in expanding the areas of impact of various diseases, such as malaria, west Nile fever, or stem rust of wheat. On the other hand, the frequency of heat waves related to these changes would have an adverse impact over the health of babies, people with cardiology or other health issues. This would give an additional stimulus to the healthcare sector.

• Clean technologies – technologies of any kind, such as hydrogen fuel cells, capture and storage of carbon dioxide, etc., which could lower greenhouse gas emissions, would have a major economic success.

In addition, climate change is one of the most serious threats for medium term and long-term development of the global economy. The studies examining their regional economic benefit drive the conclusion and the accompanying moral paradox that the least developed countries, which are not at fault for anthropogenic climate change, will carry a heavier economic burden resulting from climate change, while developed industrial countries, which has mostly caused climate change through their development, would suffer less adverse, or in some cases even positive effects. Climate change is a global problem that requires global response, but political attempts so far have shown the difficulty of finding a solution on an international level, because the aforementioned moral paradox disconnects the developed and the developing countries on the key question about who should carry the economic burden of climate change, and to what extent. Determining the degree to which developed countries have had to suffer this burden is one of the most difficult moments in time in the negotiation for signing agreements related to climate and environmental protection. Another similar point is the temptation of a country to take the position of a free rider, taking a decision not to burden that country’s economy with climate protection measures, instead letting other countries carry that burden, but benefiting from measures taken by the other countries anyway. The insignificant political progress regarding climate change on an international scale is also related to the fact that changes are a relatively long-term process, which does not correspond to the shorter-term interests of the governments in power.

According to Stern (2007), only international efforts could solve the issue, and the main elements of future international framework should include: emissions trading, technology cooperation, action to reduce deforestation and adaptation.

Both in the past and in the present, climate change has had a significant impact over a series of public processes. The topics of climate change, environmental protection, and sustainable development of society and business have been the subject to active political and public discussion for just several decades. In 1920, in his work The Economics of Welfare, the British economist Pigou (1920) suggested the introduction of a tax that is used to balance adverse externalities created by certain business activities, which are not calculated in the price of the product but result in its overconsumption. The first conference under the auspices of the UN with a focus on environmental protection was held in 1972. The human environment conference of the UN has been held in Stockholm. Despite serious disputes between developing and developed countries, which had come to light during that conference, it gave the start of a series of similar meetings, which have shaped environmental efforts in the area of environmental protection. During that conference, the decision was taken for the establishment of the United Nations Environmental Program (UNEP).

The creation of the modern concept for sustainable development is related to the activity of the Brundtland commission, also
known as the World Commission on Environment and Development (WCED) and the report published by it in 1987 - “Our Common Future”. Sustainable development is a concept appealing to a future based on economic development, environmental protection, and social justice. In its report, the Commission defines sustainable development as:

“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987, p. 43).

The Brundtland commission has stated the argument that environment is integral to the development of humanity. The UN conference on the environment and development, also known as the Rio de Janeiro Conference, was held in 1992. The purpose of the conference was to strengthen international efforts in the direction of sustainable development. A significant result from the Conference was the adoption of the Convention on Climate Change that appeared to be the foundation of the Kyoto Protocol, signed in 1997, and the Paris Agreement, signed in 2016. Ten years later, in 2002, again under the auspices of the UN, a World Summit has been held once again, the result of which is the Johannesburg Declaration. In 2012, the UN Conference on sustainable development has been held again, and at that conference 192 heads of state and governments have signed the document, entitled The Future We Want.

Furthermore, circular economy is also a concept that would contribute to the fight against climate change. According to the popular definition of Geissdoerfer et. al, circular economy is:

“Regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling” (Geissdoerfer, Savaget, Bocken and Hultink, 2017, p. 760).

According to Ekins at al. (2019), the foundations of the circular economy concept may be found in industrial ecology of the 1940’s and 1950’s of the XX century, and in the article of Boulding (1966) ‘The economics of the coming spaceship Earth’. According to the advisory company PWC, in order to integrate the principles of the circular economy, a company should follow the following 10 strategies:

- Circular orders;
- Circular design;
- Effectiveness of resources;
- Product as a service;
- Sharing / Virtualization;
- Optimizing the use / Maintenance;
- Repeated use / Reallocation;
- Remediation / Processing;
- Industrial Symbiosis / Recycling for manufacturing;
- Recycling after consumption (Dinkel, 2020).

Two types of measures exist, which could be applied in combating climate change, each of them having its own economic effects:

1. **Measures for mitigating climate change** – they represent measures aiming at limiting global warming through the lowering of greenhouse gas emissions in the atmosphere. Political measures for lowering emissions are directed toward cap-and-trade or carbon tax imposition. Both types of measures result in reaching a certain price of carbon emissions and respectively adjusting prices of products or services for the business activities involved in emissions generation. Due to their more flexible form, the currently preferred measures are of the cap-and-trade type. Through them, the market can find the most economically effective method to limit emissions. The largest system of this type is the Emissions Trading System of the European Union. Established in 2005, the system is currently in its fourth phase. It limits the volumes of greenhouse gas that companies from sectors polluting the environment could generate, and the companies receive or purchase permits for generating gases, which they can trade if needed/required. Despite
criticisms toward the system referring to price volatility or number of allocated permits, according to the European Commission, that system is the foundation of decline by 35% of greenhouse gases generated by companies that participated in the system for the period between 2005 and 2019. Concurrently, many countries around the world have introduced carbon tax, with the carbon tax rate varying from 0.09 euro per ton in Poland to 90.53 euro per ton in Switzerland (Asen, 2020). According to Nordhaus, by for a policy having the objective of curbing climate change to be effective, it has to increase the price of carbon emissions, and by doing it:

“First, it will provide signals to consumers about which goods and services are carbon-intensive and should therefore be used more sparingly. Second, it will provide signals to producers about which inputs are carbon-intensive (such as coal and oil) and which are low-carbon (such as natural gas or wind power), thereby inducing firms to move to low-carbon technologies. Third, it will give market incentives for inventors, innovators, and investment bankers to invent, fund, develop, and commercialize new low-carbon products and processes. Finally, a carbon price will economize on the information required to undertake all these tasks” (Nordhaus, 2019, p. 2003).

The computer model Nordhaus used defines optimal price of a ton of carbon dioxide emissions, being 36 USD/ton, but in case of more ambitious climate goals being set, such as preserving the temperature rise within 2 degrees centigrade, “the social cost of carbon” would increase to 158-279 USD/ton.

A significant incentive en route to decreasing emissions are the changes in the behaviour of consumers, which prefer more environmentally friendly products and services. In a large-scale opinion poll of clients, the US advisory company CGS (2019) has reached the following details: 68% of Americans consider that sustainability of a single product is an important factor for their decision to buy it; 35% of respondents are ready to pay 25% higher price for a sustainable product; representatives of the so-called generation Z (people born between 1997 – 2012) would be willing to pay 50% or even up to 100% higher price for such products.

The market of environmental, bio, socially responsible and sustainable products has grown seriously over the course of the last decade. In an article for Harvard Business Review, Whelan, and Kronthal-Sacco (2019) have established that 50% of the growth of consumer-packaged goods marketed in the USA for the period 2013 – 2018 has been caused by sustainable products. Using company data for processing of large data arrays IRI, obtained from bar code scanning in a large number of stores for fast-moving consumer goods, both authors have reached the conclusion that the share of the sustainable products has grown from 14.3% to 16.6% over the same period, reaching an absolute amount of 114 billion dollars. At the same time, sales of products branded as sustainable, have grown 5.6 times faster than the ones that do not have such a brand.

Decreasing carbon emissions depends on the economically effective imposition and use of low carbon emission technologies, such as:

• Electric power output from renewable energy sources, such as wind, sun, rivers, high and low tides, and waves;
• Capture and storage of carbon dioxide;
• Use of hydrogen for heating and transportation fuels;
• The use of smart networks in the production, transportation, and consumption of electric power;
• Better insulation materials in construction
• Technology for electric, hydrogen and hybrid motor vehicles.

2. Adaptive measures - Climate is an inert system, and despite undertaken climate change mitigation measures, humanity will need to adapt to the effects of rising temperatures. There is a diversity of adaptive measures, and potential measures differ for each region, depending on the risks caused by climate change. The following are possible adaptive measures:
• Building sea walls or other facilities which counteract rise of global sea level;
• Improvement of pipelines for settlements endangered by floods due to the increasing precipitation volume;
• Change in construction standards requiring taller building foundations in areas endangered by flooding;
• Building rainwater storage facilities;
• Transition to growing plant crops and animal species with higher sustainability to drought;
• Using white and light-coloured materials for building roofs in large settlements, as a method for diminishing the effect of heat waves;
• Insurance against potential damages as a method for risk transfer and risk mitigation.

According to an analysis of the Economics of Climate Adaptation Working Group (2009), which represents a partnership by and between McKinsey, SwissRe, Rockefeller Foundation, Climate Works Foundation, the European Commission, and Standard Chartered Bank, the investment in adaptive measures is significantly more economically profitable than dealing with the damage caused by climate change. According to the expectations of the group for certain specifically reviewed towns, adaptive measures may prevent between 40% and 68% of economic losses that would arise by 2030, as the consequence of climate change caused events. Due to the existing diversity of potential adaptive measures, each district/municipality should perform an analysis of the risks that climate change has created for the respective region, and subsequently analyse the costs and benefits, related to the particular adaptive measure.

Conclusions

Anthropogenic climate change is a huge challenge to humanity and the ecosystems of the planet. They shall have an increasingly significant impact on multiple aspects of people’s lives. From the point of view of the economy, climate change will have an adverse impact on the global economy. The adverse impact would be profoundly expressed in the countries in Africa, South-East Asia and Latin America, and a moderate rise of temperatures (up to 1.5-2 degrees centigrade) could have a slightly positive impact over the economies of the countries in Northern Europe and Canada. A higher level of temperature rise would result in adverse impacts even for countries from the northern part of the Northern hemisphere. Another significant conclusion from the analysis is that climate change is a global problem, one that requires a global solution. The efforts of the international community in this area are stifled by the moral paradox that industrial countries, which are predominantly responsible for climate change, are the ones who would be the least affected by it. Two types of measures exist, which should be undertaken - climate change mitigation and adaptive measures. Concepts on the development of the society and the economy such as sustainable development and circular economy would support decreasing the hazardous impacts and overcoming the consequences of climate change.

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