CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

Department of Economics

Bachelor Thesis

Economic Analysis of Climate Change

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Department of Economics

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BACHELOR THESIS ASSIGNMENT

Vojtíšek Petr

Agricultural Economics and Management

Thesis title

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Assess value of global climate using one of the methods of non-market valuation.

Methodology

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Recommended information sources

Al Gore. Our Choice: A plan to solve our climate crisis. ilustrated edition Bloomsbury Publishing, 2009. 414 p. ISBN 9780747590989

Robert O. Mendelsohn, Ariel Dinar. Climate change and agriculture: an economic analysis of global impacts, adaptation and distributional effects. ilustrated edition. Edward Elgar Publishing, 2009. 246 p. ISBN 1847206700, 9781847206701

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Prague March 20, 2012

DECLARATION

I hereby declare that I have worked on my Bachelor Thesis titled "Economic Analysis of Climate Change" solely and I have used the literature and sources listed in bibliography.

In Prague, 30th March 2012

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Petr Vojtíšek

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The great thank belongs to my parents for supporting me in all possible ways and for giving me the opportunity of university education.

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Economic Analysis of Climate Change

Ekonomická analýza změny klimatu

Summary:

The bachelor thesis themed "Economic Analysis of Climate Change" focuses on the climate change from an economical point of view. The theoretical part sums up the basic facts about climate change, go through the most important social, environmental and economic impacts, main opinions about the climate change and also the main ideas of the mitigation and adaptation processes. The analyses tries to give the climate a monetary value with a use of non-market method to find out how much would be students of the Czech University of Life Sciences pay for the mitigation and adaptation.

Keywords:

Economic analysis, economic impacts, climate change, global warming, contingent valuation method

Souhrn:

Bakalářská práce Ekonomická analýza změny klimatu se soustředí na změnu klimatu z ekonomického hlediska. Teoretická část shrnuje základní fakta týkající se změny klimatu, nastíní nejdůležitější sociální, environmentální a ekonomické důsledky, hlavní názory o změně klimatu a také hlavní části procesu zmírnění a adaptace. Analýza se pokouší přiřadit změně klimatu peněžní hodnotu pomocí jedné z „non-market" metod aby se podařilo naznačit kolik by studenti České Zemědělské Univerzity byli schopni zaplatit za zmírnění a adaptaci vůči změně klimatu.

Klíčová slova:

Ekonomická analýza, ekonomické důsledky, změna klimatu, globální oteplování, kontingenční metoda oceňování

1 INTRODUCTION

Climate change has become one of the most discussed issues globally in recent years and it is definitely one of the biggest global threats our world is facing today. The effects are already visible, including melting of ice and glaziers, rising of sea level, increasing precipitation, increasing number of extreme weather events etc. Intensity of changes differs all around the world, but the impacts will affect all of us eventually. There are many different opinions about it, some people even deny that global warming exists. That theory is known as the global warming skepticism. Despite these theories, the majority of scientists and environmentalists believe that global warming is caused mainly by emissions of greenhouse gases, therefore is man-made. Climate change has many impacts, on the national level, but more importantly, on the global level. These impacts are social, environmental and economic, and each person treats them with different importance, awareness and opinion. But since the climate can be recognized as public good, it needs to be treated globally. What should be done to help the climate? It probably cannot be stopped completely, but reduction is definitely possible. But it needs something that has proven to be really difficult many times before – The global cooperation.

2 OBJECTIVES OF THESIS AND METHODOLOGY

2.1 Objectives of Thesis

The main objective of the thesis is to assess the value of global climate using one of the non-market valuation methods.

Other minor objective will be finding out what influences the amount of money people would pay for the climate change mitigation and adaptation process, if it is their socio-economic or the their own importance value and awareness of the climate change.

Objective of the theoretical part is to sum up the basic facts, with the focus on differences between developed and developing countries and the right approach to adaptation and mitigation process.

2.2 Methodology

Non-market method Contingent Valuation Method is used to reach the main objective of the thesis, which is assessing the value of global climate. The method contains the survey, made online through the Google documents and half of the surveys sent online to the students of Czech University of Life Sciences, half of them in person around the campus and various faculties.

The Willingness to Pay method is used asking the students how much would they willing to pay for mitigation and adaptation processes, then the average is computed and multiplied by all the students of the university. The final sum is computed with the consideration of the confidence level.

The minor objective, finding relations between the sum paid and other variables, is reached by using graphs in and both Simple and Multiple regressions, the analysis for relation between dependent and independent variables, in Microsoft Excel. Process of deduction is used when making the assumptions about the questions from survey, based on

the theoretical part, assumptions are eventually confirmed or rejected relating to the survey results.

3 LITERATURE OVERVIEW

3.1 Basic facts about the climate change

Average global temperatures have climbed 0.8 degree Celsius around the world since 1880, much of this in recent decades, according to NASA's Goddard Institute for Space Studies. The rate of warming is increasing. According to a number of climate studies, the 20th century's last two decades were the hottest in 400 years and possibly the warmest in several millennia. And the Intergovernmental Panel on Climate Change (IPCC) reports, that 11 of the past 12 years are among the dozen warmest since 1850. The Arctic is feeling these changes the most.

Average temperatures in Alaska, western Canada, and eastern Russia had risen at twice the global average, according to the multinational Arctic Climate Impact Assessment report compiled between 2000 and 2004. Arctic ice is rapidly disappearing and polar bears and indigenous cultures are already suffering from the ice loss. Sea level has risen much faster over the last century. Glaciers and mountain snow are also rapidly melting. For example, Montana's Glacier National Park now has only 27 glaciers, versus 150 glaciers in 1910. Coral reefs, which are highly sensitive to any changes of water temperature, suffered the worst bleaching (die-off in response to stress) in 1998, with some areas having bleach rates around 70%. Extreme weather events has been recently increasing, such as wildfires, heat waves, strong tropical storms etc. [1]

3.2 Future Scenarios

IPPC report warns that global warming could lead to the large scale water and food shortages and might have catastrophic impacts on wildlife. Sea level could rise between 20 to 60 centimeters by the end of the century, according to the IPPC’s report. Rise just about 10 centimeters could flood many South Seas islands and swamp large parts of Southeast Asia.

About one hundred million people live in the area within one meter of mean sea level. Much of the world’s population also lives at vulnerable big coastal cities like Florida. Glaciers around the world could continue to melt rapidly causing sea level to rise even more. Inevitably, less fresh water will be available.

For example, if the Quelccaya ice cap in Peru continues to melt at its current rate, it will be gone by 2100, leaving thousands of people who rely on it as a source for drinking water without it.

Droughts, strong hurricanes, wildfires, droughts, tsunamis may become much more common in many parts of the world and cause lot of deaths and destruction. More than a million species will face the extinction from changing ecosystems, disappearing habitat and acidifying oceans. On the other hand, some other species like mosquitos could survive in higher magnitudes and spread fatal diseases like malaria. [1]

3.3 The main cause of the climate change

There are many opinions about how climate change is caused. Some people believe that it is just a natural process, looking back to history to periods of ice ages followed by warm periods. Some people also believe that global warming is happening thanks to increasing solar activity. But majority of experts involved believe that recent climate change is mostly caused not only by natural factors, but mostly by the human population, namely by our emissions of greenhouse gases. These gases include Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxide (N2O) and other gases. [2]

Greenhouse gases play important role in the creation of greenhouse effect. When the sun's radiation reaches our atmosphere, some is reflected back to the space and some is absorbed by the Earth. This causes the surface of the Earth to warm up. Heat from the Earth is then radiated upward and absorbed by the greenhouse gases in the atmosphere. This process prevents heat disappearing to the space and helps the Earth to stay warm enough to sustain life. But some human activities cause releasing of additional greenhouse gases to the atmosphere and intensify the warming effect. [3]

Carbon dioxide (CO2), the most prevalent greenhouse gas, is produced primarily by the burning of fossil fuels in cars, power plants and industry. Emissions of CO2 have been increasing rapidly each year. Plants and trees absorb CO2 in process of photosynthesis, so deforestation also affects the amount of CO2 in the atmosphere.

Methane (CH4) is less abundant then C02, but has much stronger greenhouse effect. Methane is emitted by burning of fossil fuels, it also comes from livestock and decomposing waste.

Nitrous oxide (N2O) is primarily emitted by crop fertilization and other agricultural activities. But the most significant gas is still considered to be CO2 which is by many experts highly correlated with the process of global warming. [3]

3.4 Theories

As mentioned already, there are many different opinions about the climate change. The main two are Environmentalism vs. Skepticism [4] each represented by one "role model" whose opinion is usually followed by many people.

3.4.1 Environmentalism

Probably the most popular environmentalist has been the ex-vice president of USA, **Al Gore**. He insists we need to emphasize the need of environment protection and maximum reduction of the greenhouse gases in any case.

According to Al Gore, humans need to change things now to avoid the worst in the future. He sums up his ideas and findings in the book and the movie called "The Inconvenient truth" made in 2006. Movie won the Oscar in 2007 as the best documentary and critics also talked about it like one of the most important documentaries to watch. But the movie has been also criticized for using lot of susceptibilities, such as using a lot of pictures and videos of destroyed nature and desperate animals (animation of polar bear trying to find a piece of glazier he could stay on, when he finally does, the ice breaks in half and leave the bear drowning in the middle of nowhere).Gore has also written a book called Our choice, where he summarizes the impacts again and then every chapter explains how we should use each renewable source to make the maximum effort to reduce emissions.[4]

Lot of people criticize Al Gore saying he doesn't live really environmentally friendly himself, living in a big mansion and using more energy (causing more emission) than an average American citizen. Al Gore received the Nobel prize for peace, which is considered just as controversial by many people.

3.4.2 Skepticism

Completely different attitude, Skepticism, is represented for example by the Czech president **Vaclav Klaus.** He and others believe, that climate change is only a natural process and humans have nothing to do with it. Vaclav Klaus refuses to fight against it because he thinks it is a natural process, without any human influence. Klaus considers environmentalism as a new form of political leftism, trying to gain control over the lives of normal people throughout the environment policies. He says that people should focus on economic improvements, which are possible only by the free market without any environmental restrictions. He thinks that climatologists exaggerate the issue of climate change only to get more money for their activities and he completely ignores the threats climate change causes, even though some of them are already happening. Vaclav Klaus is a very influential person as and a lot of Czech citizens actually seems to agree with him. [5]

3.4.3 Skeptical Environmentalism

The approach represented by Danish "skeptical environmentalist" **Bjorn Lomborg,** agree with parts of both previous theories. As he stated in his book Cool It, he agrees that global warming is man-made and the main cause is the emissions of greenhouse gasses. But he also sees different and global problems such as HIV/AIDS, malaria, lack of clean drinking water etc. According to Lomberg, these problems could be solved much more easily and cheaper than focusing mostly on the climate change. He doesn't agree with Al Gore's catastrophic views and he thinks global warming should be solved more progressively, with smaller investments and in smarter way then starting to reduce emissions rapidly which would be very expansive. [5]

3.4.4 Summary

These opinions divide people into different groups. Some people don't believe in global warming at all and ignore all the alarming information, some people think it's a natural thing and we can do nothing about it, some people have been trying to combat it already, but they are discouraged by others who don't care at all. There is not one only opinion about the issue which makes everything much more difficult. But the obvious fact, even though some people ignore it as mentioned before, is that climate change (global warming) exists. We can discuss what portion of it is man-made, what portion is natural

process, but it doesn't change the fact that global temperatures globally are rising which will have some impact on the world. [1]

3.5 Economic impacts

Let's summarize the economic impacts of the climate change. We can divide countries into two groups – developing and developed countries. Developing countries are mostly dependent on agriculture, which usually represents their main economic activity. It employs the prevailing share of economically active population and it forms the main source of export. [6]

3.5.1 Agriculture

Agriculture itself is and will be one of the most sensitive sectors to global warming. Even though many crops show positive responses to elevated carbon dioxide and low levels of warming, higher levels of warming often negatively affect growth and yields. Extreme events like heavy rains and droughts are likely to reduce crop yields because surpluses or deficits of water have negative impacts on plants. Weeds, diseases, and insect pests benefit from warming, and weeds also benefit from a higher carbon dioxide concentration, increasing stress on crop plants and requiring more attention to pest and weed control. Increased heat, disease, and weather extremes are likely to reduce livestock productivity.

There are just a few of the most important impacts that climate change has on agriculture. And because it is a main part of economy in developing countries, it makes them much more vulnerable. [6]

3.5.2 Developing vs. Developed countries

For example Guinea Bissau, one of the poorest countries in the world has economy depending mainly on farming and fishing. To be more specific, agriculture forms 55% of country's GDP and employs 82% of the economically active population. Only 18% of people are employed in industry and services. Agriculture in other developing countries usually holds between 20-40% of GDP, but still employs the majority of population. [7]

On the other hand, in developed countries, where the main part of GDP is a combination of industry and services, agriculture is usually just few percent of the total of GDP. It also employs still decreasing share of economically active population and represents decreasing share in the total export. [6]

Developing countries are also usually disadvantaged by their geographical position. There is warmer average climate already and there is also big precipitation variability, which means that even warmer climate will cause lot of troubles which they don't have enough money to adapt to. Many countries already struggle with the climate they have right now, so even a minor warming will mean lots of complications for them. Thanks to their vulnerability, it is probable that climate change will decrease the already low incomes in developing countries and increase the illness and death rate there. Decreasing incomes from agriculture, where most of the people work, will lead to more poverty which some countries already fight with. It will deepen the differences between developed and developing countries a lot.

Especially if the warming is not that significant, in case of warming around 2 or 3 °C, developed countries with higher latitude might even benefit from the warming. Countries like Canada, Russia, and Scandinavian countries could benefit overall thanks to higher agricultural yields, smaller death rate in winter, cheaper heating and possibly more tourism in that area.

Developed countries with lower latitude will be more vulnerable, though. If the global temperature rises 2°C, the availability of water and yields from agriculture crops in south part of Europe are expected to decrease by 20%. Areas with the lack of water already will get into serious complications. There will also be higher costs associated with the extreme weather (storms, hurricanes, typhoons, floods, draughts and heat waves) that will be more likely to happen with the warming. Number of hurricanes is associated with the increasing temperature of sea. When sun hits the ice, the most of it is radiated back to the atmosphere. But when the ice and glaciers melt there is nothing to radiate the sun back to, and sea absorbs the most of it and gets warmer. The warmer see get, the better conditions for the forming of new hurricane. Especially situation in US could be critical, since the increase of hurricanes between 5 to 10% would double the costs associated with the damage. [8]

3.6 Possible solutions

3.6.1 Introduction to the solution

Climate change probably cannot be stopped, but it can definitely be reduced. But it is going to be very difficult task, because there are many different opinions. Most of the experts believe that human activity has a big impact on our climate and that greenhouse emissions are the main reason causing the global warming. [2] Even if they are not, it is the only thing we can change, because other reasons would be clearly natural.

3.6.2 Emission levels

The mitigation of climate change, which basically means reducing the emission levels, has been the main focus in recent years. Current concentration of CO2 is around 390 parts per million (ppm) compared to only 280 ppm in times before the industrial revolution. [9]

Growth of this number goes hand in hand with investing the money to the high carbon infrastructure of growing economies and with the global increasing demand for energy and transport. This actually means that the more industrialized the country is, the more emissions it is emitting.

Therefore, China gets the first place, with emitting 7711 million tones CO2 in 2009. Only 3 years before that, in 2006, China was in second place behind United States. But during years 2008-2009, rapid growth has matched the country's 9-10 growth in GDP. China's emissions increased enormously, over 170% since year 2000.

The second place is taken by United States, with 5425 million tones CO2. US emissions went down for the second time in a row after almost uninterrupted year on year grow since 1980. The decline is linked with the country's economic woes after recession, but also with the new policies and increasing adaptation to renewable resources.

After China and the USA, there is a big gap with India taking the 3rd place with 1602 million tones, followed by Russia with 1572 million tones. This shows that emissions really differ among countries. [10]

So it doesn't really matter globally if one country reduces emissions, because other countries may not and it will not make any difference. There need to be some international

policies making sure all countries are trying to do something and there is no free riders only benefiting from the others efforts.

3.6.3 Kyoto protocol

The major international agreement dealing with emissions of greenhouse gasses is the Kyoto Protocol, an international agreement linked to the United Nations Framework Convention on Climate Change.The Kyoto protocol was adopted in Kyoto, Japan, on 11th December 1997 and it entered into force on 16th February 2005. The major feature of the Kyoto protocol is that it sets targets for 37 industrialized countries for reducing greenhouse gasses (GHG) emissions. The target has been to reduce the emissions of GHG by 5.2% on average during the 2008-2012 five year period. As mentioned already, the protocol came into force 7 years after it was adopted. This was caused by two conditions that had to be fulfilled before protocol could have become valid.

1) Ratification by 55 countries at least.
2) Annex 1(developed countries) ratifying countries had to represent at least 55 percent of the world's total carbon dioxide emissions for 1990

The first condition was met on 23rd May 2002, when Iceland became the 55th country to ratify the Kyoto protocol.

Meeting of the second condition was much more difficult. Especially when the United States, making about 36% of emission from all the Anex 1 countries, refused to signed. The ratification's success depended on Russia, which eventually ratified the protocol at the end of year 2004 and made it possible to come to force. [11]

Countries must meet their targets primarily through national measures. However, the Kyoto Protocol offers them an additional three flexible market-based mechanisms.

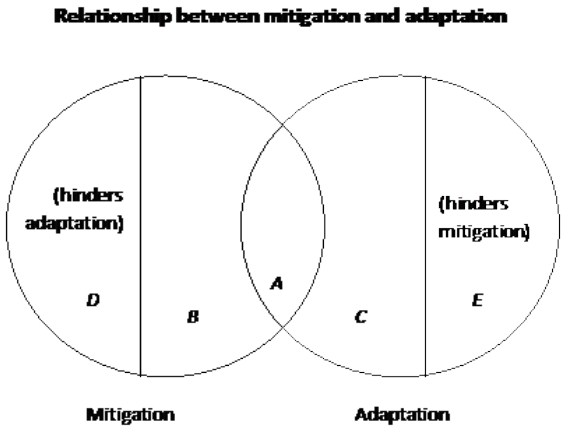
1) Emission trading – known as "the carbon market"
2) Clean development mechanism
3) Joint implementation

These mechanisms help to improve the green investment and help countries meet their emission targets in a cost-effective way. The protocol is generally seen as an important first step towards global emissions reduction regime that will decrease the emissions of GHG and it is a good example for other international agreements that are needed to be made in the future. [12]

3.6.4 Mitigation and adaptation processes

The whole mitigation process needs to go hand in hand with the process of adaptation. People's failure to prevent excessive GHG emissions in the 20th century has led to today's need to prepare for the climate change. Every year that humans continue extensive reliance on fossil fuels means that adaptation will be more and more difficult, expensive and ultimately less effective. Mitigation and adaptation are more connected than

Picture 1: Mitigation and Adaptation



Source : http://climatechangeecon.net/in 1

it might seem. Some processes to mitigate even hinders the adaptation, the same way some processes to adapt hinders mitigation. The picture explains the situation.

In section A, the activities serve both mitigation and adaptation purposes. It can be for example urban tree planting, which captures carbon from the atmosphere and also cools down nearby dwellings during heat waves.

In section B, mitigation tactic such as reducing miles driving in a vehicle helps mitigation but doesn't hurt or help adaptation.

In section C, adaptation tactic such as improved storm warning doesn't help or hurt mitigation.

In section D, mitigation tactic undermine adaptation efforts, for example using of biodiesel to reduce the use of fossil fuels results in poorer air quality that might have existed.

In section E, adaptation negatively affects mitigation, for example with installing new air conditioning systems to combat heat waves which increases electricity use and thus raises GHG emissions at a power plant burning coal and natural gas.

The focus should be made mostly on the A section, which means doing both processes simultaneously. On the other hand, too many of D and E cases should be tried to avoid. Adaptation processes undertaken these days should be designed to avoid compromising mitigation whenever possible. If not, it could ironically lead to more difficult long-term adaptation process. [13]

4 ASSESING THE VALUE OF THE CLIMATE CHANGE USING THE CONTINGENT VALUATION METHOD

4.1 Introduction

First goal of this part is collecting general public's opinion about the climate change itself, with purpose of making few conclusions which will confirm or reject assumptions mentioned in the theoretical part. The main part is focused on mitigation and adaptation in Czech Republic and asking students of Czech University of Life Sciences using Contingent Valuation Method, which is the most suitable of non-market methods for analyzing this issue.

4.2 Obtaining general knowledge about the climate change

First of all there is a simple questionnaire to get some opinions from general public about the climate change. The questionnaire was made on the internet through the Google documents and spread through the internet as well. It contained following questions (See Supplements).

The questionnaire is in form of multiple choices, with only one possibility to answer. In total, 50 people were asked to answer.

4.2.1 Assumptions

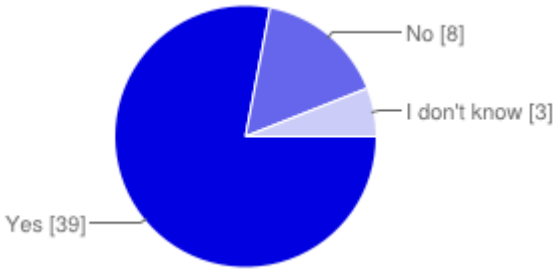
Assumptions are that most people would be aware of the climate change issue, since it has been one of the recent most discussed topics and most of the respondents could think it exists. The answers relating to the cause of the climate change might be on the even level, it depends on the area where people are from.

The main opinion in Czech Republic could be Vaclav Klaus's opinion of a natural process, since he is the Czech president and therefore very influential person

. The same could apply to United States and Al Gore, whose documentary "The Inconvenient truth" has been very popular source of information in the United States.

1st Question – 39 people (78%) thinks that said that global warming exists, 8 people (16%) said that it doesn't and the rest, 3 people (6%) didn't know.

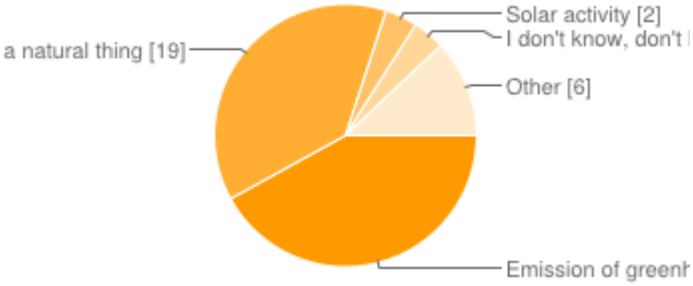
Chart 1: Global warming opinion



Source: Own processing

2nd Question – 21 people (42%) think the main cause is emissions of greenhouse gases, 19 people (38%) thinks it is a natural thing, 2 people (4%) think it is caused by solar activity

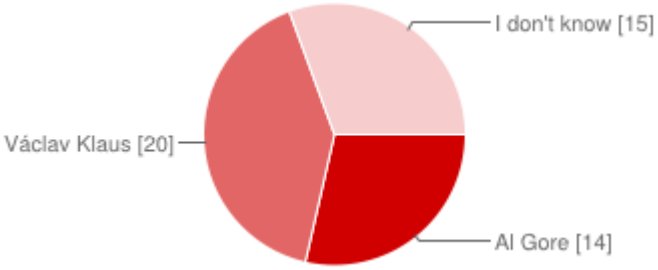
Chart 2: Global warming main cause



Source: Own processing

3rd Question – 14 people (28%) agrees more with Al Gore, 20 people (40%) agrees more with Czech president Vaclav Klaus, 15 people (30%) don't know, 1 person obviously didn't answer.

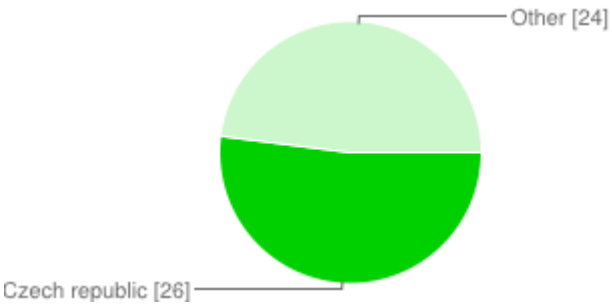
Chart 3: Favorite famous opinion



Source: Own processing

4th Question – 26 people asked were from Czech Republic, 24 people were from other countries (Slovakia, United States, Canada, Bermuda

Chart 4: Nationality



Source: Own processing

4.2.2 Assumptions confirmation or rejection

Majority of people believe global warming is happening, which is a good sign of awareness. The 8 people who didn't think so are all Czech citizens who relate to Vaclav Klaus's opinion that global warming doesn't really exists and it is a natural thing to happen.

Is global warming caused mostly by emissions or is it a natural thing?

The answers ended up almost even as predicted, which confirms the assumption as well. But it is not as dependent on the location as it was assumed to be. 60% of Americans answered the main cause as the emissions of greenhouse gases and agreed with Al gore, while 14 out of 26 Czech people (53,8%) agreed with Vaclav Klaus. This also leads to one of the most surprising fact of the responses.

Four Czech People (16,6% of the Czech people asked) thinks that emissions are the main cause of global warming, but still say that they agree with Vaclav Klaus more. Vice versa, one American who said it is a natural thing says he agrees more with Al Gore more.

They are probably either not really aware of what the politician's opinions are, don't really know them, or just agree with someone of the same nationality because they heard they are related to the problem and know them as powerful people representing their

country. Especially here in the Czech Republic, the problem of climate change is not really an issue popular to discuss, and if we are supposed to do something about it people should be made more aware.

4.3 Climate change from economical point of view

Climate itself can be described as a global public good. It is non-rival (one's consumption doesn't reduce the amount available for others) and non-excludable (it is impossible to prevent anyone from consuming the good).

It is shared across the boarders, across generations and by all population. When a global public good is threatened, it affects everyone and takes everyone working together to solve the problem. Climate, like most of the other public goods, is not, and could never be exchanged at the markets. [14]

Non market goods cannot be bought or sold directly. Their economic value – how much would people be willing to pay for them – is not given in market prices. The only option to assign the monetary value to non-market goods are non-market valuation methods.

4.4 Contingent valuation method

This leads to the main part of this paper. Contingent Valuation Method (CVM) will be applied to count willingness to pay for the climate change mitigation and adaptation in the Czech Republic. CVM is used in estimating economic values for eco-system and environmental services. It can be used to estimate both use and non-use values, and it is the most widely used method for estimating non-use values. CVM is probably the most controversial non-market method. It is referred to as a "stated preference" method and uses hypothetical situations. The fact it asks people what they would do is the source of its greatest strengths and weaknesses at the same time. [15]

4.4.1 Structure of the survey

In this paper, CVM will be applied on one particular group of people, namely students of the Czech University of Life Sciences in Prague – since they are regarded as young people, the future generation, who should have better general knowledge about the climate change issue then the sample from general public. The university even contains faculty of

environment and the agricultural subjects are still taught quite a lot at this university throughout all the courses.

As mentioned in the practical part, the agriculture is the sector most vulnerable to the climate change, [6] so students from this university should have better knowledge about the issue. Therefore, it won't express the opinions of general public, but people who will be asked will be able to answer the questions that random sample of individuals may not be able to. If survey was made asking general public, it would definitely give different results and it would be more similar to the first general questionnaire where some really strange answers occurred. (People who were sure to agree with Vaclav Klaus on the climate change issue, but said that global warming is caused by emissions of GHG and that we should do something about it).

The following survey will not be that general and most of the people are proven to know they are aware of the climate change issue, because of the university they study. Students will be asked following questions.

The Questions relate not only to the climate change problem, but also ask respondents for their socioeconomic variables, like gender, age and income. It is important to know this to see how it relates to the climate change questions.

4.4.2 Assumptions

The first questions asking the cause of the climate change is probably going to have most of respondents sharing 3 middle answers, combination of natural processes and human activities, or primary and secondary cause. It would be surprising to hear many people saying only human activities or natural processes, maybe in case of people following the Czech president.

Second question is asking about the income of the climate change at the national level in the present. Assumption is that people in Czech Republic will find the impacts on the national level less important than the global impacts. The reason for this assumption is that Czech Republic is not considered as developing country, the agriculture only makes about 2-3 % of GPD, and also lies in a good location, in the middle of Europe. Minor warming would not threaten Czech Republic a lot, so impacts are not that important nowadays as much as they are globally. If the survey was made in some developing country, the impact would be more important there than on the global level. But that is not the case of Czech Republic.

The third question about the future situation at the national level will most probably increase the level of because climate change is getting more and more significant last decades and this trend is likely to continue, especially because emissions reduced nowadays would only help the climate in around 50 years from now.

The fourth question is about the importance of incomes at the global level in the future. As mentioned before, the importance is assumed to be much more significant than on the national level.

Question number 5 deals with the global situation in 25 years from now, the same thing applies as on the national level, importance is likely to be much higher.

Following question asking about the income is one of the few socioeconomic variables. The main purpose of it is not to find out how many crowns students earn, but to see how it is related to their willingness to Pay (WTP) for mitigation and adaptation. The regression functions will be made to see how it relates.

The question number 7 asks if students would consider paying any monthly fee. Assumption is that students who consider climate change impact importance as high will be more likely to pay. Also the income will most likely play an important role.

Following question asks people who answered they would they pay monthly how much would they pay. It will depend on their income and the importance chosen. Higher the income and chosen importance, higher the fee they would be willing to pay monthly.

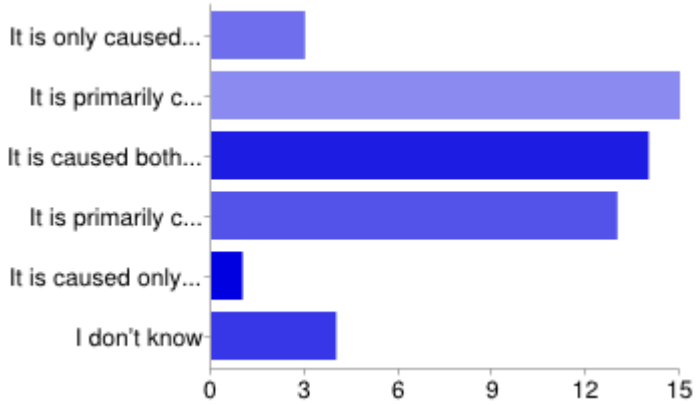
In case people chose not to pay, the question n.9 asks them why they didn't. Lower the income, higher the probability of the answer they cannot afford it. Many people will definitely say it is an international issue and it should be treated globally, as the importance of the global impacts is expected to be much higher than on the national level. Some people will also definitely say that the state should pay for this and most people who think that climate change is the natural process at first will probably disagree with paying in general.

Last two questions are socioeconomic variables to see if age or gender has anything to do with other answers. The only assumptions could be that older people have more years of education and might have higher incomes, therefore might be willing to pay more. Gender probably will not have any significant influence. Answers, which are anonymous, were following

4.4.3 Results , assumptions confirmation or rejection

1st question – 3 people (6%) said that climate change is caused only by natural processes, 15 people (30%) said that it is primarily by natural processes, secondarily by human activities, 14 people (28%) said it is by both equally, 13 people (26%) said it is primarily caused by human activities and secondarily by natural processes, 1 person (2%) said that it is caused only by human activities and 4 people (8%) don't know.

Chart 5: Climate change cause

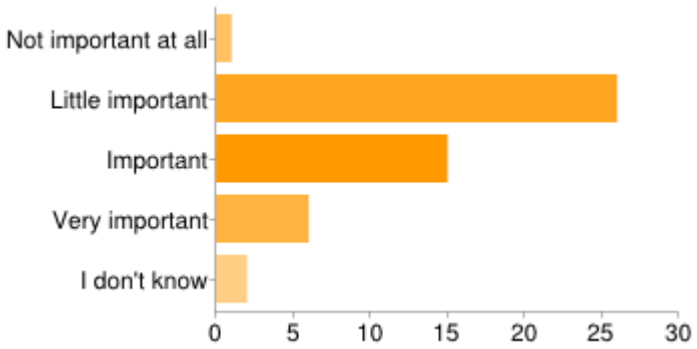


Source: Own processing

Assumption related to the first question was that most people would think climate change is combination of both natural processes and human activities. This assumption was confirmed after the results, when only 4 people (8%) think it is either only natural processes or human activities and 4 (8%) people don't know. The rest 42 students (84%) consider global warming as the combination of both, with varying primary and secondarily cause.

2nd question – 1 person (2%) said that impacts of climate change at the national level in present are not important at all, 26 people (52%) said impacts are little important, 15 people (30%) said that impacts are important, 6 people (12%) said that impacts are very important and 2 people (4%) don't know.

Chart 7: Impacts - National level, Present



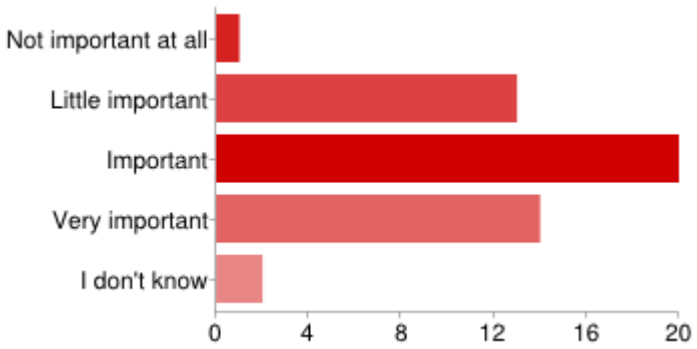
Source: Own processing

Assumption about this question was that most people would think that impacts in Czech Republic are not very important nowadays. This assumption was confirmed, with majority of 26 people thinking that impacts are little important. 15 people consider impacts already important and 6 people thought that impacts are already very important. Each option have number assigned according to its importance (0- Not important at all, 1 – Little important, 2– Important, 3 – Very important). Calculating average importance value will find out how much does the importance change through all 4 questions and will help to confirm if the assumptions were right. Opinion "I don't know" will not be used for this calculation.

Using this method, average importance value is 1.54 relating to the impact on the national level in present. That means students consider it somewhere between little important and important, little bit closer to the important. But the results still confirms that situation in Czech Republic is not as bad as it would be in many other countries, especially developing ones and the ones on the sea-side.

3rd question – 1 person (2%) said that impacts of climate change at the national level in the future will not be important at all, 13 people (26%) said that impacts will be little important, 20 people (40%) think that impacts will be important, 14 people (28%) think that impacts will be very important and 2 people (4%) don't know.

Chart 8: Impacts - National level, Future

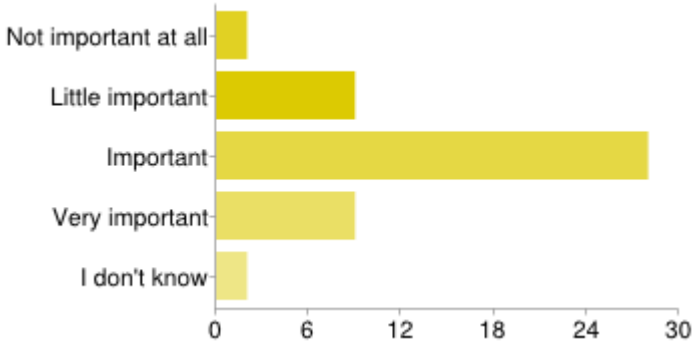


Source: Own processing

Compared to the question about the present, the answer little important is decreased by 26%, while the answer important increased by 10% and the answer very important increased by 16%. The average importance value computed for this question is 1.97, which is higher than 1.54 relating to the question about the present, therefore assumption that people will consider impacts more important in the future is confirmed.

4th question – 2 people (4%) said that impacts of climate change at the global level are not important at all in present, 9 people (18%) said that impacts are little important, 28 people (56%) said that impacts are important, 9 people said (18%) that impacts are very important and 2 people (4%) don't know.

Chart 9: Impacts - Global level, Present



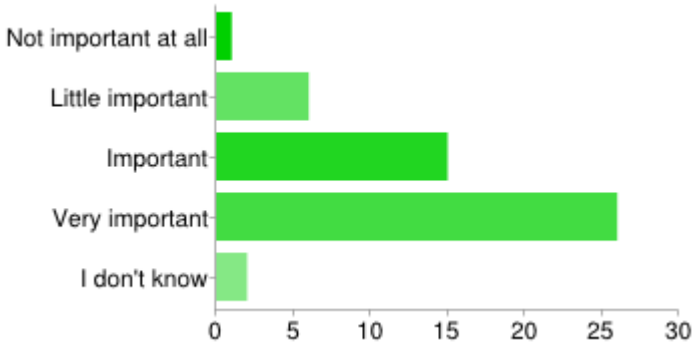
Source: Own processing

Compared to the national level in present, option little important decreased by 34%, while the option important increased by 26% and the option very important increased by 6%. The importance value calculated for this question is 1.91, which is higher than 1.54 relating to

the first question, therefore assumption that Czech students consider global impacts more important than global ones is right.

5th question – 1 person (2%) thinks that impacts of climate change at the global level will not be important at all in the future, 6 people (12%) think impacts will be little important, 15 people (30%) think impacts will be important, 26 people (52%) think that impacts will be very important in the future and 2 people (4%) don't know.

Chart 10: Impacts - Global level, Future

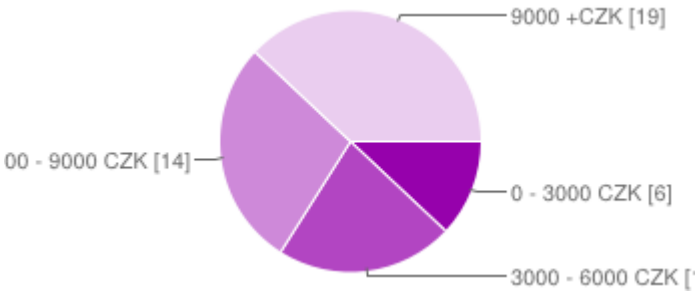


Source: Own processing

Compared to the global level nowadays, option little important decreased by 6%, same as the option important which decreased by 26%. But the answer very important increased by 34%. The average importance value for this question was calculated 2.33, which is higher than 1.91, therefore confirms the assumption that even on the global level, people consider impacts of the climate change more important in the future.

6th question – 6 students (12%) have monthly average income between 0 to 3000 CZK, 11 students (22%) have income between 3000 to 6000 CZK, 14 students (28%) have income between 6000 to 9000 CZK and 19 students (38%) have income higher than 9000 CZK.

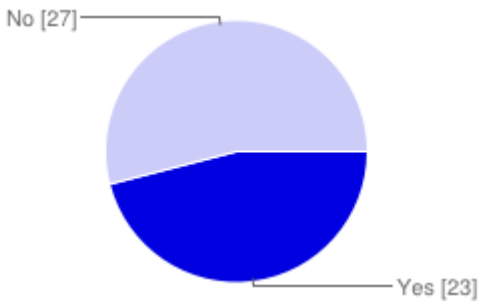
Chart 11: Income



Source: Own processing

7th question – 23 people (46%) would consider to pay any national monthly fee for the mitigation and adaptation process of climate change, 27 people (54%) would not.

Chart 12: Willingness To Pay



Source: Own processing

This answer shows that 46% of people would pay a national monthly fee. The assumption was that the number of people willing to pay will be related to their income and their subjective importance of the climate change impacts. Data were copied to the Microsoft excel and the simple regression was used. WTP options YES or NO were put in as numerical values 1(yes) and 0 (no). The same applied to the income (1 = 0-3000CZK, 2 = 3000-6000CZK, 3 = 6000 – 9000 CZK, 4 = 9000+ CZK). Willingness to pay is dependent variable, income is independent (explanatory).

Assumption was that higher the number of income, more likely the option 1 would be. The simple regression analysis will be used, because it is the method which is best for analyzing one dependent and independent variables. The coefficient of regression was only 0.06 which could mean that willingness to pay changes slightly (6%) when the income grows. But the p-value of the regression is also an important factor. It is the probability that

the independent variable is really significant. Closer the p-value is to zero, higher the probability that it is significant. P-value of 0,05 means 95% probability, p-value of 0,001 means 99.9% probability etc. In this case the p-value reached 0.37% which means it is only 63% probability of income being really significant

Another think that was assumed to influence the WTP was the level of importance. For this case, the average importance value was computed for each student who answered. This value related to questions about importance of impacts at the national level (present, future) and the global level (present, future). So if someone answers with importance levels 2, 3, 3, 4, his average importance value would be 3. The simple regression was done again with WTP as dependent variable and average importance value of each student as independent one. The coefficient is 0,23 which shows more significant relation. The p-value also proves it, because it is 0,01 this time which means there is 99% chance that the variable is really significant. Two graphs below show the relation of student's income and importance value to the decision whether they pay or not.

Chart 13: Relation between WTP and Income

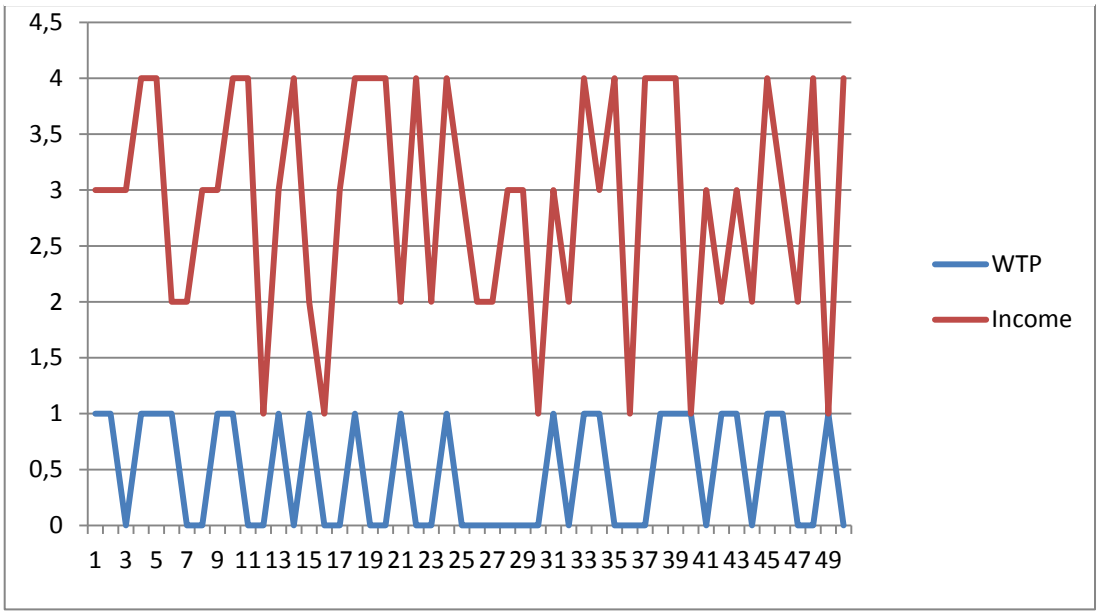
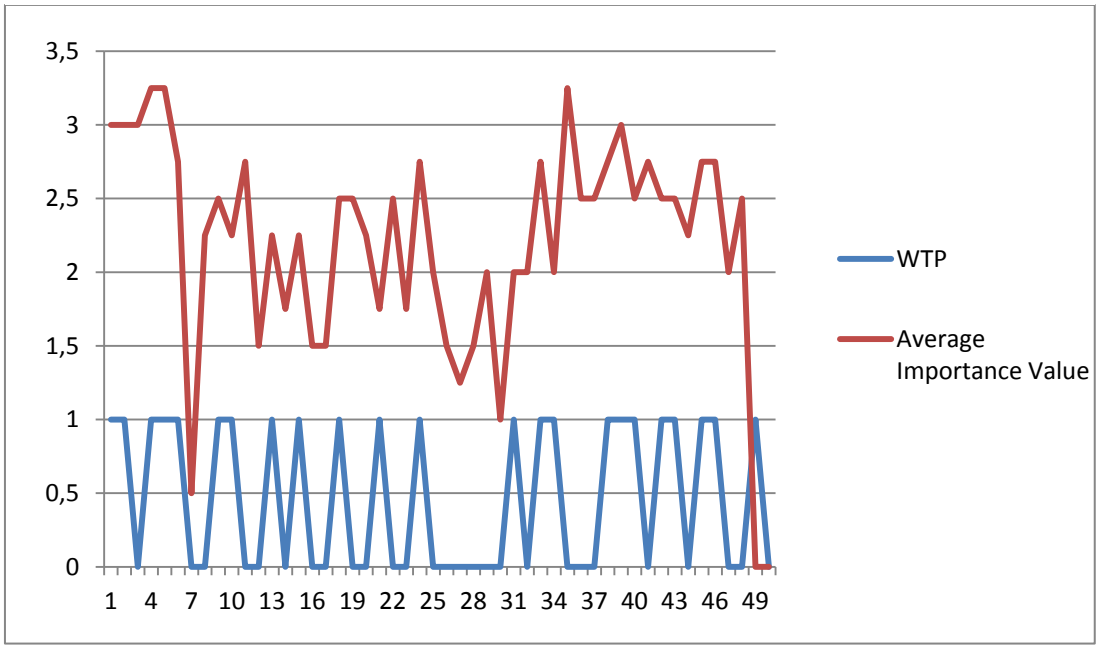


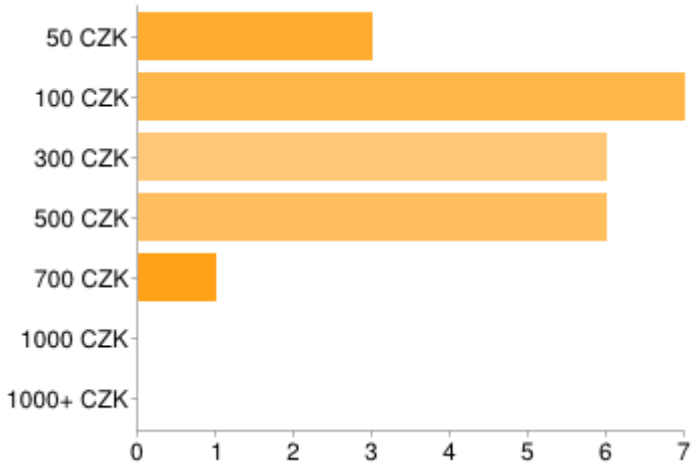
Chart 14: Own processing

Chart 15:relation between WTP and average importance value



Source: Own processing

8th question – Out of 23 people who would consider paying a monthly fee, 3 of them would pay 50 CZK a month, 7 of them would pay 100 CZK, 6 of them would pay 300 CZK, 6 of them would pay 500 CZK and one person would pay 700 CZK



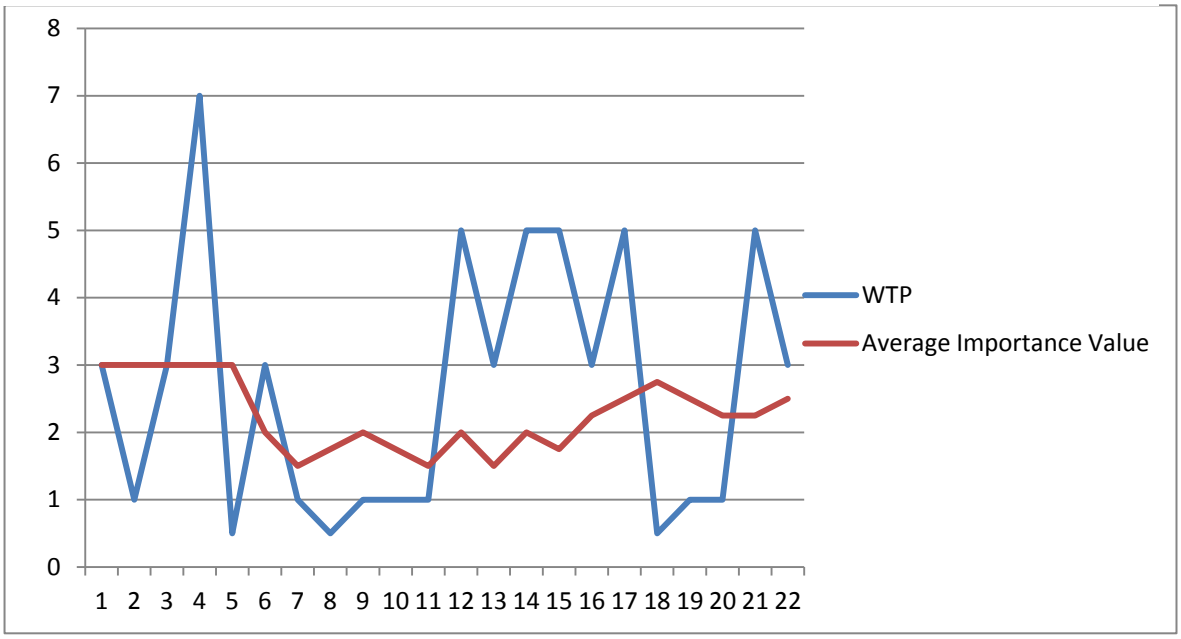
Assumptions were that the amount of money paid by each individual could relate to his importance and income. With each paying individual's average importance value and the money paid put into regression analysis, we get the coefficient number - 0.30, which could mean that with the growing importance value the sum of money paid actually decrease. But the p-value of 0.64 % meaning only about 36% of probability means it is really insignificant.

Even using the correlation function that is used for getting relations between two random variables, therefore there might be many more random relations because of the lack of dependence, only computed number – 0,9, which means these two values are not really related at all, there is even little negative relation as the regression function indicated .

This rejects the assumption that that with higher importance value, the sum students are willing to pay grows.

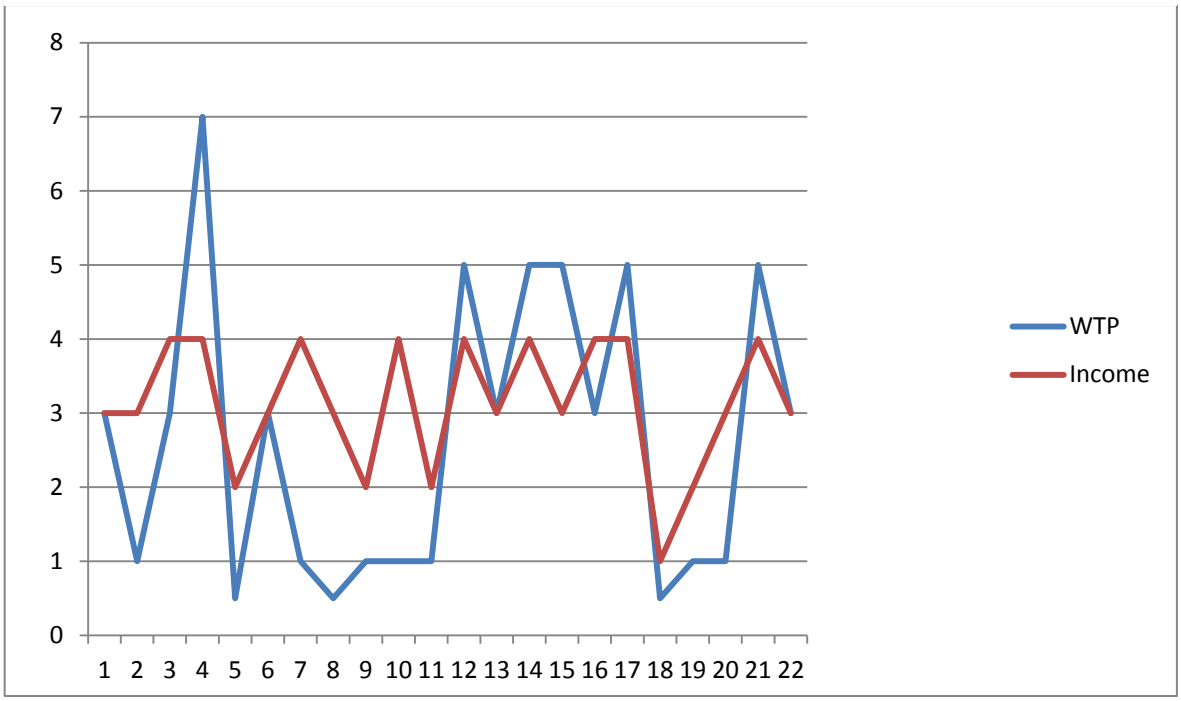
In case of income, the coefficient of regression is 84.70, which means that WTP is highly dependent on the income. The p-value of this variable is 0,05 which means there is 95% probability that influence of this value is really significant. This makes the income most important variable influencing people who pay the fee on how much they actually pay. Two graphs on the next page are showing the relations. To help putting these numbers to the graph and showing relation, the money paid by each student were divided by hundred.

Chart 17: Relation between average importance value and money paid for WTP



Source: own processing

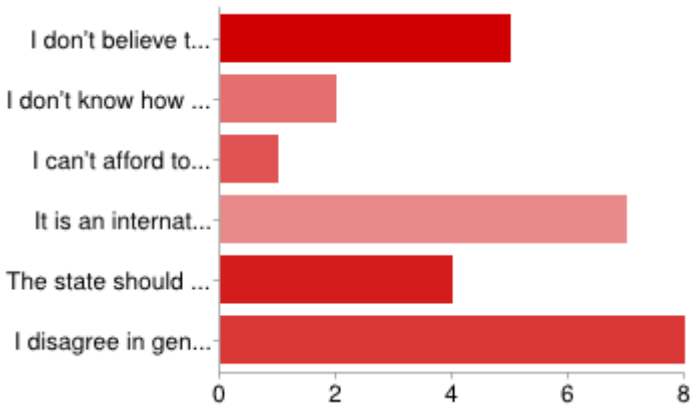
Chart 16: Relation between income and money paid for WTP



Source: own processing

9th question – out of 27 people who would not consider paying any monthly fee, 5 people don't believe the approach, 2 people don't know how much they would pay, 1 person couldn't afford to pay, 7 people think that climate change is an international issue and should be treated globally, 4 people think that state should pay for it and 8 people disagree in general and are not willing to pay.

Chart 18: Reason for not paying a monthly fee



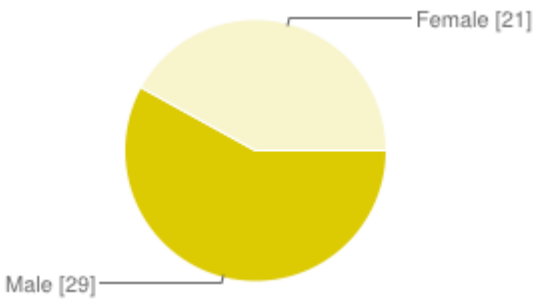
Source: own processing

Disagreeing in general and not willing to pay for various reasons is the most popular option chosen by 8 people, followed by 7 people saying it is an international issue and should be treated globally. This relates to lower importance level of impacts on the national level compared to the global level. It also confirms that climate change issue is public good and should be treated mostly by international agreements. 5 people don't believe that paying monthly fee is the best approach for mitigation and adaptation process.

4 people think it is not their responsibility and the state should pay for it. Only one person could not afford to pay.

10th question – Out of 50 people asked, 29 were males (58%) and 21 females (42%)

Chart 19:Gender



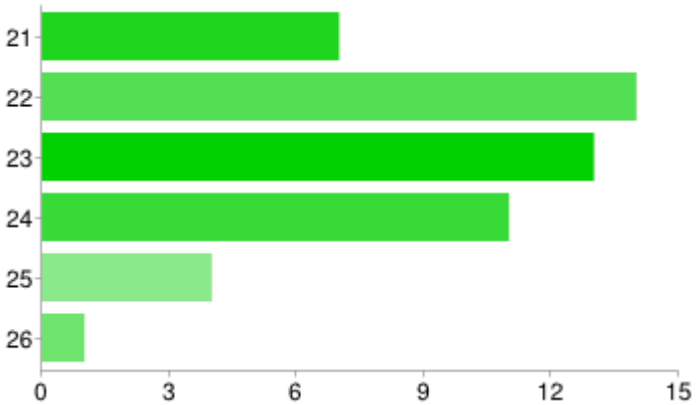
Source: Own processing 1

Does the gender have any influence on the willingness to pay? Putting the gender and the willingness to pay into the regression analysis surprisingly gave the highest coefficient number of all, 116. 33.

It means when Gender value increase by 1 (the genders are represented by values 0(women) and 1(men)) the willingness to pay is likely to rise by 116% percent. The p-value is 0.03, so there is about 97% probability that results are significant.

11th question – out of 50 people asked, 7 people are 21 years old, 14 people are 22 years old, 13 people are 23 years old, 11 people are 24 years old, 4 people are 25 years old and one person is 26 years old

Chart 20: Age



Source: Own processing

Assumption relating to age was that higher the age, the higher might be the income and the willingness to pay. Starting with the income and age, the coefficient of regression is of the income and age is 0.26, with the p-value 0.02. The coefficient value is positive that means higher income with growing age. But only by 26% which is not that much significant.

Applying the same to the age and willingness to pay, the regression gives the coefficient of 78.18 with the p-value of 0,0001 which means 99.99% of probability that variable is significant. This basically means that with every one year older, the willingness to pay is expected to rise by 78%. Older the participant, the higher amount and the more likely he is to pay the monthly fee. Therefore, age and gender seems to be the most significant variables WTP is dependent on. This finding will be confirmed or rejected by doing the multiple regression analysis, examining all the independent variables at the same time. Simple regression was done according to every assumption to confirm or reject it.

4.5 Multiple regression

Putting all data together and using the multiple regression will compare the independent variables and it will it will confirm which one of them really has the biggest impact on willingness to pay.

4.5.1 The method

Willingness to pay will be dependent variable and income, age, gender and average importance value will be independent. This time, it will be total willingness to pay, not only sums of money within the people who decided to pay.

In regression with multiple independent variables, the coefficient shows how much the dependent variable is expected to increase when that independent variable increases by one, **holding all the other independent variables constant**. The regression analysis gave following output.

Picture 2: Multiple regression function

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,5588
R Square	0,312258
Adjusted R Square	0,249736
Standard Error	166,3549
Observations	49

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	552855,9	138214	4,994369	0,002086
Residual	44	1217654	27673,96		
Total	48	1770510			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	-1471,21	449,5273	-3,2728	0,002077	-2377,18	-565,252	-2377,18	-565,252
3	7,226189	27,52639	0,262519	0,794147	-48,2496	62,70199	-48,2496	62,70199
23	63,90819	20,80237	3,072159	0,003639	21,98377	105,8326	21,98377	105,8326
1	65,61802	51,80277	1,266689	0,211931	-38,7836	170,0196	-38,7836	170,0196
3	34,05157	37,63383	0,904813	0,370492	-41,7944	109,8976	-41,7944	109,8976

Source: own processing

4.5.2 Results

The multiple regression function more or less confirms the previous simple regressions made for assumptions. The highest coefficient 65.61 belongs to the 3rd independent variable, the gender, but the p-value is quite high, meaning "only" 79% probability. The most significant variable remains the age with coefficient 63.90 and p-value of 0.003 which means 99.97% of probability that variable is significant. Other two variables are almost un-related at all according to the analysis. The Income is the worst, having coefficient of 7.22 and the p-value 0.79 which means only 21% probability.

It is quite surprising finding that socio-economic variables have the biggest influence on student's willingness to pay. The next chapter will tell more about the WTP itself.

4.6 Willingness to pay

The most important parts of the questionnaire are question n.7 and question n.8. These two questions are about willingness to pay for the climate change mitigation and

adaptation, other questions were just made to see what is students opinion about the issue, what are their socio-economic variables, and to see how it is related to the WTP.

Economically, willingness to pay is the largest sum of money that individual is agreeable to pay for good or service or to avoid something undesirable. On the other hand,

Willingness to accept (WTA) is the minimum compensation that individual is willing to accept in exchange for giving up some good or service, or the minimum sum that he is willing to give up a prospective gain. In this case, WTP was chosen for the problem, because it better fits the issue of mitigation and adaptation process.

As mentioned before, 50 students of Czech University of Life Sciences were asked. 23 of them would pay, which is 46% of the students asked. The total sum they would pay is 6350 CZK. The answers differed a lot within the options.

The maximum sum that would be paid was 700 CZK, the minimum was 50 CZK. On average, students would pay 276 CZK a month, which makes it 3312 CZK a year per student.

Only 50 out of 22000 students of Czech University of Life Sciences were asked though. For getting the possible results of all the university students, the confidence interval needs to be calculated. Confidence interval is the plus minus percentage figure where person can be "sure" that if the whole number of people (all the students) answered the survey the results would be same within percentage plus minus the range of the confidence interval. In case of this issue and the university students, 46% out of 50 people are willing to pay a monthly fee. Confidence interval for 22000 students is 14. That means when asking 22000 people, it would be 95% sure that percentage of (32% - 60%) would be willing to pay. [16]

If assuming results would be more or less similar if all the students were asked, it is possible to get a total WTP for all students of the university. 46% out of 22000 is 10120 students, multiplied by the average sum paid, which is 276, equals 2 793 120 CZK paid by all the students together monthly.

5 CONCLUSION

The main objective of the thesis was to assess the value of global climate using one of the non-market valuation methods. This objective was reached using the Contingent Valuation Method – making a questionnaire and asking 50 students of Czech University of Life Sciences various questions about the climate change. The main two question for reaching the objective were about Willingness To Pay (WTP). 23 out of 50 students (46%) said they would have paid a monthly fee for the mitigation and adaptation process. The total sum was 6350 CZK, on average 276 CZK paid by each student every month. When level of confidence was taken into consideration and the method was applied to the whole number of 22000 students at the university, the result ended up that students would pay 2 793 120 CZK every month.

These are the result considering only the Czech University of the Live Sciences. If the sample of general public was taken, the sum would have most definitely been lower. The same would probably apply to most of other universities.

There is also some controversy about the CVM method in general. Everything is only hypothetical, which is CVM's main weakness and strength at the same time. The strength because it can easily asses the value to the non-market values using these hypothetical situation. But the weakness because nobody knows if the results would be the same if the situation actually happened. Therefore, results cannot be taken too seriously, it is not confirmed calculation and people would most likely act differently in a real life. But it is a good way of preparing on what we could expect.

The minor objective was also examining relations that independent variable have with the willingness to pay. In this case, the independent variables were the socio-economic values, such as age, income and gender. One more variable was made from the questionnaire, each student's average importance level, made by averaging each student's answer on 4 questions about the importance of the climate change (national and global level, present and future). The objective was reached by the regression analysis using Microsoft Excel. It showed really surprising fact, that it's not the importance and income that are significant, but most significant are actually age and gender. To be clear, when

deciding how much to pay when people already had decided to pay, the income was a relevant factor. But it was not when all the variables were checked through the multiple regression function. The older the person is, the more likely he is going to pay and men are willing to pay more than women. Out of 6350 CZK, 5100 would be paid by man. It might be partly because men usually have little higher wages, but it is really significant difference. Another option could possibly be men care more about the climate change. When thinking about popular people it is mostly men who are related to this issue, the same with most of the studies that are mostly made by men economists and environmentalists.

The last minor objective was looking for the right approach to mitigation and adaptation processes, which are more connected than it might seem. Some processes to mitigate even hinders the adaptation, the same way some processes to adapt hinders mitigation. For example with installing new air conditioning systems to combat heat waves which increases electricity use and thus raises GHG emissions at a power plant burning coal and natural gas. The solutions should be helping both mitigation and adaptation, like urban tree planting, which captures carbon from the atmosphere and also cools down nearby dwellings during heat waves. This might be one of the keys how to successfully combat the climate change.

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