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THE ECONOMICS OF THE FIGHT AGAINST CLIMATE CHANGE

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Abstract

The paper analyzes the economic perspectives of dealing with climate change. Recent data shows that concentration of greenhouse gasses significantly increased since industrial revolution, which is causing temperature increases and consequently many unfavourable developments. There are three options to dealing with climate change: (1) do nothing, (2) try to adapt and (3) fight against climate change. Each option is related to some economic costs. The article presents a review of estimates of economic costs related with each option.

Keywords: climate change, costs, mitigation, adaptation

1. INTRODUCTION

Global climate system has changed notably on both global and regional scales since the pre-industrial era. At least some of these changes are directly and indirectly attributable to human activities. Atmospheric concentrations of key anthropogenic greenhouse gases[1] reached their highest recorded levels, primarily due to the combustion of fossil fuels, agriculture, and land use changes ("Climate change" 2008). Global warming is evident from observations of increased global average air and ocean temperatures, melting of snow and ice and rising global average sea level.

Scientists worry that human society and natural ecosystems could not adjust to rapid climate changes. In order to tackle the challenges in a timely manner, several international treaties and numerous other activities have taken

[1] These include besides CO_2 also nitrous oxide (N2O), methane (CH4), chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorinated carbons (PFCs), and others.

place. Most importantly, in 1994 the United Nations Framework Convention on Climate Change entered into force and by today it has been ratified by 193 countries. In 1997 the Kyoto protocol, which prescribes a 5% reduction of emissions against the 1990 level over the 2008-2012 period, was adopted and entered into force in 2005. As of December 3rd 2009, 190 countries and 1 regional economic integration organization (EEC) have deposited instruments of ratification, accession, approval or acceptance (Kyoto protocol: Status of ratification, 2010). European Union went even beyond the demands of the protocol with the first and second European Climate Change Programme (ECCP) and is taking the initiative to become the leader of the global policy initiatives in the fight against climate change. The latest studies and environmental data (See Climate change 2007: Assessment Report 4 by IPPCC) suggest that even more stringent goals might be needed to achieve the desired climate impact.

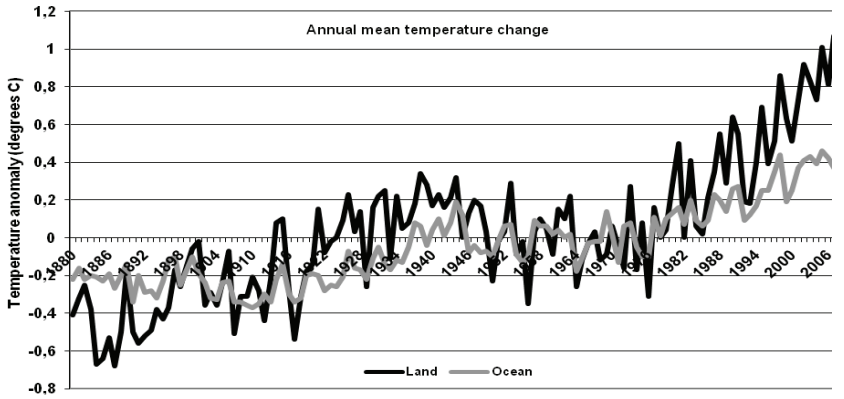
But is such action enough? Or is it too extensive given the circumstances? And what will be the economic consequences? Global policymakers and opinion makers had the choice between three options regarding climate change. The first was to neglect and overlook the problem and simply do nothing. The second option was to adapt to new reality under less favourable climate circumstances. The last was to fight climate change. The purpose of this review article is to examine the economic rationale behind the decision for the preparation and implementation of the Kyoto protocol as the first more important step towards fighting climate change. To do that, the costs of all three options will be presented and compared.

The structure of the article is as follows. First, the facts about climate change are presented, followed by the presentation of its potential impacts as an introduction to the analysis of costs. Once potential outcomes are presented, the economic rationale for not fighting, fighting and adapting to climate change is presented. In the end, a comparison and conclusion is provided.

2. CLIMATE CHANGE

Twelve of the last thirteen years ranked among the warmest years since the beginning of global temperature analysis. NASA Goddard Institute for Space Studies estimated in their Surface Temperature Analysis (2010) that 2009 tied with a cluster of years 1998, 2002, 2003, 2006 and 2007 for the second warmest year behind record holding 2005 since 1880 (Figure 1). They add (Surface Temperature Analysis, 2008) that the unusual warmth in 2007 is especially important because it occurs at a time when solar irradiance is at a minimum and the equatorial Pacific Ocean is in the cool phase of its natural El Niño-La Niña cycle. Grimaud and Tournemaine (2007) report that linear warming trend over the 50 years from 1956 to 2005 (0.13°C per decade) is nearly twice that for the 100 years from 1906 to 2005. Authors also report that the global average sea level rose at an average rate of 1.8 mm per year over 1961 to 2003 and at an average rate of about 3.1 mm per year from 1993 to 2003. Surface Temperature Analysis

(2008) reports that that the greatest warming has been in the Arctic and neighboring high latitude regions. Polar amplification is said to be expected characteristic of global warming, because the loss of ice and snow engenders a positive feedback via increased absorption of sunlight. NASA (2008) in its Global Warming brief summarizes the researches on future predictions claiming that the average temperature will rise an additional 1.4 to 5.8 degrees C by 2100.



Data: GISS Surface Temperature Analysis: Analysis Graphs and Plots, 2008.

* Temperature anomalies are computed relative to the base period 1951-1980. The reason to work with anomalies, rather than absolute temperature is that absolute temperature varies markedly in short distances, while monthly or annual temperature anomalies are representative of a much larger region. (. Best estimate for absolute global mean for 1951-1980 is 14C = 57.2F

Figure 1. Annual mean temperature change (anomaly from average temperature global mean for 1951-1980 of 14C)

Industrialization and other human related activities increased the relative presence of the human factor dramatically. Anthropogenic GHG emissions have been growing very fast. The atmospheric concentrations of CO2 and other GHGs have been growing similarly fast. Prior to industrial revolution the atmospheric CO2 concentration was about 280 ppm; now it is about 370 ppm and rising. Concentrations of other GHGs are also increasing: N2O, and CH4 concentrations increased by about 17% and 151%, respectively, since 1750. The present CO2 concentration has not been exceeded in the last 420,000 years and probably not during the past 20 million years. And the current rate of increase is highest in the past 20,000 years. Current GHG concentrations are responsible for about 2.4 watts per square meter of net radiative forcing, which implies that the incoming solar radiation exceeds outgoing radiation by 2.4 w/m2. The process lead to an

increase in mean global surface temperature (Sterman and Sweeney 2002). Sterman and Sweeney (2002) also stress that that mean global temperatures rose in the 20th century by 0.6 ± 0.2 °C, which was accompanied by decreasing glaciers, lower winter snow cover, a 40% decline in summer sea-ice thickness in the arctic, increased average precipitation, more likely extreme weather events, and increased sea level by 0.1 – 0.2 meter.

3. THE CONSEQUENCES OF CLIMATE CHANGE

Climate change is feared due to many potentially very dangerous and costly developments associated with it, in many aspects of natural environment and human related systems. The 2007 Climate change: synthesis report (pp. 30-33) lists many changes in natural system due to global warming. Besides the already mentioned, they also report that changes in snow and glacier covers changed the number and size of glacial lakes, increased ground instability and led to changes in Arctic and Antarctic ecosystems. Also hydrological conditions have been changing with warming; affecting both the quality and quantity of warming water. Recent warming trend are also blamed for earlier timing of spring events and poleward and upward shifts in plant and animal ranges. The reliability that these changes are related to global warming is high. The Climate change (2007) reports that out of 29 thousand data series in 75 studies 89% gave results that are consistent with the direction of change expected as a response to warming, although they state the problem of lacking data and research for developing world.

The Climate change report (2007, p. 48-50) systematically analyzes the major impacts by sectors. In agriculture, forestry and ecosystems, the major projected impacts are impacts on crop yields and crop quality due to either fewer colder days and nights (with positive impacts) or due to more frequent hot days and nights, hot spell, drought, heavy precipitation events, intense tropical storms, which will all have a negative impact on crop yield and quality. These phenomena will also increase the incidence of wildfires, increase soil eroision and soil quality, lead to soil water logging and increase the problems with coastal lands.

The climate changes will also impact water resources (Climate change report 2007, p. 49). First, there will be impacts on water resources depending on snow melting, also water demand will increase, there will be more problems with water quality and scarcity. Water supply will also impact power supply and public water supply.

Human health will also be under impact. Although human mortality due to cold is expected to decrease, heat-related mortality is likely to increase, especially for elderly, chronically sick, very young and those socially isolated. Extreme weather events will also increase the likelihood of deaths due to injuries,

infections, respiratory disease and skin diseases. Food and water shortage might also lead to malnutrition (Climate change report, 2007, p. 48)..

Last, the often most feared impacts, are the impacts on industry, settlements and society. First, warming will lead to changes in the demand for heating, it will increase the demand for cooling, air quality in cities will decline even further, there will be fewer problems in transport related to reduced snow precipitation, which will also negatively impact snow tourism in some areas. The quality of life in warm areas will decrease, the pressure will be felt especially by those without appropriate housing, elderly, very young and poor. Flooding could cause damage to settlements, commerce, transport and other infrastructural elements. Extreme weather will increase the potential for property damage, which might in turn reduce the potential coverage by insurance companies, also it might stimulate migration (Climate change report (2007, p. 48-50).

Other studies report of similar negative outcomes of climate change. Watkiss et al. (2005), for example, claim that the major consequences on European and global level are: (1) changes in natural environment (impacts of sea rise, erosion, loss of coastal land, impacts on water resources (supply and quality), impacts on ecosystems and the loss of biodiversity, potential droughts and flooding, extreme weather conditions, and other, (2) changes in human health (impact on human health from changes in cold related and heat related effects and impacts on human health from the disease burden (and other secondary effects); (3) impacts on economic elements (agriculture, energy use, water resources, supply and quality, changes to tourism potential and impact on destinations, damages from extreme weather and other). Of course, all climate change impacts could mirror themselves in damages to economic system and growth, some directly, other indirectly, some soon, other in the longer run.

The Stern review, one of the most cited reports on climate change, claims that 'Climate change threatens the basic elements of life for people around the world - access to water, food production, health, and use of land and the environment' (The Stern Review: Economics of climate change, 2006: Executive summary, p. vi). The review forecasts that on current trends, the planet would warm by another 2-3 degrees in the next fifty years. This is expected to have several negative impacts, as the review claims, often related to water. Melting glaciers are expected to first increase flood risks and later reduce water supply, threatening mainly India, parts of China and the Andes. Lower crop yield would, especially in Africa, increase problems with food shortage. Although the report stresses that with temperatures rising from 2-3 °C crop yield would increase in today less fertile areas (mid and high latitudes), but with warming of 4 °C and more, world food production will be seriously threatened. Rising sea levels will increase flooding. The report even warns that 'by the middle of the century, 200 million people may become permanently displaced due to rising sea levels, heavier floods, and more intense droughts'. Warming could also cause abrupt and huge changes like sudden shifts in the regional weather (monsoon in South Asia and El Nino). Warming by 2-3°C could also irreversibly damage the Amazon forest.

The reports and studies are quite unanimous at forecasting the outcomes of continuous climate change. The dramatic consequences should worry policy makers, businessmen and wider society, but the doom projections often leave the decision makers too hesitant. First, because of the distant time horizon and second, more importantly, because of the fear of the cost of fighting climate change.

4. THE ECONOMICS OF THE GLOBAL FIGHT AGAINST CLIMATE CHANGE

The potential impacts of global climate change are wide and hard to predict as well as it is hard to assess their potential economic consequences. Continuous warming data leaves the population with the decision to fight against climate change, not to fight it or to adapt to the changed climate as much as possible. The decision has been already made with the Kyoto protocol. In continuing, we present the alternatives three alternatives and their economic consequences: (1) inaction, (2) adjustment and (3) fight against climate change in order to put the Kyoto process into the perspective with other alternatives.

Although many studies have been dealing with the problems of climate change, it is important to mention at the beginning also the many critiques of these estimations. It is important that one is aware of the potential problems with assumptions and models, although these problems must not overshadow the problem of climate change. The critiques mainly point to the problems with assumptions about discounting, especially the discount rate, the possibility and costs of adaptation, extreme weather forecasts, non-market damages, future demographics, knock-on damages, uncertainty regarding the projections and the accounting for this uncertainty, equity and mitigation and abatement costs.

4.1. The costs of inaction

The first option in the process of the 'fight against climate change' is to do nothing. The Climate Change 2001: Synthesis Report (IPCC, 2001) reports on the basis on projections using SRES emission scenarios that without mitigation the average surface temperature could globally increase from 1,4 to 5,8 °C in the period between 1990 and 2100. This is reported to be about two to ten times larger than the warming in the 20th century and unprecedented in the past 10 thousand years. Ackerman and Stanton (2006) report that although many ecosystems are adaptable beyond our expectations, a rise of above 2°C more ecosystems will reach the limits of adaptability, while 4°C of warming could cause serious damage to ecosystems worldwide, including harming significantly agriculture, human health and create an environment more prone to catastrophic episodes.

Estimates of economic impacts of 'inaction' differ, but nonetheless they are significant. The Stern review (2006, pp. 143-158) reports that the cost heavily depends on the actual progress of warming, which is associated with a lot of uncertainty, especially if projecting the changes for the next century or more. The Review reports that most studies so far have used a assumption of 2-3 °C additional warming, which was calculated to lead to a 0-3% loss of global GDP on average, with poor countries suffering higher cost. But, as Stern review stresses 'business as usual' could lead to higher increases in global temperature, which would increase the scope of negative impacts, leading to GDP losses of 5-10% globally, with poor countries suffering most. Although, due to uncertainty, the actual losses could be much higher. Also, the Review stresses that if the models took account of three additional factors (on the environment and human health, the higher responsiveness of climate to GHG emissions (some evidence shows that the elasticity is higher than previously assumed) and the disproportionate impact on poorer economies), the cost would even increase, leading to lower per capita consumption by approximately 20% now and forever (5-11% for environment impact and human health, 5-14% for the costs related to higher elasticity of climate change to GHG emissions).

Kemfert (2005a, p. 45) reports that the economic damage from extreme weather has risen by fifteen times in the last 30 years. The study provides a 2002 calculations of damages prepared by the insurance company Muenchner Rueck, which calculated that the global damages amounted to approximately 55 billion US$. An extrapolation to 2050 shows that the damages could increase to 600 billion $, but the share of insurance covered damage will decrease to roughly one-fifth of all damages, since the pressure of extreme events will lead to less willingness from insurance companies to cover for such damages. The results of the simulation with WIAGEM shows that a rise in temperatures of 1°C could lead to damages of about 214 trillion US$ (2002 prices) (including damages to agriculture, energy production, industry impacts and ecological impacts (e.g. loss of forests due to fires, loss of species) and the impacts on health. In her other article Kemfert (2005b) stresses that if active climate policy starts today damages of up to 12 trillion US$ globally could be avoided in 2100, which is estimated to be around 5% of projected GDP in 2100. Delaying climate policy till 2025 would increase the costs for 2100 to 15 trillion globally. The author also says that the costs of a well-timed active climate policy are estimated to be about 430 billion US$ in 2050 and around 3 trillion US$ in 2100. Delaying climate protection till 2025 would result in an additional costs of up to 50 billion US$ in 2050 and 340 billion US$ in 2100. But that would also imply that global surface temperature would rise by about 3.5 °C till 2100 compared to preindustrial levels, and that would also imply more substantial climate change damages. These estimates indicate the potential cost of inaction is very high in lost GDP and lost welfare and that the cost of action is much lower than the cost of inaction.

Several studies dealt also with the problem of putting a price on warming on a national level. Ackerman and Stanton (2008) report that global

warming will be expensive for all nations across the globe. Should the past trends continue, the cost could reach even 3,6% of GDP. Four global warming consequences alone (hurricane damage, real estate losses, energy costs and water costs) will cost the USA 1,8% of GDP by 2100 annually. The cost of hurricane damage will from 2025 till 2100 increase from 0,05% of GDP annually to 0,41%, the real-estate losses from 0,17% of GDP to 0,35%, energy sector costs will remain relatively stable at 0,14% of GDP and water costs will increase mainly in the Western states, but the total cost will slightly drop from a 1% of GDP to 0,93% of GDP. The total cost of these four consequences alone will thus rise from 1,36% of GDP in 2025 to 1,84% in 2100. The total costs of climate change, including economic losses, non-economic damages and increased disaster risks, amount to 3,6% of US GDP in 2100.

4.2. The costs of adaptation

Adaptation is not new. 'The need to adapt to climatic conditions has been a feature of human life since the beginning of time. It is an ongoing challenge that affects the way we live, how we design our infrastructure and how we produce our goods and services. Adaptation is not a new activity introduced as a consequence of climate change. What climate change forces us to do is to re-adjust our economies and our behaviour to reflect the new climate realities.' (Frankhauser, 2010, p.5) Can the world adapt to climate change and provide the same quality of life as before? Ackerman and Stanton (2006) report that although many ecosystems are adaptable beyond our expectations, with a rise of above 2°C more ecosystems will reach the limits of adaptability, while 4°C of warming could cause serious damage to ecosystems worldwide, including harming significantly agriculture, human health and create an environment more prone to catastrophic episodes. More adaptation due to more severe climate change requires more investment.

Adaptation covers all activities and costs that are required to cope with the future climate change. Some of these activities are planned, conducted by the government or some other institutions; some are spontaneous and undertaken by people themselves. Several studies have coped with the challenge of estimating these costs. According to The costs to developing countries of adapting to climate change (2009, p.3) are challenging to estimate, the following elements should be carefully considered: (1) picking the year of interest (baseline), (2) choosing the climate projection used in simulations, (3) predicting impacts, which refers to the impact of climate change on various economic activities, people behaviour (for example in consumption, health), on environmental dimensions (water availability, oceans, forests), and on physical capital (e.g. infrastructure) and last (4) the adaptation alternatives must be developed and their costs evaluated for each of the sectors of interest.

The literature on adjustment has been developing for quite long. The articles studying impacts, processes, potentials, obstacles, case studies of

adaptation, have been developed continuously since the nineteen eighties (Wigley et al., 1981; Smith et al. 1996, Feenstra et al., 1998; and many other). The scope of adaptation costs varies significantly in the literature. Frakhauser (2010) stresses that the costs, which vary from 25 billion to 100 billion per year in the period between 2015-2030 likely underestimate the actual costs. The wide range of estimates points to lack of good knowledge both scope and depth of the problems in the field, the author claims.

The study 'The costs to developing countries of adapting to climate change (2009)' refers to the problem in developing countries. The Copenhagen round success depended also on more stringent commitment by the developing countries that consequently needed an insight into the size of the problem. The impact of climate change on developing countries has been studied several times and the results vary significantly. Some of the more often cited studies were performed by the World Bank (2006, the programme is continued, the study The costs to developing countries... (2009) is a part of this study), the Stern report (2007), Oxfam (2007), UNFCC (2007), Parry et al. (2009) and the aforementioned study. The studies differ significantly in results, although the sectors covered were similar (infrastructure, coastal zones, water supply and flood protection, agriculture, forestry and fisheries, human health and extreme weather events). 'The costs to developing countries of adapting to climate change (2009)' study compares the estimates of the 2007 UNFCC study, with its own. UNFCC (2007) estimates the costs to range from 28 to 67 billion, while Parry et al. (2009) costs reach over 100 billion, while 'The costs to developing countries of adapting to climate change (2009)' study estimates the costs to be between 77 and 89 billion (including the cost of extreme weather, which the first two do not include). But the reports similarly find the prevalence of infrastructure costs. 'The costs to developing countries of adapting to climate change (2009)' study also shows that there will be regional disparities in the costs due to different impacts of climate change. The costs are expected to be highest in Sub-Saharan Africa (up to 0.70% of GDP per year) and lowest in Europe and Central Asia and Middle East and North Africa, where the estimates are quite close together, ranging from 0.06 to 0.11 % of GDP. If comparing the costs depending on development level, the costs will be largest in those least developed (up to 0.39% of GDP per year) and lowest in the lower-middle income countries (up to 0.16% of GDP per year). The upper-middle income countries are expected to pay up to 0.19% of GDP per year due to more developed infrastructure.

The UNFCC study presented in the '|Assessing the costs of adaptation to climate change' report by Parry et al. (2009) presents the results of six studies, commissioned by the UNFCCC, which focus on: (1) agriculture, forestry and fisheries, (2) water supply, (3) human health, (4) coastal zones, (5) infrastructure and (6) ecosystems. The report estimates that by 2030 the funds required for adaptation would be from $49-171 billion per year, out of which 27-66 billion in developing countries (Table 1). The most important cost represents the investment in infrastructure, up to ¾ of total cost. The costs do not include the

costs of ecosystems adjustment due to the problems of estimating probable figures for the costs of adjustments and the value of the services the ecosystems provide. Therefore, the report (2009, p.17) admits that this area is an important source of underestimation. The results are nonetheless interesting and very indicative of many open issues due to significant ranges in estimates, pointed to also by other authors (for example, Frankhauser, 2010).

Parry et al. (2009, p.8) at the end warn that so far several cricisms can be pointed towards the existing studies: (1) none of the studies are substantive, (2) they are closely linked, borrow from each other and are not independent, (3) they have not been subjected to peer review in economic literature. The criticism is widespread and the problems are mentioned systematically in many studies (Franhauser, 2009).

Table 1

UNFCCC estimates of global investment costs for adaptation by 2030

Sector	Global cost ($billion per year)	Of which		
		Developed countries	Developing countries	Residual damage
Agriculture	14	7	7	-
Water	11	2	9	-
Human health	5	0	5	-
Coastal zones	11	7	4	1.5
Infrastructure	8-130	6-88	2-41	-
Total	49-171	22-105	27-66	1.5

Source: Parry et al. (2009, p.25)

Also, according to many, adaptation and mitigation are complimentary due to the limited ability of adaptation, delayed reaction of nations to climate changes and its exponentially increasing costs.

4.3. The cost of mitigation

In order to tackle the challenges in a timely manner, several international treaties and numerous other activities have taken place. Most importantly, in 1994 the United Nations Framework Convention on Climate Change entered into force and by today it has been ratified by 192 countries. In 1997 the Kyoto protocol was adopted and entered into force in 2005. As of December 3rd 2009, 190 countries and 1 regional economic integration organization (EEC) have deposited instruments of ratification, accession, approval or acceptance (Kyoto protocol: Status of ratification, 2010).

The Protocol sets binding targets for 37 industrialized countries and the European community for reduction of GHG emissions to an average of 5% against the 1990 level (also known as Annex I countries). The reduction must be achieved over the 2008-12 period. Given that the developed industrialized economies are also the biggest emitters and have been since industrialization the primary cause of the accumulation of GHG emissions, the Protocol sets a heavier burden on the developed economies under the principle of "common but differentiated responsibilities" (Kyoto Protocol Reference Manual on Accounting of Emissions and Assigned Amounts, 2007)

The Kyoto protocol introduced three new mechanisms to help economies achieve their targets: (1) emissions trading (2) clean development mechanism (CDM) and (3) joint implementation. Article 17 (Decision 18/CP.7., 2001) of the treaty presents the basic guidelines on emissions trading. Countries can sell their spare emissions units to countries that are over their limits. The European Union has taken the lead in the field in 2005 by opening a new market for a new commodity 'GHG emissions'. The market is known as 'ETS – European emissions trading' and was opened in 2005 (Emission Trading Scheme, 2008), being the largest emissions market in the world. In 2006, the EU ETS globally accounted for around 81% of the global carbon market in terms of value and 67% in terms of volume. In the first two years, the desire was to enable a critical mass for the market to be able to function efficiently. The first assessment shows that the market gained the desired credibility, that real trading has evolved and actually helped economies reach their Kyoto targets (Accompanying document to the Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC, 2008).

Clean development mechanism stimulated investment into emission reduction projects. It allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets. CDM stimulates sustainable development and emission reductions, and at the same time provides the industrialized countries some flexibility in how they meet their emission reduction or limitation targets (Clean development mechanism, 2008).

"Joint implementation," is a mechanism by which a country with an emission reduction or limitation commitment under the Kyoto Protocol (Annex B Party) can earn emission reduction units in order to meet its Kyoto target (ERUs, each equivalent to one tonne of CO2) from an emission-reduction or emission removal project in another Annex B Party. The mechanism offers countries an interesting option of fulfilling their commitment, while also stimulating FDI and technology transfer to developing economies, thereby stimulating also their development (Joint implementation, 2008).

The Kyoto Protocol is an important step towards a greener tomorrow, since it is striving to become a global commitment for GHG emission reduction. In 2012 the first commitment period will end. The international efforts continue. In December 2009 the Copenhagen round brought new results and hopes. The Copenhagen Accord (2009) recognizes the need to stem the temperature growth to below 2°C, reconsidering this goal (rather making it 1,5), it calls for examination of efficiency of existing policies and it also established a 'Copenhagen Green Climate Fund', through which the rich countries would channel 30 billion dollars to developing in the next three years and help them with environmental problems. The Accord also forsees additional funds for mitigation and adaptation. But, unfortunately many shortfalls are mentioned, especially the absence of an instrument that would replace the Kyoto and the lack of ability to determine a deadline for its establishment, and it does not set target for the 2050 emissions (COP15 Daily Brief: The Copenhagen Accord).

Mitigation is, similarly to adaptation, often analyzed for its economic dimensions. The first major concern is the impact of pollution reduction on economic performance, growth and GDP. The Kyoto protocol will surely have an impact on economic development, especially in economies with strong industrial sector. But results of simulations done by a number of authors show that the costs of compliance with Kyoto will not be high in terms of lost GDP. Studies generally show that: (1) welfare loss in terms of GDP and lost growth in EU is low, (2) it differs among economies, (3) the structure of the Kyoto coalition is important and (3) permit trading and permit price (in either global or regional markets) is highly correlated with the welfare loss.

The Stern review (The Stern Review: Economics of climate change, 2006), one of the most cited studies, argues that global climate change will affect all countries, but most dramatically the already poor. But the risks of the worst impacts of climate change could be significantly reduced if GHG levels in the atmosphere were stabilised between 450 and 550ppm CO2 equivalent (currently at 430 ppm, rising 2ppm per year). Stabilisation to required range would require emissions to be cut by at least 25% below current levels by 2050. The report adds that the costs of stabilization to a range of 500-550 ppm would be low, at around 1% of global GDP, especially if compared to the risks of inaction. The costs would not be evenly distributed across sectors or among countries. But, activities to protect the environment are expected to create new business opportunities, as new markets are created in low-carbon energy technologies and other low-carbon goods and services. These markets could grow to be worth hundreds of billions of dollars each year, and employment in these sectors will expand accordingly (The Stern Review, 2006).

Gielen and Koopmans (1998) study the impact of Kyoto using the world economic model Worldscan. Real consumption is forecasted to fall slightly, from 0,3 percentage points in EU, to just over 1 in CIS (emissions in EU should fall by 29% and in CIS even grow slightly). But emissions trading can dramatically lower the costs, especially for exporters of permits, which actually benefit.

Authors also claim that Kyoto will lead to substantial structural changes in the economy. They forecast that especially energy intensive industries will due to limited energy input substitutes experience increased costs, which will worsen their international competitiveness.

Bollen, Manders and Veenendaal (2004) examine 'how much does a 30% emission reduction cost'. The study assumes that by 2020 industrial countries will achieve a 30% reduction of GHG emission compared to 1990s. Results of the simulations using Worldscan model show that the costs for industrialized countries mainly stem from the imports of permits, which depends also on the levels of future economic growth. More moderate growth clearly indicates lower costs. But the costs also depend on whether the developing countries participate in the abatement. Estimates show that for Annex I countries the impact of the reduction within a global coalition can be limited to 0,6% of national income, half of this loss due to purchasing emission rights. The production loss is expected to be 0,1% of GDP[2]. Such amounts are also forecasted for EU. The non-Annex I countries are even expected to benefit around 0,8% of NI, which will despite the production loss experience a growth of NI of about 0,3%.

Viguier et al. (2003) study the impact of Kyoto among European economies. Their main conclusion is that the costs of Kyoto, measured in GDP loss, depend on domestic economic structure and the differences in electricity sector. The results show that if EU countries were to individually meet the EU allocation of the Community-wide carbon cap specified in the Kyoto Protocol, that carbon prices would vary from $91 in the United Kingdom to $385 in Denmark; while welfare costs would range from 0.6% to 5%. In most EU economies, the negative impact of emission constraint on GNP would be reduced by a positive trade effect. But this positive impact of climate policy on comparative advantage can differ significantly among economies depending primarily on the structure of international trade, and especially on the weight of fuels and energy-intensive goods in total imports.

Several reports also agree that green future does not contradict competitive and successful economic performance (e.g. Watkiss et al., 2004, Watkiss et al., 2005 and other). In The contribution of good environmental regulation to competitiveness (2005) European environmental agencies sum up their views on the relationship between environment, regulation and competitiveness. They claim based on other research results that modern environmental regulation can (pp.1-8): (1) reduce costs for firms due to energy efficiency and waste management, (2) create new markets for environmental goods and services that are in size comparable already with those for pharmaceutical industries. Consequently, jobs and production will follow. (3)

[2] Authors point out (p.21) that the components (change in national income does not equal to change in GDP (production loss) + trade in emmission rights) do not add up to the drop of national income due to terms of trade effects and changes in the capital return on foreign capital investments.

Environmental regulation is expected also to drive innovation both in environmentally friendly production techniques or products that are less environmentally burdening. This is an additional source of competitiveness. (4) compliance with high environmental standards is also expected to earn additional confidence to firms in investment markets and with insurers and this can lead to additional savings due to more favourable firm evaluations. (5) Better environmental quality will also improve the health of the workforce and of the wider public, which can (if at the moment we overlook the moral importance the state providing healthy living conditions) lead to additional savings for both firms and the state and can result also in higher productivity. (6) last, the authors also point to the overlooked importance of protecting the natural balance in the eco-systems. Stable climate and the natural resources (water, air), which we all depend on, are too often taken for granted..

5. CONCLUSION

Climate change is today a buzzword. The problem that the scientists have been warning about for three decades is now finally being dealt with on a supranational level. The climate change is caused, according to the studies, by fast increasing concentrations of GHGs, which can be largely attributed to human activities. The process of global warming is feared to have significant negative impacts in the environment (warming, changes in snow and glacier covers and size of glacial lakes, increased ground instability and changes in Arctic and Antarctic ecosystems, changed hydrological conditions, earlier timing of spring events and pole-ward and upward shifts in plant and animal ranges. There will be also significant sectoral changes: in agriculture, forestry and ecosystems, crop yields and crop quality will change, also the incidence of wildfires, increase soil erosion and soil quality, lead to soil water-logging and increase the problems with coastal lands. The climate changes will also impact water resources: water quality and scarcity. Human health will also be impacted. Extreme weather events will also increase the likelihood of deaths due to injuries, infections, respiratory disease and skin diseases. Last, the often most feared impacts, are the impacts on industry, settlements and society

Due to the fears of lower wellbeing, the international fight against climate change has been developing fiercely since the 1990s. The Kyoto agreement represents the peak of international attempts and commitment and also offers specific mechanisms for dealing with GHG emissions in both developed and developing economies. The Kyoto agreement was feared by many due to the perceived loss of income for mitigation purposes and therewith related cost. But the estimates show that the cost is expected to be low, around 1 percent of GDP. The other alternative, not doing anything, is estimated to be much pricier for mankind and is expected to be much higher, up to one fifth of the product. The middle way, adaptation, is estimated to have a moderate cost, but the estimates vary significantly and also only few sectors are considered, which significantly

lowers the credibility of results. Also, adaptation is expected to go hand in hand with mitigation, since human kind will be forced to adapt to the environmental damage caused by existing emissions and the expected raise of temperature by 2 degrees Celsius.

This field of research is developing fast, but it is also very demanding and hard to model due to many unknown parameters. But the fact that researchers are aware of the shortfalls of existing literature is a strong element of future commitment to improving the research.

REFERENCES

Accompanying document to the Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading system: Impact Assessment, (2008), COMMISSION OF THE EUROPEAN COMMUNITIES, Internet: http://ec.europa.eu/ environment/climat/emission/pdf/com_2008_16_ia_en.pdf[Accessed 0/11/2009]

Ackerman, F. and Stanton, E., (2006), *Climate change – the cost of inaction*. Global Development and Environment Institute, Tufts University. Internet:
http://netdrive.montclair.edu/~lebelp/GDAEClimateChangeCosts2006.pdf
[Accessed 15/11/2009]

Ackerman, Frank F. & and Stanton, Elizabeth E.A., (2008), "A comment on "Economy-wide estimates of the implications of climate change: Human health"," *Ecological Economics*, 66 (1): 8-13.

Bollen, J., Manders, T. in and Veenendaal P., (2004), How much does a 30% emission reduction cost? CPB document No. 64, CPB Netherlands Bureau for Economic Policy Analysis. Internet: http://www.cpb.nl/nl/pub/c pbreeksen/document/64/doc64.pdf [Accessed 14/10/2009]

Clean Development Mechanism (CDM), (2008), United Nations Framework Convention on Climate Change. Internet: http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/ite ms/2718.php [Accessed 15/11/2009]

Climate change (2008). Internet: http://www.un.org/esa/ sustdev/sdissues/climate_change/climate_change.htm. [Accessed 9/10/2009]

Climate change 2001: Synthesis report (2001), Intergovernmental panel for climate change. Internet: http://www.grida.no/publications/other/ipcc_tar/ [Accessed 8/10/2009]

Climate change 2007: Synthesis report, (2007), Intergovernmental panel for climate change. Internet: http://unfccc.int/playground/items /5524.php[Accessed 8/10/2009]

COP15 Daily Brief: the Copenhagen Accord, (2010), Copenhagen Climate Council. Internet: http://www.copenhagenclimatecouncil.com/get-informed/news/cop15-daily-brief-the-copenhagen-accord.html [Accessed 29/12/2009]

Copenhagen Accord. Draft decision-/CP.15, (2009), United Nations Framework Convention on climate change. Internet: http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf [Accessed 29/12/2009]

Decision 18/CP.7. Modalities, rules and guidelines for emissions trading under Article 17 of the Kyoto Protocol, (2001). Internet: http://unfccc.int/files/kyoto_mechanisms/cdm/application/pdf/13a02.pdf#page=50 [Accessed 10/11/2008]

Emmission Trading Scheme, (2008), EUROPA European Commission, Environment. Internet: http://ec.europa.eu/environment/climat/emission /index_en.htm [Accessed 17/11/2009]

Feenstra, J., I. Burton, J. Smith, and R. Tol (eds.), (1998), *Handbook on Methods for Climate Impact Assessment and Adaptation Strategies, 2,* United Nations Environment Program, Institute for Environmental Studies, Amsterdam..

Frankhauser, S., (2010), A Perspective Paper on Adaptation as a Response to Climate Change. Copenhagen consensus centre. Obtained through the Internet:. http://fixtheclimate.com/uploads/tx_templavoila/PP_Adaptation _Fankhauser_v.3.0.pdf [Accessed 30/11/2009]

Gielen, A. and Koopmans, C., (1998), *The economic consequences of Kyoto*, CPB Report 98/1. Internet:. http://www.cpb.nl/nl/pub/ cpbreeksen/cpbreport/1998_1/s3_1.pdf.[Accessed 15/11/2009]

GISS Surface Temperature Analysis: Analysis Graphs and Plots, Goddard Institute for space studies, (2010). Internet:. http://data.giss.nasa.gov/gistemp/graphs/ [Accessed 15/2/2010]

GISS Surface Temperature Analysis: Global Temperature Trends: 2007 Summation, (2008), Goddard Institute for space studies. Internet:. http://data.giss.nasa.gov/gistemp/2007/ [Accessed 10/10/2008]

Global warming, (2008), NASA. Internet: http://www.nasa.gov/ worldbook/global_warming_worldbook.html [Accessed 10/10/2008]

Grimaud, A. and Tournemaine F., (2007), "Why can an environmental policy tax promote growth through the channel of education?" *Ecological Economics*, 62 (1): 27-36.

Joint Implementation, (2008), United Nations Framework Convention on Climate Change. Internet: http://unfccc.int/kyoto_protocol /mechanisms/joint_implementation/items/1674.php [Accessed 8/11/2009]

Kemfert, C., (2005a), "Induced technological change in a multi-regional, multi-sectoral, integrated assessment model (WIAGEM): Impact assessment of climate policy strategies", *Ecological Economics*, 54(2-3): 293-305.

Kemfert, C., (2005b), Global Climate Protection – Immediate Action Will Avert High Costs, German Institute for Economic Research (DIW) Berlin Weekly Report. Internet: http://www.diw.de/documents/publikationen /73/43084/diw_wr_2005-12.pdf [Accessed 15/1/2010]

Kyoto Protocol Reference Manual on Accounting of Emissions and Assigned Amounts, (2007), UNFCCC secretariat. Internet: http://unfccc.int/files/national_reports/accounting_reporting_and_review_under_the_kyoto_protocol/application/pdf/rm_final.pdf [Accessed 8/11/2009]

Kyoto protocol: Status of ratification of Kyoto protocol, 2010, United Nations Framework Convention on Climate Change. Internet: http://unfccc.int/playground/items/5524.php [Accessed 15/11/2009]

Oxfam, (2007), Adapting to Climate Change. What is Needed in Poor Countries and Who Should Pay? Oxfam Briefing Paper 104. Internet: http://www.oxfam.org/sites/www.oxfam.org/files/adapting%20to%20climate%20change.pdf [Accessed 10.1. 2010]

Parry, M., Arnell, N., Berry, P., Dodman, D., Frankhauser, S., Hope, C., Kovats, S., Nicholls, R., Satterthwaite, D., Tiffin, R., Wheeler, T., (2009), Assessing the costs of adaptation to climate change. A review of the UNFCCC and other recent estimates. Imperial college London, Grantham Institute for Climate change. Internet: http://www.iied.org/pubs/pdfs/11501IIED.pdf [Accessed 15/11/2009]

Smith, J.B., N. Bhatti, N., G. Menzhulin, G., R. Benioff, R., M.I. Budyko, M.I., M. Campos, M., B. Jallow, B. and F. Rijsberman, F. (eds.), (1996), *Adapting to Climate Change: An International Perspective*. Springer- Verlag, New York.

Sterman, J. D. and Sweeney L. B., (2002), "Cloudy Skies: Assessing Public Understanding of Global Warming." *System Dynamics Review* 18(2): 36-49.

Stern Review: The economics of climate change, by Nicholas Stern, (2006), London, UK: Her Majesty's Treasury, 2006. Internet: http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm [Accessed 15/9/2008]

The Costs to Developing Countries of Adapting to Climate Change: New Methods and Estimates, (2009), The World Bank. Internet:

http://siteresources.worldbank.org/INTCC/Resources/EACCReport0928Final.pdf [Accessed 10/1/2010]

UNDP, (2007), *Human Development Report 2007/08*, New York: Palgrave McMillan. Internet: http://hdr.undp.org/en/reports/global/hdr2007-2008/ [Accessed 12/1/2010]

UNFCCC, (2007), *Investment and Financial Flows to Address Climate Change*. Bonn: Climate Change Secretariat. Internet: http://unfccc.int/cooperation_and_support/financial_mechanism/items/4053.php [Accessed 15/11/2009]

Viguier, L. L., Babiker, M. H. and Reilly, J. M., (2003), "The costs of the Kyoto Protocol in the European Union". *Energy Policy* 31: 459–481.

Watkiss P., Downing T., Handley C., and Butterfield R., (2005), *The impacts and costs of climate change*, AEA Technology Environment, Stockholm Environment Institute, Oxford. . Internet: http://ec.europa.eu/environment /climat/pdf/final_report2.pdf [Accessed 15/11/2009]

Watkiss, P., Forster, D., Hunt, A., Smith, A. and Taylor, T., (2004), "A *Comparison of EU Air Pollution Policies and Legislation with Other Countries*". Review of the Implications for the Competitiveness of European Industry Report for DG Enterprise. Internet: http://europa.eu.int/comm/enterprise/environment /reports_studies/reports/study1.pdf. [Accessed 11/11/2008]

Wigley, T., M. Ingram, and Farmer G., (1981), Past climates and their impact on man: a review. In: *Climate and History* [Ingram, M., G. Farmer, and T. Wigley (eds.)]. Cambridge University Press, Cambridge, pp. 3–50.

World Bank, (2006), Investment Framework for Clean Energy and Development, Washington DC: World Bank. Internet: http://siteresources.worldbank.org/DEVCOMMINT/Documentation/20890696/DC2006-0002(E)-CleanEnergy.pdf [Accessed 12/2/2010]

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EKONOMSKI ASPEKTI BORBE PROTIV KLIMATSKIH PROMJENA

Sažetak

U članku se analiziraju ekonomski aspekti suočavanja s klimatskim promjenama. Podaci pokazuju da se koncentracija stakleničkih plinova znatno povećala od industrijske revolucije, što je dovelo do povećanja temperature i drugih nepovoljnih pojava. Tri su mogućnosti suočavanja s klimatskim promjenama: 1) ništa ne raditi, 2) prilagoditi se, 3) boriti se. Sve tri opcije povlače ekonomske troškove. Članak daje pregled procjene ekonomskih troškova za svaku opciju.

Ključne riječi: klimatske promjene, troškovi, ublažavanje, prilagodba

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