KAUNAS UNIVERSITY OF TECHNOLOGY

SCHOOL OF ECONOMICS AND BUSINESS

Adam Ginaev

ECONOMIC ASSESSMENT OF INNOVATIONS IN THE ROAD TRANSPORT SECTOR IN TERMS OF CLIMATE CHANGE

MASTER'S DEGREE PROJECT

Supervisor lekt. dr. Rima Kontautienė

KAUNAS, 2017

KAUNAS UNIVERSITY OF TECHNOLOGY
SCHOOL OF ECONOMICS AND BUSINESS

ECONOMIC ASSESSMENT OF INNOVATIONS IN THE ROAD TRANSPORT SECTOR IN TERMS OF CLIMATE CHANGE

Business Economics (621L17001)

MASTER'S DEGREE PROJECT

Student.....signature.....

Adam Ginaev, VBV-6 gr.

2017 December 18

Supervisor.....signature.....

lekt. dr. Rima Kontautienė

2017 December 18

Reviewer.....signature.....

2017 December 18

KAUNAS, 2017

KAUNAS UNIVERSITY OF TECHNOLOGY

School of Economics and Business

Adam Ginaev

Business Economics, 621L17001

"Assessment of innovations in the road transport sector in terms of climate change"

DECLARATION OF ACADEMIC INTEGRITY

2017 December 18

Kaunas

I confirm that the Masters' Final Thesis of mine, **Adam Ginaev**, on the subject "Assessment of innovations in the road transport sector in terms of climate change" is written completely by myself; all the provided data and research results are correct and have been obtained honestly. None of the parts of this thesis have been plagiarized from any printed, Internet-based or otherwise recorded sources. All direct and indirect quotations from external resources are indicated in the list of references. No monetary funds (unless required by law) have been paid to anyone for any contribution to this thesis.

I fully and completely understand that any discovery of any manifestations/case/facts of dishonesty inevitably results in me incurring a penalty according to the procedure(s) effective at Kaunas University of Technology.

Name, last name	*Signature*

Adam Ginaev. Inovacijų diegimo kelių transporto sektoriuje ekonominis vertinimas klimato kaitos požiūriu. Magistro baigiamasis darbas / vadovė lekt. dr. Rima Kontautienė. Kauno technologijos universitetas, Ekonomikos ir verslo fakultetas.

Socialiniai mokslai: 04 S Ekonomika.

Reikšminiai žodžiai: aplinkosauga, inovacijos, ekonominis vertinimas, klimato kaita, kelių transporto sektorius.

Kaunas, 2018. 67 p.

SANTRAUKA

Temos aktualumas. Pasaulyje vis didesnį mokslininkų susidomėjimą kelia aplinkosauga. Tokia globalinė problema kaip klimato kaita tampa vis aktualesnė politinėse bei mokslinėse diskusijose. Didėjantis mokslininkų susidomėjimas klimato kaita yra pagrindžiamas tuo, kad klimato kaita neigiamai veikia visuomenės gerovę, todėl yra būtina imtis tinkamų priemonių tam, kad sumažinti veiksnius, įtakojančius klimato kaitą. Pastaruoju metu mokslinėje literatūroje inovacijų diegimo alternatyvos yra svarstomos kaip veiksmingos priemonės prieš globalines problemas. Mokslininkų atlikti tyrimai parodė, kad klimato kaitą veikia išmetamosios dujos. Išmetamosios dujos, dėl kurių susidaro tokie teršalai, kaip ozonas, yra dideliais kiekiais išmetamos būtent transporto priemonių, Lietuvoje išmetamųjų dujų koncentracija ore taip pat kelia susirūpinimą. Darant prielaidą, kad kelių transportas, palyginus su jūros, oro bei vandens transportu, labiausiai teršia aplinką ir remiantis innovacijų diegimo veiksmingumu šios problemos atžvilgiu, pateikiamu mokslinėje literatūroje, šiame baigiamajame darbe atliktas inovacijų diegimo kelių transporto sektoriuje ekonominis vertinimas klimato kaitos požiūriu.

Tyrimo objektas – inovacijos kelių transporto sektoriuje klimato kaitos požiūriu.

Tyrimo tikslas – inovacijų diegimo kelių transporto sektoriuje ekonominis vertinimas klimato kaitos požiūriu.

Uždaviniai:

1. išnagrinėti inovacijų svarbą klimato kaitos požiūriu;
2. išanalizuoti teorinius inovacijų diegimo sprendimus, orientuotus į klimato kaitą;
3. suformuluoti metodologinius principus inovacijų kelių transporto sektoriuje ekonominiam vertinimui;
4. atlikti inovacijų Lietuvos kelių transporto sektoriuje ekonominį vertinimą klimato kaitos požiūriu;
5. pasiūlyti priemones, skatinančias aplinkosauginių inovacijų diegimą Lietuvos transporto sektoriuje.

Tyrimo metodai: mokslinės literatūros lyginamoji ir sisteminė analizė, statistinių rodiklių analizė, koreliacijos analizė, grafinė analizė, rezultatų sintezė, loginis išvadų generavimas.

Pagrindiniai darbo rezultatai: Atliktas tyrimas parodė, kad diegiamos aplinkosauginės inovacijos kelių transporto sektoriuje, didėjančios investicijos į tyrimus ir plėtrą daro teigiamą poveikį taršos mažinimui. Inovacijų diegimas kelių transporto sektoriuje pastaraisiais metais auga, tačiau, palyginus su kitais ekonominės veiklos sektoriais, transporto sektoriuje aplinkosauginių inovacijų įdiegta mažiausiai. Pagrindinės priežastys, trukdančios aplinkosauginio inovatyvumo transporto sektoriuje plėtrai, yra vartotojų paklausos trūkumas, nepakankamas bendradarbiavimas tarp transporto sektoriaus ir kitų sektorių įmonių, finansavimo ir paramos iš kitų šaltinių trūkumas, nuosavų lėšų trūkumas. Atsižvelgiant į šias priežastis ir remiantis atliktais tyrimais, buvo pateikti pasiūlymai kaip paspartinti aplinkosauginių plėtrą transporto sektoriuje, t. y. pasiūlyta didinti įmonių darbuotojų žinias apie klimato kaitos pasekmes ir apie transporto įtaką taršos didėjimui, sukurti bendradarbiavimo tinklus, mokyti būsimus transporto įmonių darbuotojus išorinių finansavimo projektų ypatumų, diegti pažangias technologijas, kurios nereikalauja didelių sąnaudų (informacijos ir ryšių technologijos).

CONTENTS

List of figures

List of tables

INTRODUCTION

Relevance of the study. In the present day increasing attention is given to environmental problems. Global issues such as climate change are often present in political as well as scientific discussions. The importance of climate change research is accentuated by the pressing need to mitigate climate change and its detrimental effects on the wellbeing of the society. Climate change in current times is a direct consequence of greenhouse gas (GHG) emissions such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) that are released into the atmosphere by mankind's irresponsible industrial activities. Studies have shown that the largest sector contributing to greenhouse gas emissions in Lithuania is the energy sector and that energy consumption is predominantly governed by transport. Therefore, in this paper we perform an assessment of innovations in the road transport sector in relation to climate change. The thesis focuses on road transport under the assumption that it is a larger contributor to GHG emissions compared to other types of transportation (Water, Air or Rail transport).

After performing a literature review in foreign sources, it was revealed alarmingly that attention afforded to this topic has been lacking despite its critical importance. Information found on the internet is mostly limited to United Nations reports. These include Lithuania's Second Biennial Report under the United Nations Framework Convention on Climate Change (2015) in which greenhouse gas emissions reduction related targets are described as well as achievements in and projections for the transport sector and national policies. Additionally, the document from the European Bank for Reconstruction and Development (2016) focuses mostly on the energy sector in general. The work of the Jordaan et al. (2017), offers some thoughts on reducing road transport gas emissions with the help of innovations, but this study is unrelated to Lithuania and rather focuses on the Canada. These reports and the majority of the current literature do not contain information which directly addresses the topic at hand. Domestic literature is mainly focused on transport policy (Europos Sąjunga, 2014), or Lithuania's perspectives in the transportation sector (Šliupas, 2016) and many scientific papers on the analysis of the transportation sector itself. Some works do offer thoughts on the transportation sector in the context of sustainable development, however those papers fail to address the role of innovation in meeting Lithuania's obligations to climate agreements. Nevertheless, the lack of relevant literature does not diminish the urgency of performing an assessment of innovations in the road transport sector in terms of climate change.

The scientific problem is how to evaluate the implementation of Lithuania's obligations towards international agreements on climate change through innovation in the transport sector.

The object of the scientific research is innovations in the road transport sector in terms of climate change.

The aim of the scientific research is to assess the implementation of innovations in the road transport sector in terms of climate change.

The objectives of the scientific research:

1. To examine the importance of innovations in terms of climate change.
2. To analyse theoretical solutions of innovations implementation in terms of climate change.
3. To formulate the methodological principles of economic assessment of innovations in the road transport sector.
4. To carry out empirical research of innovations in the Lithuanian road transport sector in terms of climate change.
5. To propose measures to increase environmental innovativeness within road transport sector.

The methods of the research include: systematic and comparative analysis of scientific literature based on the methods of comparison, classification, systematization and generalization; synthesis of analysis results and logical generation of conclusions; statistical analysis of secondary data; correlation analysis

The paper is structured as follows:

Firstly, a full analysis of the problem will be conducted. This will address the reasons behind and the consequences of climate change as well as the position of Lithuania in general and its eco innovations relative to other European countries. Secondly, theoretical solutions to emerging climate change problems will be presented. Those include a discussion on responsible innovation, the concept of green economy as well as more practical application of Information and Communication Technologies (ICT) within the transportation sector. Thirdly, the method used in this paper for analysis is presented. This is comprised of quantitative correlation analysis complemented by qualitative analysis of secondary data. At this stage, three hypotheses relating to the different aspects of climate change specific to Lithuania are formulated. Finally, an analysis of innovativeness, specific to the context of combating climate change, in the Lithuanian transport sector is carried out. In this analysis the importance of innovative activities in reducing GHG emissions as well as their positive effects on the economy is demonstrated. Furthermore, obstacles to innovation are identified. Those are then taken into account before recommending the appropriate measures necessary for increasing environmental innovativeness in the transport sector. The analysis is finally concluded with the general findings of this paper.

1. IMPORTANCE OF INNOVATIONS IN TERM OF CLIMATE CHANGE

In this section the necessity to take measures to reduce the negative impacts of climate change is addressed. To do so, firstly, the reasons and consequences of climate change are presented. Secondly, the position of Lithuania in eco innovations and how Lithuania can meet international obligations on climate change is investigated.

After conducting a literature review of the topic of interest, it was decided to present innovations as an instrument to solve wicked problems in this paper. One can observe the increasing the level of attention afforded to innovation policy over the past few years in the literature. Innovation policy is often used to address global environmental challenges that our society faces at the moment (Edler and Fagerberg, 2017). Figure 1 illustrates how frequently the term innovation policy was used in each year. The figure clearly shows a sharp increase in discourse surrounding innovation policy in 1995 and it has only continued to rise in the period since

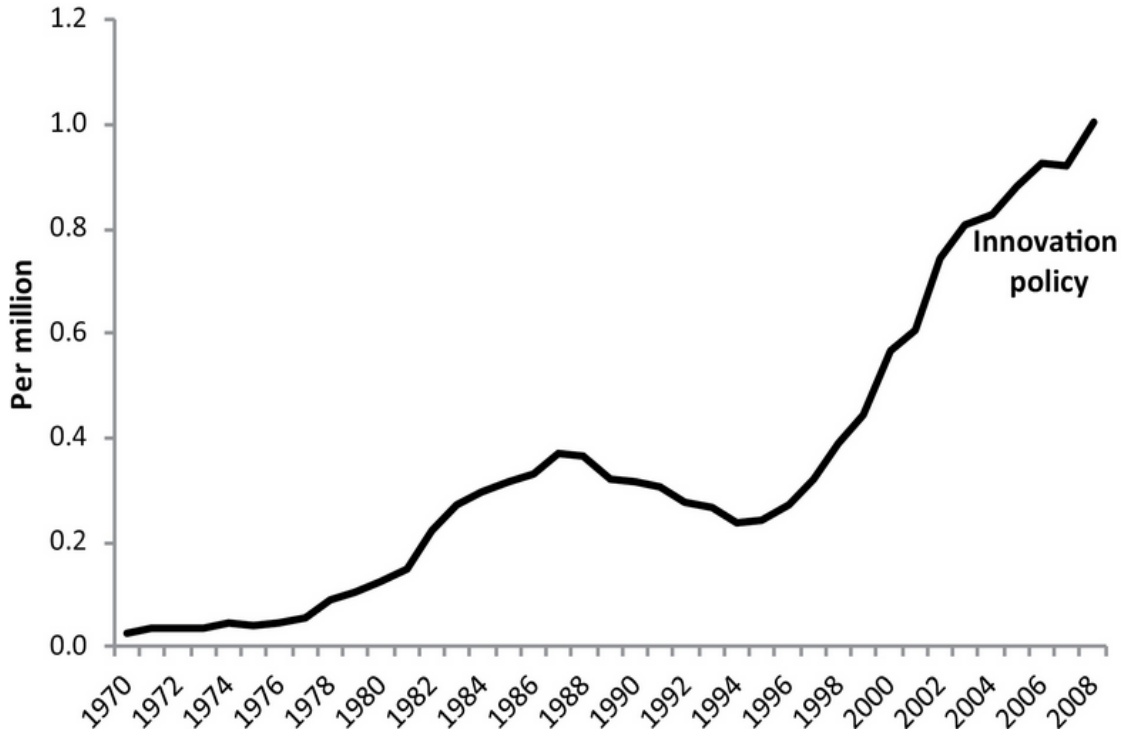

Figure 1. The frequency of using the term "innovation policy" (based on Edler and Fagerberg 2017, p. 3).

A more detailed overview of the theories designed to solve the issues related to environmental problems such as climate change is presented in the theoretical part of this paper. Before we address those however, it is important to clarify how global challenges such as global warming occur, why it is necessary to take measures to reduce environmental harm and how Lithuania contributes to global warming.

1.1. Reasons and consequences of global climate change

In contemporary literature, innovation is analysed from different aspects. Innovation is no longer treated as only commercialization of invented products or services but also as a wider concept that can have negative impacts on society such as innovations that trigger global warming, for example, anthropogenic climate change or increased concentrations of CO2 in the atmosphere. According to the United Nations (2013), both phenomena are mainly caused by the enormous increase in energy consumption due to rapid economic growth in the last decades. But there are also sustainability oriented innovations, these types of innovations are presented in the theoretical part of this thesis.

Climate change is important because it threatens human wellbeing. It is alarming in two ways: Firstly, through direct effects such as "extreme weather, changes in the frequency, distribution or burden of 'climate-sensitive' diseases", and secondly, through indirect effects, for example the availability of water or other natural resources (Wilkinson 2009, Close and Crabbe 2016). The second effect of climate change is critical for sustainable living because essential resources are diminished, and the scarcity of these resources is one of the major challenges for today's society. Scarcity of natural resources was not topic of interest previously, as the prices for resources were falling in the 20th century, however with rapid economic growth followed by climate change, this topic became of importance for scientists. Furthermore, with current scientific knowledge most of the resources can be substituted by produced capital, however there are resources that cannot be substituted and their use must be regulated (Ayres, 2007). Some resources are interconnected, for example land, water and energy, these resources are linked to the production of food and this makes them critical for sustainable existence. With a growing population on a global level not all the needs are met and therefore the use of these resources is expected to increase further. Coupled with the problem of climate change these resources may become scarce. This threat raises the importance of better distributional solutions and strict regulations on the use of these resources (United Nations, 2013).

When we refer to the climate change, we refer to the current discourse surrounding global warming. According to May (2017), in the last decade the Earth's temperature increased around 1-degree Fahrenheit and this seemingly insignificant increase should not mislead us as even small changes in average temperature have large consequences. Figure 2 illustrates how average temperature has changed over time.

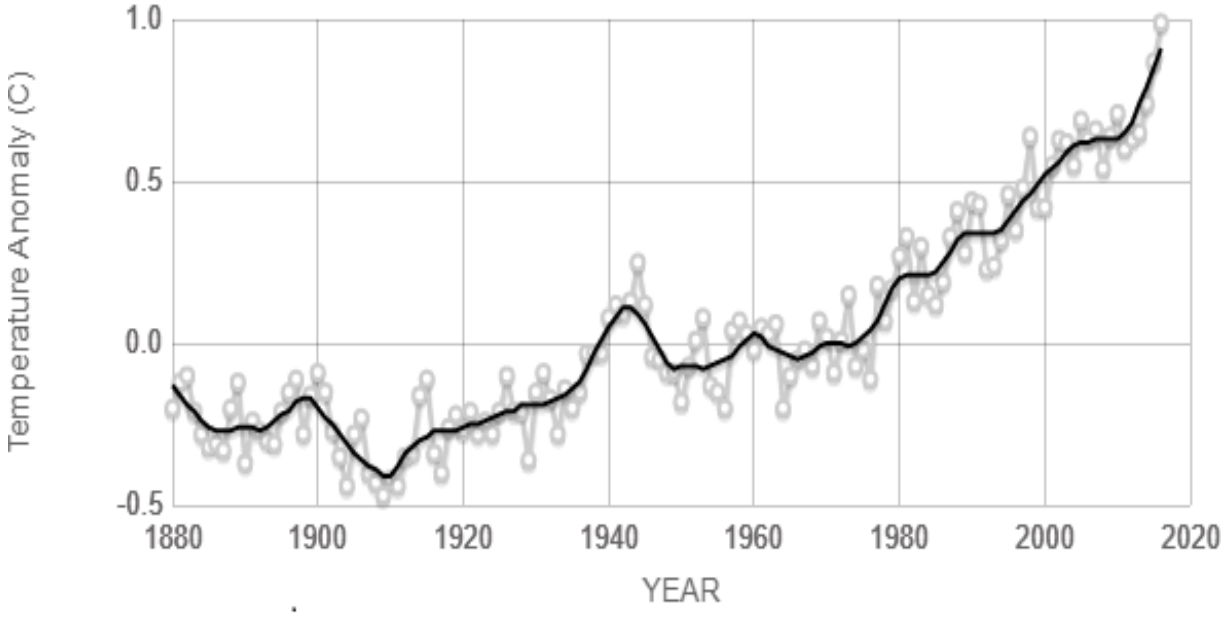

Figure 2. Change in the average temperature (1880-2016) (based on climate.nasa.gov/vital-signs/global-temperature/)

The change illustrated in this figure is calculated as relative to 1951-1980-year temperatures. The Black line illustrates a five-year mean and the grey line shows the annual mean. From the results that are demonstrated, it is clear that the average temperature is indeed increasing and the maximum average temperature witnessed was in the year 2016. The major cause of these changes in average temperatures is harmful human activities that lead to the emission of greenhouse gases (GHG). These emissions together with other anthropogenic forces perhaps account for more than half of average temperature increase observed for the years 1951-2010. The worrying fact is that these gasses are increasing despite the large number of policies that have been introduced to address the climate change problem (IPCC, 2014).

According to EPA (2017), GHG's can be divided into two categories - naturally occurring greenhouse gases and gasses occurring only from industrial activities (see Figure 3). Alarmingly, even the levels of naturally occurring gases in the atmosphere are rapidly rising due to harmful human activities.

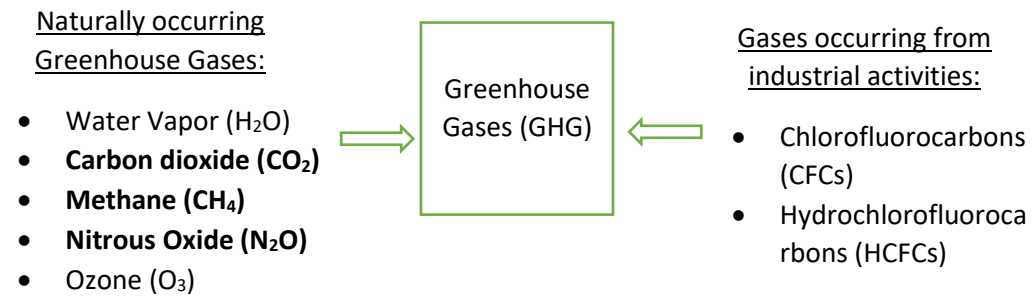

Figure 3. Greenhouse Gases (GHG) (composed by author based on IPCC 2014 and EPA 2017).

Of the many gases listed in the figure above, the most significant contributors to climate change are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (EPA (2017), IPCC (2014)). In Lithuania, greenhouse gas emissions are observed at their highest level in the energy sector. As illustrated in Figure 4, the single largest contributor to the greenhouse effect in the energy sector is carbon dioxide (CO_2). Emissions of this gas significantly diminished between 1991 and 1993, but only slow reductions in emissions are achieved in the run-up to 2000 while slight increases are observed thereafter. In the past 15 years we have witnessed an almost constant level of emissions of gasses that contribute to the greenhouse effect. Emissions of N_2O have decreased over the period analyzed whereas CH_4 remained almost unchanged, but these two types of gases have miniscule emissions compared to CO_2. Therefore, it is reasonable to say the focus of the policy in reduction of greenhouse gas emissions should be on the reduction of CO_2 in particular.

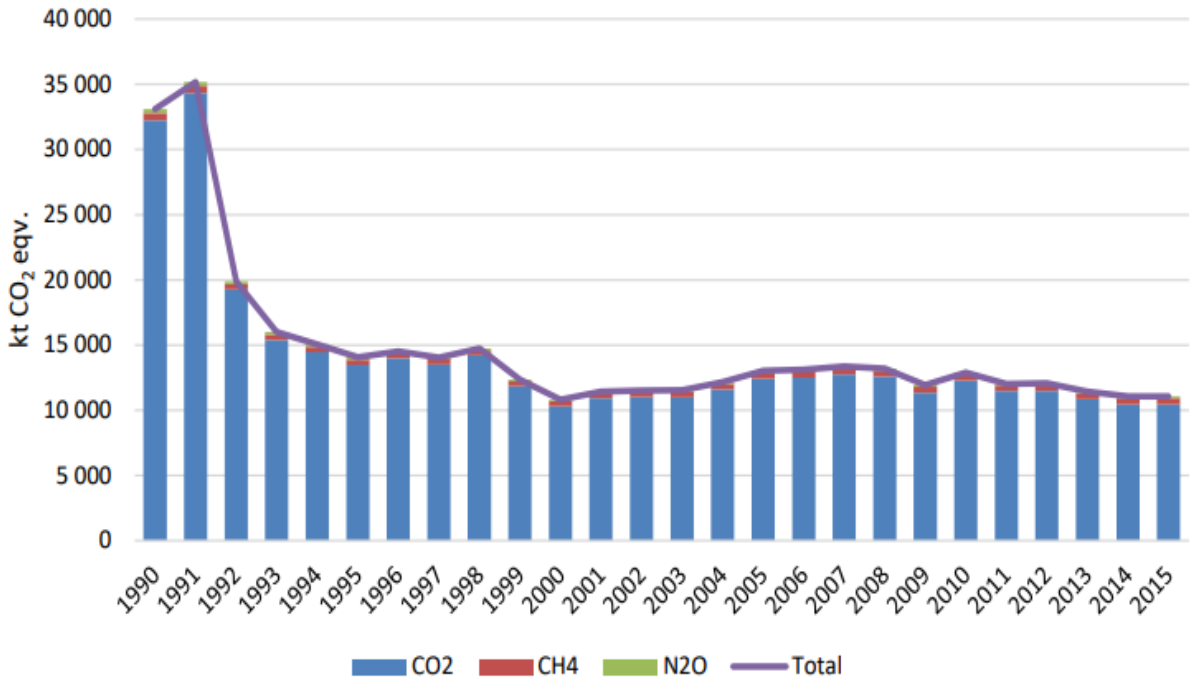

Figure 4. Greenhouse gas emission in Lithuanian energy sector (based on Konstantinavičiūtė and Byčenkienė, 2017, p. 78)

Energy consumption is highly determined by the sector of the economy. Figure 5 illustrates energy consumption in 5 sectors of Lithuanian economy. This figure shows that energy consumption has dropped significantly since 1990 in the industrial sector and commercial/institutional sector. Energy consumption in agriculture and fishing also dropped, even though energy consumption in this sector was not as high as in the other four sectors to begin with. Energy consumption in the residential sector has not changed significantly in the years past. The transportation sector has seen a reduction in consumption in the period from 1992 till 2000, however after 2000 it started to increase. According to Konstantinavičiūtė and Byčenkienė (2017), the decrease in energy consumption in 2009 is attributable

to the economic recession which caused a reduction in the construction sector by 34.9 % and in the transport sector by 18.5%. However, with the recovery of the economy in the year 2010 energy consumption is showing signs of increase again. This further supports our assertion that current global warming is indeed caused by harmful human activities that lead to economic growth.

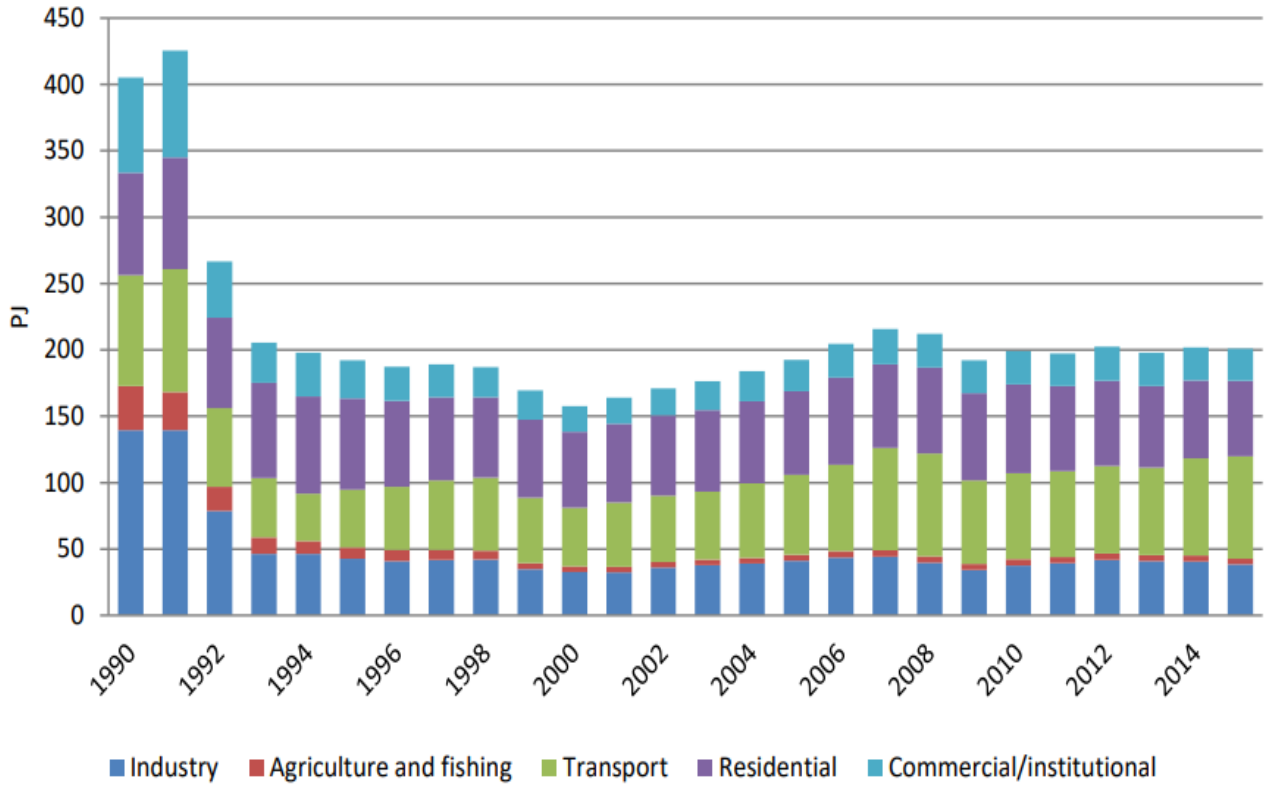

Figure 5. Energy consumption by five sectors of the economy (based on Konstantinavičiūtė and Byčenkienė 2017, p. 75)

Economic growth is important for the wellbeing of society however, it has adverse effects on the climate and in the long run will lead to major problems including economic problems. Even though Figure 5 suggests that energy consumption has declined compared to the 1990's, this is not enough for sustainable development.

Projections made by scientists suggest that the temperature will continue to rise if more radical action is not taken. The Intergovernmental Panel on Climate Change (IPCC) performed research on how temperatures will increase based on several possible scenarios. In scenario (A1) the economy grows with open trade and high innovation progress but sustainability issues are sidelined without significant attention. In scenario (B2) sustainability issues are of high importance for the economies. Additionally, scenario (A2) is devised to represent modern society, where free trade is promoted and sustainability issues receive some attention (at least more so than in scenario (A1)). The study concluded that the outcomes of each scenario will begin to diverge as soon as 2040. At the end of this century the increase

in temperature in Europe will be around 2.5-5.5 degrees, with some European countries suffering an even greater rise of up to 7 degrees. Scenario (B2), on the other hand, would cause an increase of only 1-4 degrees. For Lithuania, the consequences of such a rise in temperature will include an increase in rainfall by 10-20 percent, a substantial change in extreme weather conditions, and coastal erosion etc. (Kelemen et al., 2009).

Worryingly, the projections made by researchers show that GHG emissions in Lithuania will be increasing over time even assuming that measures to reduce GHG emissions are already being introduced by the Lithuanian government. These projections are illustrated in a Figure 6.

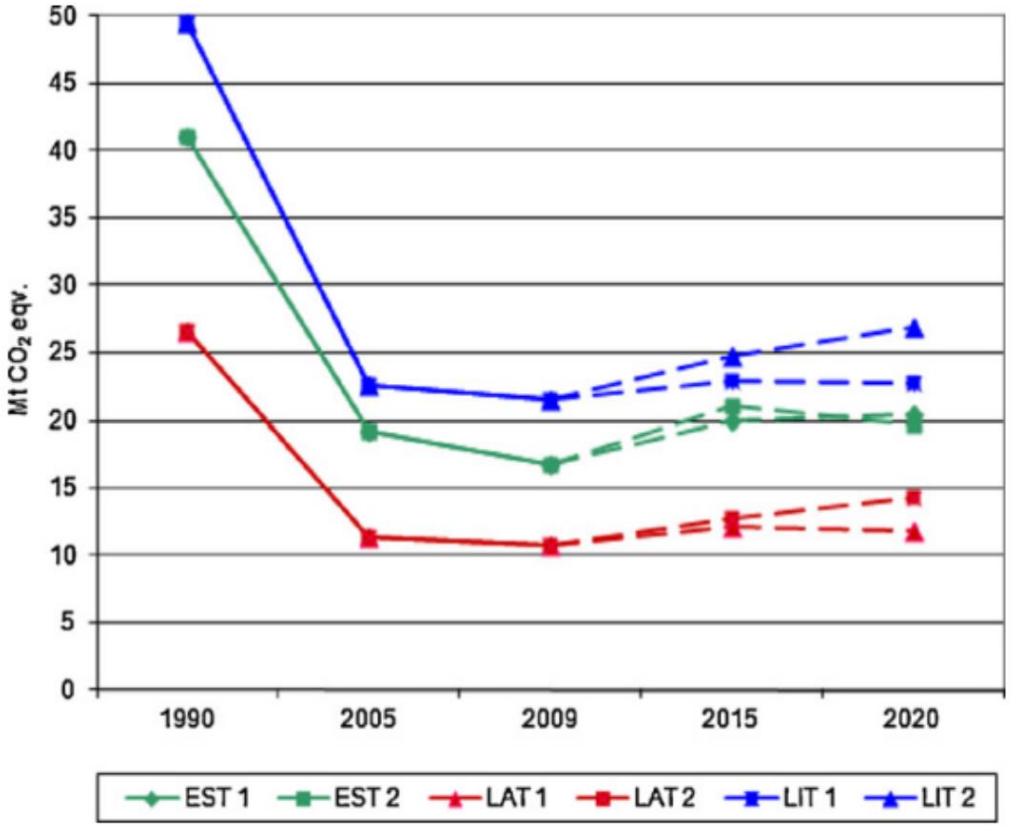

Figure 6. Two scenarios forecast of GHG emissions in Baltic states for the years 2010-2020 (based on Roos et al., 2012, p. 2144)

Scenarios presented in this figure differ only by the method of calculation. Scenario one is developed with the help of PRIME model by the Technical University of Athens, while the development of second scenario is based on the national forecasts made for international reports (Roos et al., 2012).

Progress on GHG emission reduction in Lithuania is impeded by the absence of any significant measures devised towards that objective. Policies that are already in place to this end in Lithuania are focused on the supply sector and are overly reliant on large-scale costly supply-side measures. The government's commitment to building a nuclear power plant has unfortunately resulted in it being touted

as the primary solution while renewable energy sources remain completely overlooked (Roos et al., 2012).

Climate change which is a result of GHG emissions will have detrimental effect on the future of Lithuania. The projection that demonstrate rise in GHG emissions in the future suggest that measures that have been already introduced are not enough. Therefore, in the next section it is necessary to trace the performance of Lithuania in the context of environmental innovations and innovations in general.

1.2. Eco-innovations in Lithuania

To evaluate innovative activities in Lithuania innovations were analysed from two perspectives: from the perspective of all innovative activities and so called eco-innovations. Eco-innovation is "the production, assimilation or exploitation of a product, production process, service or management or business method that is novel to the organisation (developing or adopting it) and which results, throughout its life cycle, in a reduction of environmental risk, pollution and other negative impacts of resources use (including energy use) compared to relevant alternatives." As such, the principal factor distinguishing eco-innovations from normal innovations is that they offer solutions which are more environmentally friendly than other viable alternatives (Kemp and Peaerson, 2007).

Figure 7. presented below illustrates the share of innovative enterprises in all European Countries for the year 2017.

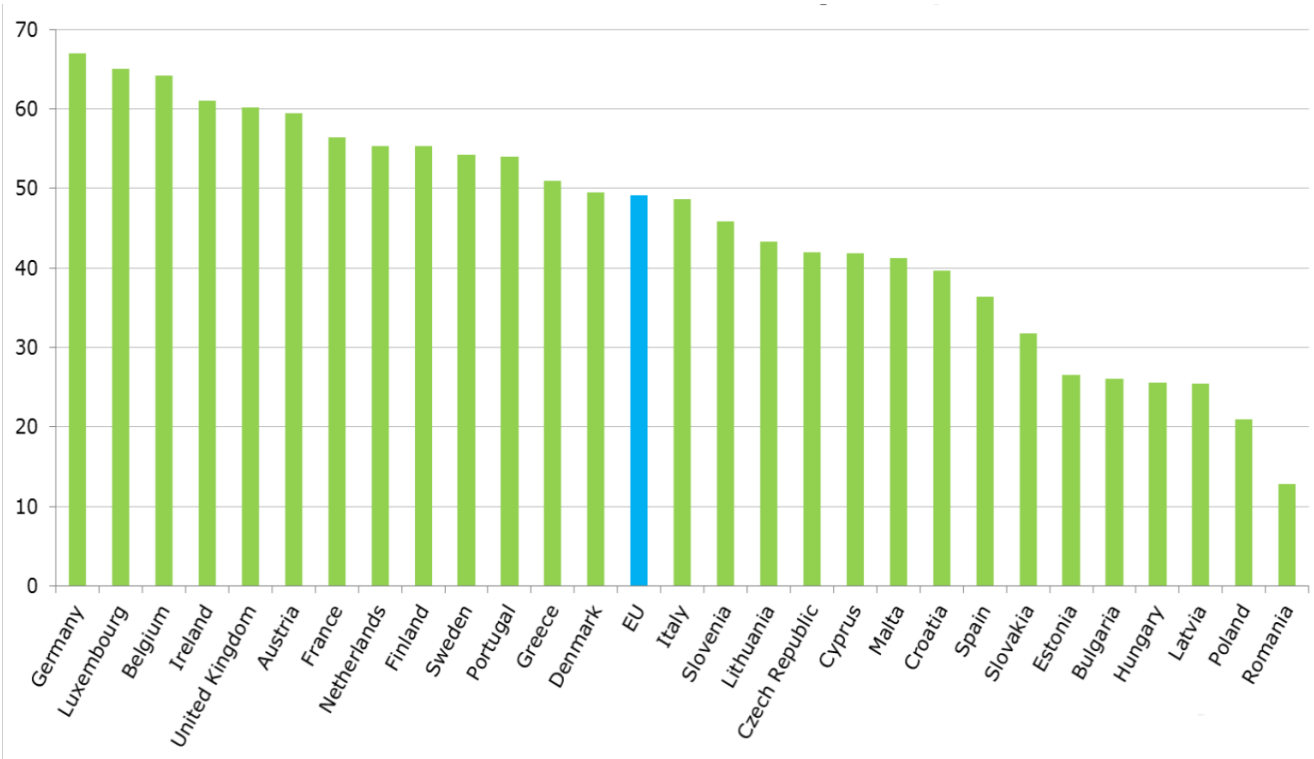

Figure 7. Share of innovative enterprises compared to all enterprises, %. (based on http://ec.europa.eu/eurostat)

Figure 7 shows that share of innovative enterprises in Lithuania is higher that in many countries including the Baltic countries (Estonia and Latvia), however it is still lower than the EU average (see Figure 7).

With regards to eco-innovation, Lithuania is currently performing better than in the past emerging well ahead of several European countries. This could be the result of the National Innovation Strateg, however, it is impossible to test whether the improvement in eco-innovation score is indeed attributable to the adoption of said strategy. Figure 8 shows that back in the year 2011 Lithuania had lowest eco-innovation score in Europe (52 points) and by 2016 Lithuania had achieved 86 points, when the maximum score in Europe was 140 (Germany). Despite the improved situation in Lithuania, it is still outperformed by sixteen European countries (out of 28), suggesting that further improvements in this area have to be made.

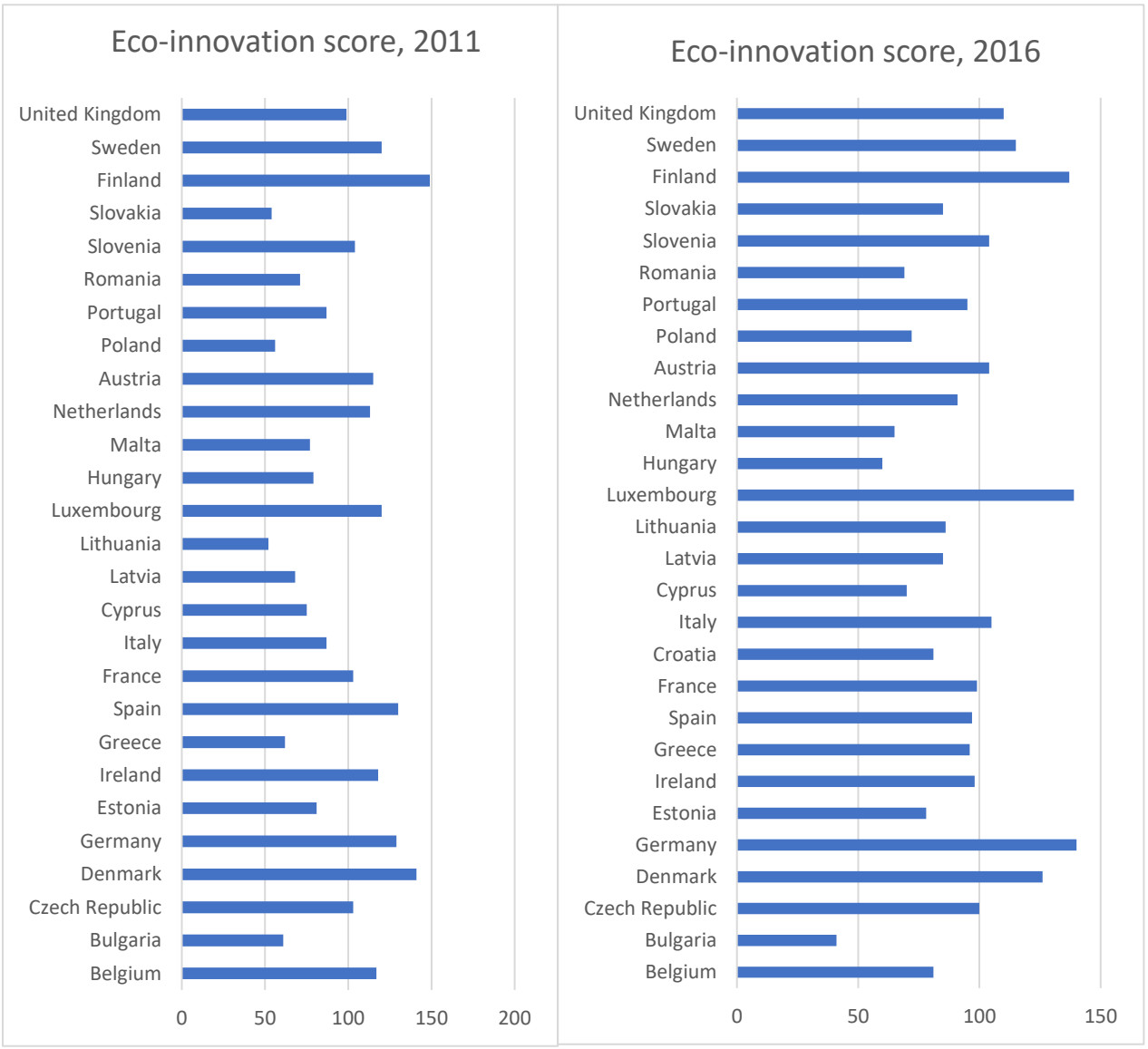

Figure 8. Eco-innovation score in different countries for the years 2011 and 2016. (based on http://database.eco-innovation.eu)

The goal is not only to perform better than other countries in eco-innovations but to also meet Lithuania's obligations with the help of innovations in the transport sector. Lithuania is obligated to reduce Greenhouse gas emissions by 9 percent in the period between 2021 and 2030. Unfortunately, prognosis shows that this goal will not be reached. The implementation of measures to reduce Greenhouse gas emissions is especially complicated in the transportation and agriculture sectors of the economy. If this goal of reduction in GHG emissions is not reached, Lithuania will be obligated to pay a fine as imposed by EU law (Jockus, 2017). Therefore, special measures have to be taken to achieve this goal, especially in the transportation sector as there is no straightforward solution.

Analysis of the existing material related to the topic of interest revealed that this topic lacks due attention, nevertheless it is highly important for the future of all countries including Lithuania. Lithuania at the moment is not able to meet international obligations on climate change and one of the major sectors that is considered as complicated is transport sector. Climate change depends on the emissions of greenhouse gasses and the energy sector is the largest contributor to the greenhouse effect in Lithuania. The highest levels of energy consumption in the past few years were recorded in the transport sector and have been found to increase with economic growth. Innovations in the transport sector could be the answer to reducing energy consumption. As such, the next section of this thesis presents theoretical solutions and discusses examples from other countries in meeting international obligations through innovations in the transport sector.

2. THEORETICAL SOLUTIONS OF INNOVATION IMPLEMENTATION IN TERMS OF CLIMATE CHANGE

The aim of this section is to provide insights on how to address existing climate change issues from a theoretical perspective. To do so the existing literature was analysed and most relevant theories for this thesis were selected, namely- responsible innovation and the concept of green economy. In addition to these theories the role of information and communications technologies (ICT) was also presented. ICT in the transport sector provides innovative solutions that can be applied practically or have been already implemented in other countries. The concepts of responsible innovation and "green economy" are very similar. Since the "green economy" is considered as a policy measure itself, we combine the discussion of green economy with the discussion of international agreements and regulations using these regulations as an instrument to fight climate change.

2.1. Responsible innovation and its dimensions

The discussion of responsible innovation started with the definition of the concept of responsible innovation. Then, the dimensions and parties concerned with responsible innovation and research were described. Finally, the application of the principles of responsible innovation as well as limitations of this theory were presented.

Definition of Responsible Innovation

In recent years European research policy has paid close attention to the concept of responsible innovation (Burget et al., 2017). Responsible innovation or alternatively social innovation (Bock, 2012), is not a well-defined concept and its definitions in the literature vary, however it is clear that innovation should not focus solely on specific economic agents but instead be beneficial to all society and lead to socially desirable outcomes (Owen et al., 2013)). According to Voegtlin and Scherer (2017), responsible innovation can be defined with a three-dimensional view. The first dimension posits the concept of responsible innovation as one that is holding back potential harm from society. The second dimension stresses the importance of the introduction of new products (innovations) that solve the problems facing society and pushes forward sustainable development. Lastly, the third dimension is for governance schemes that would support the first two dimensions. According to the authors the problem with the dimensions of responsible innovation is that most research papers are focused on one dimension only, oftentimes this is either the first or second dimension. The third dimension (governance schemes) is neither well explained in the literature nor effectively applied in practice.

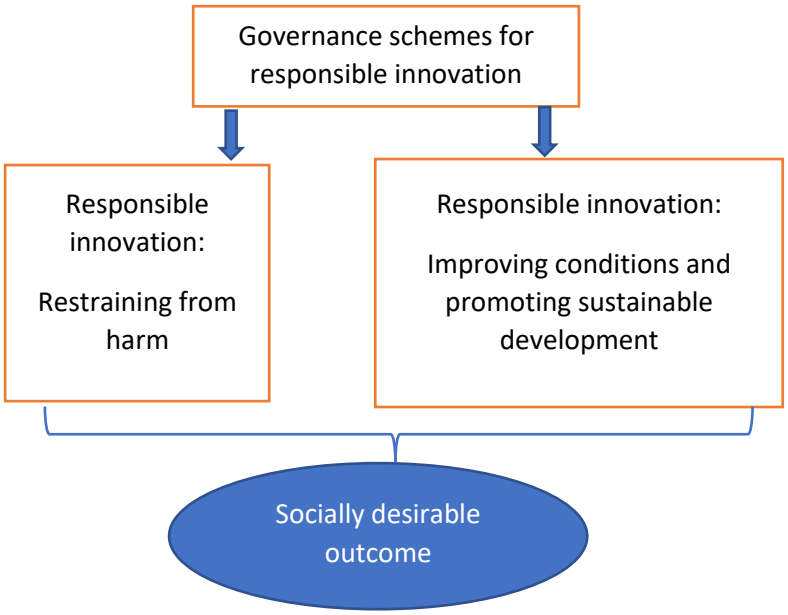

Figure 9. Definitions of responsible innovation (based on the definitions of Voegtlin and Scherer, 2017)

Dimensions and interested parties in Responsible Innovation and Research

In addition to the three dimensions of responsible innovation that were proposed by Voegtlin and Scherer (2017) to define responsible innovation, Stilgoe et al. (2013) present a framework for responsible innovation constituted of four dimensions. The authors theorize that these dimensions are formed from the questions arising in public debates in response to emerging areas of technology. If the interests and concerns of society can be traced from these questions, then responsible innovation would imply giving due consideration to these questions within innovative activities. The four dimensions in this case constitute a framework for responding to these questions that are particularly important to society. These *four dimensions* are:

1. *Anticipation*. The importance of better anticipation in governance is emphasized by different sources. On the academic level this can be a critical discussion of particular models of governance such as top-down risk-based models or, alternatively, environmental as well as political concerns related to technological change. Anticipation requires researchers and organizations to think systematically, build the capacity to recover from difficulties and introduce new opportunities for innovation at the same time (Stilgoe et al. 2013). The anticipation dimension involves describing the impacts of innovation that are predicted as well as discussing those economic, social or environmental impacts that are disregarded and/or neglected by predictions. This suggests that scientists have to ask questions such as "what if?" or "what else might it do?" (Owen et al., 2013).
2. *Reflexivity*. Responsible innovation requires reflexivity on the agent and the institutional levels. According to Stilgoe et al. (2013), reflexivity in governance is particularly important at

institutional level. Reflexivity is associated with reflecting on known and unknown purposes and potential impacts, risks, assumptions and uncertainties (Owen et al., 2013).

3. *Inclusion.* This dimension involves "inclusively opening up visions, purposes, questions, and dilemmas to broad, collective deliberation through processes of dialogue, engagement, and debate, inviting and listening to wider perspectives from publics and diverse stakeholders" (Owen et al., 2013, p. 38). A positive trend is that the inclusion of the wider public in forums dedicated to innovation issues is increasingly being practiced in Northern Europe over last two decades (Stilgoe et al., 2013). Inclusion of the wider public is important because diverse thoughts and skills can generate higher quality decisions and guarantee that all perspectives are considered (RRI Tools, 2016).
4. *Responsiveness.* Flexibility in changing direction based on new circumstances and public as well as stakeholder opinions. Emending innovation systems to be innovating responsibly (Stilgoe et al., 2013).

Interested parties in Responsible Innovation

To better understand the importance of Responsible Innovation it is necessary to identify interested parties, actors that have to share responsibility to reach set goals. RRI Tools (2016) identified five major actors among which there should be a dialog while performing innovation activities and research. These actors are (see Figure 10):

- Research community- researchers, research managers, science communicators and all other actors that are related to research activities.
- Education community- teachers, families, students, science centers and etc. All agents that are interested in education including schools and universities.
- Policy makers- all the agents making decisions regarding innovation policy on national as well as international levels (policy officers, research center managers or funders).
- Business and industry- all small, medium and global businesses at all industry levels that are involved in research & development.
- Civil society organizations- individuals and organizations (NGOs, trade unions etc.).

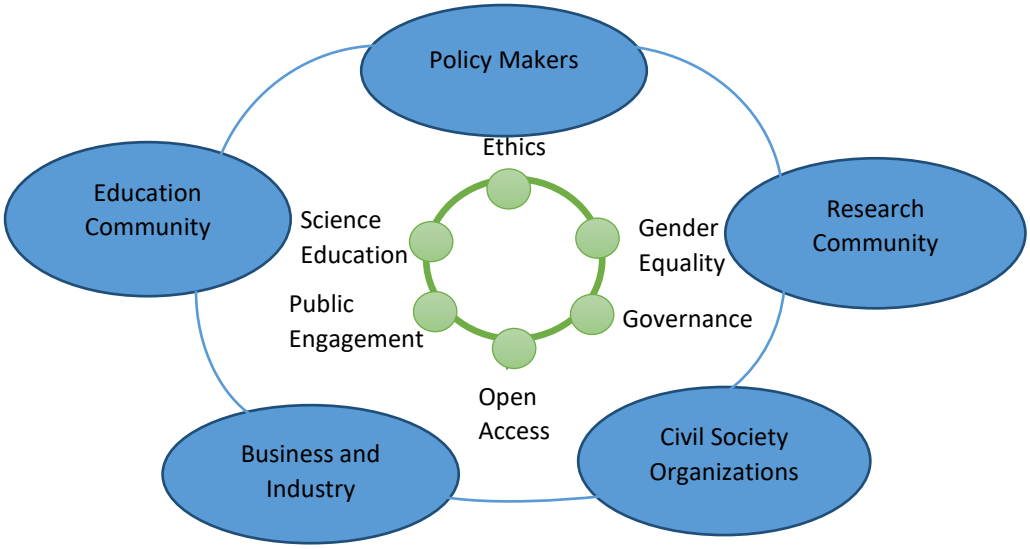

Figure 10. Interested parties in Responsible Innovation (adapted from RRI Tools, 2016).

According to RRI Tools (2016), taking into account the importance of policy for responsible innovation, the European Commission has introduced themes of high importance for policymakers. These themes are highlighted in green circles in Figure 10.

- Ethics - the research that is conducted and innovation should take into account fairness, morality and be acceptable for the society.
- Gender equality - decision making bodies should be composed of both male and female genders, this is explained by the fact that outcomes of research are relevant to both genders equally, and therefore they have to take equal part in research and decision making.
- Science Education - to promote research, science teaching should be improved enabling a larger part of the society to engage in discussions on research and innovation.
- Public Engagement - to match the values and needs of the society the wider public as well as the stakeholders have to be involved in research processes.
- Governance - governance structures must internalise RRI principles in such a way as to complement current practices whilst simultaneously remaining open and receptive to the constantly evolving landscape of research and innovation.
- Open Access - scientific research, a sector that receives vast public funding, is still restrictively expensive to access. Easing access to scientific results and data according to the FAIR principle (Findable, Accessible, Interoperable, Reusable) would facilitate joint efforts and cross-disciplinary projects thereby driving innovation and enhancing future research.

Application of the principles of responsible innovation-limitations

There have been several promising studies performed with the aim to implement the theoretical concept of responsible innovation to address real world issues. However, there are very few attempts of employing responsible innovation in the transport sector. One such attempt which received significant attention from innovation scholars is the Responsible Innovation Agenda for Competitive European Transport Industries up to 2050 (RACE2050). This is an EU funded project developed to identify key success factors that would promote the growth of the European transport sector in a way that is most socially acceptable and climate friendly.

The lack of attempts to implement responsible innovation concepts can be partly explained by the limitations of responsible innovation. For example, according to the Blok and Lemmens (2015), there are three reasons why implementation of responsible innovation is complicated:

1. Responsible innovation calls for the involvement of different stakeholders into discussion and decision making with regards to innovations. In the context of grand problems, the concept of responsible innovation excludes the possibility that each stakeholder will have their own priorities and assumes they will support decisions that are best for society as a whole. The different power of stakeholders or stakeholder groups to influence decision-making is also neglected. In reality some stakeholders usually have higher influential power, and therefore the process of innovation might be shaped in a way more favourable to a particular group of stakeholders based on what this group of people believes constitutes a "real" problem.
2. Limited "transparency" and "mutuality". Being completely transparent for the competitors is not profitable and therefore there are information asymmetries between stakeholders which can even be detrimental to responsible innovation.
3. Innovations have an unpredictable nature, and the consequences and side effects of innovations cannot be fully anticipated. The analysis performed cannot guarantee reliable result. Grand challenges are complex and solutions to these challenges cannot be simple and predictive.

2.2. The concept of "green economy" and international agreements

The strategic agenda based on climate change concerns has remained over the past few decades one of the most serious challenges for humanity. Therefore, in this section international climate policy and particularly international obligations are considered as key instruments for achieving crucial objectives in global climate policy such as stabilization of greenhouse gas emissions. In order to enhance the international response to climate change, legal agreements supported by the involved parties

including state and non-state international actors were suggested to add weight to the pressing need to solve climate change problems.

In this section the current state of international climate policy with reference to the most important international efforts against climate change and the obligations stipulated in the most significant agreements and treaties were discussed. Thereby the concept of green economy should be taken into consideration. Within the scope of green economy and sustainable development certain targets and the degree of their application need to be evaluated. In conclusion, results concerning the relevance of international agreements on climate change and the green economy concept are drawn.

When considering the obligations of different parties on climate change, it is necessary to identify the objectives embedded in the international agreements as well as measures needed to implement these obligations.

Concept of "green economy" and application under international agreements

Similar to responsible innovation, the concept of green economy is not universally defined. There is no unique officially accepted definition for a green economy. Nevertheless, the definitions represented in recent publications on the subject were outlined in this thesis. UNEP, for instance, defined green economy as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities. It is low carbon, resource efficient and socially inclusive" (UNEP, 2011). The Green Economy Coalition defines green economy as "a resilient economy that provides a better quality of life for all within the ecological limits of the planet". The latter example offers a concise representation of the concept, based on both concerns regarding environmental protection as well as the intention to raise overall quality of life (United Nations, 2015).

In this regard acting with respect to the principles of a green economy would mean that private and public investments achieve income growth and an increase in employment through the reduction of carbon emissions and pollution as well as the improvement of energy and resource efficiency. According to the report of the UNEP on sustainable development and green economy (2011), "these investments need to be catalysed and supported by targeted public expenditure, policy reforms and regulation changes (UNEP, 2011, p.16)".

The term "green economy" traces back to 1989 when the report for the Government of the United Kingdom was commissioned to advise on a definition of the term "sustainable development" and to assess its advantages with respect to the international cooperation and policies. However, the latest concept of a green economy does not replace sustainable development; it rather represents "a strategic economic policy agenda for achieving sustainable development." The overall improvement of people's quality of life in response to the current environmental challenges of climate change and the insecurity of the energy sector is obviously an essential objective of sustainable development. This objective

drastically corresponds with green policy. Yet, further to environmental problems, a green economy addresses the concerns of sustainable development with "intergenerational equity and eradicating poverty" (UNEP, 2011, p. 19).

Considering green economy in relation to international and regional regulations and agreements one should definitely emphasize the role of United Nations Framework Convention on Climate Change. This convention states as the priority objective the need to equate greenhouse gas concentrations that are already present in the environment "at a level which would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 2014). With respect to the mentioned objective, the main obligation defined and embedded in the UNFCCC is to encourage predominantly industrialized countries (so called Annex I parties), to lower emissions by the year 2000 to 1990 levels. As for developing countries, a wide range of initiatives on climate change can be pursued through financial support from industrialized countries involving the sharing of technologies, for example by means of technology-oriented agreements as well as various grants and loans (UNFCCC, 2014). The role of this Convention can be referred to as a remarkable step towards the recognition of the challenges faced on a global level and thereby require global efforts to cope with. One can observe that the Framework Convention comprises general commitments made by the relevant parties, however it doesn't officially establish any binding targets in terms of reducing greenhouse gas emissions (Federal Ministry for the Environment, 2017).

It is commonly acknowledged though, that, in international politics, legally binding agreements are proven to bring much efficiency to general international commitments and framework conventions. Initial steps towards attaining the targeted reductions in greenhouse gas emissions for industrialized countries were made during the third Conference of the Parties to the UN Framework Convention on Climate Change (COP 3) by implementing legal obligations.

The Kyoto Protocol, adopted on 11 December 1997 and entered into force on 16 February 2005, is considered an important move towards the emissions reduction on the national, regional and global levels in terms of stabilization of greenhouse gas (GHG) emissions (UNFCCC, 2014). The Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) was held in Kyoto, Japan. More than 150 nations attended and adopted the first international treaty on controlling and reducing greenhouse gases. The agreement reached in Kyoto, mandated industrialized nations to cut their greenhouse gas emissions. 191 states plus one regional economic integration organization, totalling 92 separate parties, have ratified the protocol. The protocol directs 37 industrialized nations as well as the former European Community to reduce their greenhouse gas emissions. Besides that, it also created an international trading system. A system wherein parties are rewarded with credits toward their emission target for contributing to emission reductions that extend beyond their home territories. It also

allows some degree of flexibility in a way that reduction of emissions will be achieved using developed market-based mechanisms (UNFCCC, 2011).
These mechanisms include:

- International Emissions Trading;
- Clean Development Mechanism (CDM);
- Joint implementation (JI).

Since they are likely to be the most significant instruments in relation to the obligations of the EU Members towards climate change, the first two mechanisms mentioned above are going to be analysed in the context of the Directive of the EU (2003). Reference will be made only to the main aspects of the third mechanism. As defined in Kyoto Protocol Article 6, JI allows a party obligated to reduce or limit their emissions (Annex B Party) to gain some units of reduction in emissions, so called ERUs, equivalent to one tonne of CO2 from an appropriate project in another Annex B Party. Such kind of joint implementation benefits Parties by a flexible as well as cost-efficient realization of Kyoto commitments in such a way that the host Party gains advantages from foreign investment or technology transfer. In doing so, the Kyoto Protocol accounts for fair sharing of the responsibilities for current GHG emissions levels caused by human industrial activity. Therefore, it obliges developed economies with stricter regulations under the claim of "common but differentiated responsibilities" (UNFCCC, 2014). In December 2012 during a conference in Doha, Qatar, The Kyoto Protocol was extended to the year 2020.

The next crucial phase in international environmental governance was launched with "The Paris Agreement (COP 21). The Paris conference was the 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). This agreement requires parties to comply with the climate obligations including priority of national contributions through *binding procedural commitments*. The requirement of Nationally Determined Contributions established mechanisms which would make the regulations on GHG emissions on the national level more liable and enhance already existing ambition acknowledging developed countries' UNFCCC obligations for the future. The Paris Agreement reaffirms the goal to adjust global temperature increases below 2 degrees Celsius above pre-industrial levels. This goal was set by governments in Copenhagen in 2009 and in Cancun in 2010 under the related agreements. At the same time the Paris Agreement encourages the parties to endeavor to keep the increase of overall temperature to below 1.5 degrees Celsius. With 148 parties, the Paris Agreement has been ratified in June 2017 (C2ES, 2017).

The recent major UNFCCC conference COP 23 took place in Bonn, Germany, in November 2017 under the Presidency of Fiji. The outcomes and consequences are expected to be carefully evaluated in upcoming research and publications. Though, it is obvious that COP23 concluded with steps forward to

ensure global climate action through implementation of the Paris Agreement. One of the highlights of the conference to be mentioned here, is the ambition of the European Union to remain on leading position with regards to the fight against climate change compared to other world regions This objective was announced by Commission President in his State of the Union address in 2017 (European Commission, 2017.).

The EU has declared its intentions to "deposit the ratification instruments of the Doha Amendment to the Kyoto Protocol by the end of this year". We should recall that the Doha Amendment was aimed at reducing greenhouse gas emissions of its parties by the year 2020. The EU has succeeded in accomplishing the 2020 targets in 2016 by having the 23%reduction in emissions. Furthermore, the strategic agenda set for 2018 in the context of the "Talanoa Dialogue" addressed Facilitative Dialogue as the key concept. The Facilitative Dialogue 2018 would allow the Parties to take into consideration the collective actions aimed at progress towards the implementation of the long-term goals established in the Paris Agreement (European Commission, 2017).

2.3 Technology-oriented agreements in the scope of international climate agreements

As mentioned in the previous section the main obligation in accordance with UNFCCC is to urge predominantly industrialized countries to lower emissions in a way that simultaneously provides developing countries access to financial support, technology-oriented agreements and sharing technologies for actions on climate change (UNFCCC, 2014).

According to recent studies (H. de Connck et al., 2008), existing international agreements on climate change demonstrate limitations when it comes to participation and effectiveness. Although existing international climate change agreements comprise binding procedural commitments, only certain provisions under international law are legally binding (C2ES.org, 2017). Certain countries with significantly high greenhouse gas emissions are not involved to the degree expected in international environmental governance. Examples include Australia where there is a tendency to reverse previous governments' climate policies and the United States intending to withdraw from the agreement in 2017. In light of this fact, other methods should be applied as alternatives towards implementing the principles of sustainable development and green economy. In this respect we share the position presented by H. de Coninck et al. (2008) addressing technology-oriented agreements (TOAs) as probable alternatives for existing international agreements. The TOAs are likely to be capable of increasing the overall efficiency and to be an integral part of the climate cooperation's architecture on the international level. In order to evaluate the extent to which TOAs are able to prove themselves as constructive in relation to climate change problems, it is necessary to review the main types of TOAs.

Considering agreements particularly aimed at technologies. The added value of TOAs should be assessed from the viewpoint of the interplay between near-term supply and demand for technology and also the longer-term market incentives for international trade and innovative technologies. In the context of TOAs, the obligations to actions under these agreements are determined in terms of technological development activities or technology-specific mandates and incentives, rather than in terms of the GHG emissions targets stipulated in the Kyoto Protocol. Hence, taking into account the scope of climate-mitigation strategies, four types of TOAs are classified below:

1. Knowledge sharing and coordination;
2. Research, development and demonstration (RD&D);
3. Technology transfer;
4. Technology deployment mandates, standards, and incentives.

The first type of TOAs comprises meeting, planning, information and experience exchange. These agreements are considered complementary to post-2012 international agreements on climate change. Knowledge sharing and coordination agreements tend to be low-cost relatively and have a high level of information exchange among parties and potential in the context of coordination, research agenda and technology implementation. Such partnership forums as The Carbon Sequestration Leadership Forum and the International Partnership for the Hydrogen Economy as well as The Methane to Markets Partnership, Energy Star bilateral agreements, Asia Pacific Partnership on Clean Development belong to this type of TOAs.

Activities under R&D (Research and development) are fundamental in their nature. They facilitate international scientific exchange of information and they increase the cost-effectiveness of research and developments through cost sharing and reduced duplication of effort. The European Organization for Nuclear Research serves as a good example of international research collaboration. Focusing on fundamental physics, this organization allows international cooperation among research groups for experiments in natural sciences and engineering.

Technology-transfer agreements undertake technology and project financing flowing from developed to developing countries, as well as potentially facilitating international licensing and patent protection. The idea behind it, is to encourage developing countries to develop a less GHG-intensive economy by support in obtaining climate-friendly technologies. The Multilateral fund for implementation of the Montreal Protocol and Global Environment Facility are the examples of Technology-transfer agreements.

Finally, Technology deployment mandates, standards, and incentives of TOAs include international agreements aimed at technology deployment by means of establishing deployment mandates for a specific technology or group of technologies (e.g., renewable portfolio standards),

international technology performance standards, such as automobile fuel economy or appliance efficiency), or technology deployment incentives (e.g., renewable subsidies). Examples for this type of TOAs include International Convention for the Prevention of Pollution from Ships as well as EU Renewables Directive.

Coninck et. al. (2008) identified five criteria according to which one can evaluate the contribution to international climate policy. Those are:

1. environmental effectiveness;
2. technological effectiveness;
3. economic efficiency and cost-effectiveness;
4. incentives for participation and compliance; and
5. administrative feasibility.

The criteria listed above help us to recognize the "design issues and trade-offs among TOAs" (Coninck et. al. 2008, p. 353). However, from the perspective of international climate change policy the successful implementation of these specific TOAs is rather complementary in nature than substitutional, since international climate agreements are more likely to be effective in terms of emissions reduction.

2.4. The EU obligations on a green economy under environmental agreements

The thesis also discusses the obligations of green economy under environmental agreements and regulations adopted by the European Union. Regarding the obligations on climate change particularly in Europe it is necessary to point out the most significant instruments under the climate action of the EU required to reduce general emission levels.

In order to demonstrate how the obligations on climate change are committed at the EU level, one should mention that the Kyoto Protocol's binding emission reduction targets by 2012 and 2020 respectively, were approved by all EU Member States. Reports of greenhouse gas emissions reduction are published by them on a regular basis. A key role in the commitment to the Kyoto Protocol obligations is played by the first instrument - *the EU Emissions Trading System* (EU ETS) based on the International Emissions Trading mechanism. The EU Emissions Trading System (EU ETS) was launched by the European Union in 2005 as the "cornerstone of its strategy for cutting emissions of carbon dioxide (CO2) and other greenhouse gases at least cost" (EU ETS, Publications Office, 2016). As the world's major carbon market - the Emissions Trading System continues to ever so the largest nowadays. The system of carbon trade based on measuring the financial value of each tonne of emissions allows companies in Europe to buy credits from projects designed to save emission projects around the world, in particular from countries that are considerable less developed. In this regard the EU ETS promotes research in low-carbon measures and clean technologies all over the world. Around 11,000 power stations, manufacturing plants as well as aviation activities are covered in the 28 EU Member States and countries

such as Iceland, Liechtenstein and Norway. Thereby EU ETS regulates approximately 45% of total EU greenhouse gas emissions (EU ETS, Publications Office, 2016).

When utilized as a key instrument, EU ETS obliges major emitters to scale down the greenhouse gas emissions by 21 percent by 2020 and by 43 percent by 2030 relative to the reference emission levels from 2005. The EU ETS is applied in the energy and industry sectors. For other, non-ETS sectors such as transport, agriculture, construction, minor industrial plants and waste, *the EU Effort Sharing Decision (ESD)* is provided as another instrument to diminish emissions by ten percent by 2020 and by 30 percent by 2030 respectively with reference to 2005 levels (Federal Ministry, 2017). Furthermore, a legislative proposal for the Effort Sharing Regulation (ESR) was presented by the European Commission in summer 2016 for the 2021-2030 period. This Regulation establishes binding national targets for the EU Member States on the reduction of emissions for the non-EU ETS sectors mentioned above. It covers 60% of the EU's total greenhouse gas emissions and thereby makes a valuable contribution to Europe's efforts in achieving the objectives set under Paris climate change agreement (Amaral, 2016).

When observing certain obligations and instruments stipulated by regulations for the Members of the EU, it is primarily referred to the Directive of the European Parliament and of the Council establishing a scheme for greenhouse gas emission allowance trading within the Community. Regulations of this kind serve as a good example of compatibility between international agreements and legislation of the EU. Assuming asymmetrical benefits and concerns of climate protection policy the outcomes of climate actions have a substantial influence first of all on major energy producing and consuming states. However, a very important requirement that explicitly addresses the whole Union as well as each of its members is that the mechanisms of implementation of this directive is supposed to be supplemental to domestic action and domestic action will accordingly establish a significant element of the overall effort.

Following the Kyoto Protocol approved by Council Decision 2002/358/EC of 25 April 2002, the obligations under agreement reached in Kyoto were ratified by the Community and its Members to diminish greenhouse gas emissions resulting from human activities. In cases where Member States surrender sufficient allowances to cover their emissions they are supposed to take into account certain consequences according to the regulations and directives on climate change within the EU. For example, as stated in the directive of the European Parliament and of the Council (2003), the restrictive measures concerning the allowed amount of emissions take the form of the payment of an excess emissions penalty. An excess emissions penalty amounting to 100 EUR was stipulated for each tonne of carbon dioxide equivalent emitted by an installation for which the operator has not surrendered allowances. The primary outcome expected from the implementation of this directive include increased adoption of more energy efficient technologies. One example would be combining heat and power technologies into

integrated systems which would produce less emissions per unit of output (The European Parliament and The Council of The European Union 2003, p. 37).

2.5. Green economy implementation in transport sector

The measures which contribute most effectively to green economy development particularly within the transport sector were investigated in this thesis. In a green economy, mobility needs are supposed to be diminished by means of better city design and planning. Green economy growth would be provided through high quality, low carbon transport, particularly through public transport, non-motorized transport and cleaner vehicles. Since better public transport services is a vital aspect which leads to a decrease in traffic congestion and to reductions in travel time it would definitely contribute to a better quality of life and raise the overall level of human well-being.

Investments in green transport technology are likely to promote the development of sustainable infrastructure and enable stimulation of ongoing government investment flows into the transport sector. From a long-term perspective such an attitude would be beneficial to the overall economy. The Table 1 below explicitly breaks down the economic impacts in each expense category (United Nations Environment Programme, 2011). Despite increasing road traffic, reducing emissions in the transport sector is an essential condition for the overall reduction of GHG. The CO_2 goals for cars and light commercial vehicles are accounted for in emissions regulations across Europe.

Table 1. Economic impacts per US $ 1 million expenditures (based on Chmelynski, 2008)

Expense category	Value added 2006 dollars	Employment FTEs	Compensation 2006 dollars
Auto fuel	1,139,110	12.8	516,438
Other vehicle expenses	1,088,845	13.7	600,082
Household bundles			
Including auto expenses	1,278,440	17.0	625,533
Redistributed auto expenses	1,292,362	17.3	627,465
Public transit	1,815,823	31.3	1,591,993

In accordance with the positive developing green economy trends, it is expected in the upcoming years that electricity will play an increasingly important role in the transport sector. Germany serves as an apt example here as it is one of the pioneers among the Member States facilitating electromobility, expanding rail transport as well as the employing of hybrid buses and increasing the market share of electric bicycles. In cities, measures relating to local public transport can reasonably be viewed as value

added to a green economy. Decisions aimed at the deployment of one million electric vehicles on Germany's roads by 2020 are actioned on the federal level (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2016).

We contend that in the context of this research, biofuels deserve particular attention. These are considered as a very significant instrument helping to reach the European GHG reduction targets in transport sector, particularly concerning road traffic management, and making it possible to achieve a share of ten per cent of renewable energy sources by 2020 in the transport sector. In this way biofuels represent an important complementary part of climate action goals that are aimed specifically at reducing fuel consumption and at shifting consumption towards diesel vehicles for new vehicles registered. In the long run perspective, a new generation of methane or liquid fuel, via chemical processes using green technologies based primarily on electricity, will play a crucial role in sustainability of the transport sector. For example, Power-to-Gas (PtG) methane and Power-to-Liquid (PtL), both of which use green electricity, are applicable especially in aviation and maritime transport, two sectors in which finding a viable alternative to chemical fuels is particularly difficult (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2016). In any case, the ambitions of the international community as well as the EU Member States to reduce emissions in the transport sector are likely to be fulfilled by means of deployment of efficient vehicles with lower consumption, as well as increased use of electricity as an energy source (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2016). In order to achieve the overall efficiency, international climate technology policies and agreements featuring sustainable technologies are required.

Interim conclusion

After gaining an insight into the concept of green economy, a broad overview of the international emissions reduction agreements was undertaken and thereby, the most significant steps taken toward international collaboration against the consequences of anthropogenic and technogenic influences on our environment were pointed out. The review performed of the most significant international emissions reduction agreements suggests that international policy and particularly international obligations on climate are the key instruments for achieving one of the most crucial objectives on the disputed matter, namely to reduce and control the level of GHG emissions.

We have addressed the international technology-oriented agreements as alternative agreements, which are supposed to allot emissions reduction obligations based first of all on technical possibilities (H. de Coninck at al., 2008). However, the main question concerning the development of green economy, is whether international and regional agreements, regulations and obligations existing in the international law are nowadays sufficient to meet and reverse the climate related problems. Is it

appropriate to evaluate the concept of green economy, its principles as well as obligations and mandates of the parties as an adequate global response to climate change?

Although the current international climate policies comprise binding procedural commitments, only certain provisions are legally binding and hence, the nation's commitment to obligations is unfortunately not guaranteed. This aspect causes limitations and shortcomings in the overall efforts to regulate emissions reduction system (c2es.org, 2017). At the same time, positive developments in dealing with environmental problems on national, international as well as regional levels are undeniably present, particularly in terms of fulfilling the obligations on GHG emissions and knowledge sharing and technology transfer. After all, one should note that the EU has succeeded in emissions reduction primarily due to the mechanisms adopted in the Kyoto Protocol and Paris Agreement, having decreased emissions by 23%. In addition, Member States remain the biggest donors of climate finance to developing countries with a contribution of €20.2 billion in 2016 (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, 2016).

2.6. The role of information and communications technologies in transport sector

Internationalization, demand shift towards emerging economies and other structural changes as well as regulations promoting openness of the markets are having significant effects on the European economic system. The influence of such changes on the transport sector is especially large considering the fact that transportation sector is mainly comprised of domestic infrastructure and providers. The European transport sector is characterized by competitive R&D investment and strong production and export positions, however there is a need to improve existing positions and adapt to emerging demands. This transformation to meet new needs necessitates the adoption of new approaches. Besides changing demands towards emerging economies, another challenge for the transport sector is energy issues. Even though there are many projects aiming to reduce the use of energy, it is projected that energy use will increase, including the use of energy in the transport sector which will result in rising prices. The goal to become less dependent on the fluctuation of prices has already pushed forward the development of new strategies and also materials to create more efficient and environmentally responsible transport sector. Currently transport industries are developing nanotechnologies. Some of the nano-materials that are currently being introduced into many transport industries are expected to reduce the weight of transport means therefore reducing consumption of energy and there are also materials to improve the transportation infrastructure itself. According to the authors of RACE2050 project, a major component of the transportation industry that could bring solutions to existing problems are ICT products (Moraglio, 2015).

Baptista et al. (2012, p. 716) stated that "information and communication technologies (ICT) hold the potential to dramatically change the way people drive and their mobility patterns, thus potentially reducing GHG emissions, air pollutants and fatalities". ICT technologies can be divided into three categories (Mulligan 2014):

1. Large-Scale Transport Systems. Means to improve existing systems across cities or in corporations are proposed.
2. Small-Scale Transport Systems. Innovations such as applications for smartphones and tablets to assist commuters with information on existing transport solutions. These applications are developed on the basis of the data available from different cities.
3. Industrial Disruption. Implementation of these means can be seen on both large and small-scale systems. The aim of such means is to disrupt the existing system by completely changing it or by introducing new players into the system.

Table 2. Examples of ICT solutions within three categories (based on Mulligan 2014)

Large-Scale Transport Systems	**Small-Scale Transport Systems**	**Industrial Disruption**
Intelligent Transport Systems	Transport Data Brokers	Ride Sharing
	Car and Bike Rental	Carpooling
	Taxi Services	Disrupting Last Mile Logistics
		Autonomous Vehicles

Intelligent Transport Systems

The most important systems that are currently implemented are Large-Scale Transport Systems. In particular, Intelligent Transport Systems, information marketplaces and information value chains are directly related to ITS. Therefore, these systems and their benefits have to be discussed separately. According to United Nations ESCAP (2015), intelligent transportation systems (ITS) are widely implemented within the transport sector in large cities. These systems are designed to advance the safety

conditions, improve efficiency and promote sustainability. The two important components often present in the discussion surrounding ITS are- Information Marketplaces and Information Value Chains, though the contribution of the second component to the development of the transport sector is questionable.

Some examples of enabling technologies that were summarised by Jarasuniene (2007) are listed below in Table 3.

Table 3. Examples of enabling technologies in ITS (based on Jarasuniene, 2007, p. 62)

ITS Enabling Technologies	Infrastructure Side	Vehicle Side
Location Referencing	• Digital maps • Geographical Information systems • Transport network databases	• Mobile phone location • Global Navigation Satellite Systems • Automatic Vehicle Location
Data Acquisition	• Traffic detectors • Weather monitoring • Automatic Incident Detection	• Automatic Vehicle Identification • Vehicle probes
Data Processing	• Data dictionaries • Data fusion • Data exchange	• On-board computers • Digital map matching
Communications	• Fixed microwave links • Optical fibre networks • Beacons (DSRC) • Cellphone networks	• DAB receiver • Cellphone receivers • Highway Advisory Radio, RDS-TMC receivers • Transponders
Information Distribution	• Dynamic Message Signs • Internet • Kiosks	• Handsets and Personal Digital Assistants • In-vehicle units
Information Utilisation	• Incident detection • Demand management • Congestion monitoring	• Route guidance • Advanced Driver Assistance Systems
Acronyms		
ADAS- Advanced Driver Assistance Systems AID- Automatic Incident Detection AVI- Automatic Vehicle Identification AVL- Automatic Vehicle Location DAB- Digital Audio Broadcasting DATEX- Data Exchange protocols		DMS- Dynamic Message Sign DSRC- Dedicated Short Range Communications GIS- Geographical Information System GNSS- Global Navigation Satellite System HAR- Highway Advisory Radio UTC- Urban Traffic Control

With a focus on the improvement of traffic efficiency ITS can contribute to sustainable development by providing the following benefits United Nations ESCAP (2015):

- *Efficient traffic management.* Development of ITS within transport sectors is a sufficient measure to reach more efficient traffic management. Intelligent transportation systems that have been implemented in some countries have helped to reduce traffic jams and shortened durations of travel. One of these countries is the Republic of Korea, where the implementation of ITS contributed to the increase of traffic speed by 15-20%. One of the features of ITS, real-time information about traffic, also contributed to a reduction of traffic jams, because drivers can avoid congested roads and regulate their speed. Better traffic efficiency allows traffic managers to solve traffic incidents more efficiently and prevent congestion by informing drivers about potential hazards.
- *Reduction in carbon emissions*. One major source of CO2 emissions in the transport sector is road transport, constituting over 74 per cent of all emissions in this sector. Therefore, the reduction of traffic overload would benefit the environment by reducing exhaust emissions that are also considered to have a significant contribution of pollutants. The example of Korea that has implemented ITS can prove this claim by means of the positive projections made for its future. The Department of Transport in the Republic of Korea reported that implementation of ITS in Korea is characterised by positive contributions to the reduction of greenhouse gas emissions as well as to the decrease of fuel consumption conditioned by the reduction of overload on roads and prevention of idling of motor vehicles. Trends for the future reveal that a 12 percent reduction in CO2 emissions will be achieved by the year 2020. Environmental benefits can be also gained from the implementation of integrated ITS means designed for individual vehicles. These measures can contribute to a reduction of carbon emissions by 15 per cent. Implementing Advanced Public Transportation System (APTS) would have a positive effect on the punctuality of public transport and its usability and as a result increase populations demand for public transport. Therefore, there will be less of a need and/or incentive to travel by private cars, causing a decline in greenhouse gas emissions.
- *Economic value.* Improved efficiency of transport infrastructure due to the introduction of ITS solutions can benefit the economy of a country employing them. ITS benefits the economy in different ways. For example, real-time information contributes to the improvement of existing infrastructure. Improved transportation of goods and people increases productivity and therefore benefits the economy. The example of Scandinavia demonstrates that freight tracking systems of ITS as well as on-board information systems that contribute to the reduction of route length, decreased freight movement by 15 per cent. Besides the development of a better

infrastructure, ITS also can also create a demand for integrated industries that are necessary for the infrastructure and ITS services. Some of the sectors positively affected by the introduction of ITS are: software and engineering, communication networks and automobile manufacturing among others. Due to developments in different sectors and the contributions that are made to the transportation sector as a whole, new high skilled jobs are also created. Projections made by the Department of Transportation in the United States demonstrate that implementation of ITS will contribute to the creation of 60000 new jobs in the next 20 years. The problem of poverty can also be partly addressed by the implementations of ITS solutions that will decrease the costs and reduce the time of traveling. This is especially relevant for highly populated and still developing third world countries where large fractions of the population live in areas that do not have sufficient means of transportation to reach urban places for work or other economic activities. Transport solutions for such isolated places would increase opportunities present to those that are residing in such areas.

Transport Data Brokers

The number of smartphone applications designed for drivers to facilitate their interactivity and networks is increasing. The increasing number of smartphone users positively affects the development of mapping services within the transport sector. While previously limited to general-use maps, today mapping services have specially generated maps all around the world. Some actors in the transportation industry collect and combine data from different sources and develop transport services such as Citymapper, an application which provides real-time information for its users. These services not only benefit the users but also help developers by providing information on what users think of their travel services and commutes (Mulligan, 2014).

Car and Bike Rental

Technologies increase the efficiency of rental services that enable individuals with no access to private means of transport to rent cars or other transport means such as bike. For these services, digital technologies are not enough. There is a necessity for real estate where such cars and bikes can be located. However, it is worth developing such services because estimations made in this area suggest that such services significantly reduce the number of cars in large cities. For instance, just one such shared vehicle avoids the purchasing of 32 personal vehicles (Mulligan, 2014).

Taxi Services

These organizational solutions are also present in taxi services. Applications are developed for smartphones that allow users to request a taxi based on proximity to their current location.

Ride Sharing and Carpooling

One practical realisation of applying ride sharing principles or alternatively "shared economy" are Uber and Lyft. These applications allow the users to book a space in the car of a person who registered as a driver. Potential drivers have to pass security checks and are only allowed to register as drivers upon successful completion. These services are presently competing with taxi services. Carpooling services work in a different manner. In this case, people traveling in the same direction are brought together. People driving their cars enter information regarding their destination and the number of free spaces available into the system. Users looking for a car can access this information online and join sharing the costs of travel with the driver as well as other passengers. Such applications include RideJoy (Mulligan, 2014) and BlaBlaCar (blablacar.com).

Disrupting Last Mile Logistics

Currently, the work environment in many companies is characterized by high pressure and a lack of spare time that can be spent visiting local shops or collecting bought items. Therefore, the development of "Last Mile Logistics" can benefit both customers and local businesses that are under pressure from internet shops. These services can benefit customers by saving their time and benefit businesses by increasing competitiveness with online shops. In practice this can be seen mainly in restaurant and similar businesses. However, there are also examples of so called "last mile brokers" in different large cities that provide delivery services for any commodities including designer clothes, bike parts etc. One such company is PostMater operating in the United States (Mulligan, 2014).

Autonomous Vehicles

The development and use of autonomous technologies is increasing in today's innovative world, these new technologies bring changes to the use of energy as well as to emissions of greenhouse gas (GHG). For autonomous vehicles the precise model of implementation of these technologies within the economy is not developed yet. There are many obstacles in the way of implementing autonomous vehicles, such as high costs of research, regulatory needs as well as the need for public acceptance. Despite high investments and increasing research in this area, autonomous vehicles will need time to be widely implemented (Barcham, 2014).

Currently there are two opposing views regarding the time these vehicles will be widely implemented: optimistic and pessimistic. The optimistic view presents the idea that autonomous vehicles will be widely implemented starting from 2020-2025. On the other hand, the pessimistic view suggests that it will take decades until autonomous vehicles will become widely present within markets. Despite difficulties in the implementation of autonomous vehicles, other kinds of vehicles using alternate fuels are widely spread around the world, such as electric cars and hybrid cars. However, there is still a large difference between those other types of cars that are already fully developed and autonomous vehicles.

These vehicles will benefit society not just with great increase in safety conditions but will also have a definite impact on climate mitigation. The impacts these vehicles can bring are presented in Table 4. The impacts of the introduction of autonomous vehicles cannot be foreseen yet, as there is no clear model or mechanism developed (Barcham, 2014).

Table 4. Impacts of autonomous vehicles (based on Barcham, 2014, p. 3)

Impact	**Mechanism**	**Outcome**
Fuel efficiency	Eco-driving; platoons; lighter vehicles	Increase
Travel demand	Cheaper travel; underserved groups; Shared vehicle model shrinks fleet	Ambiguous
Secondary land use impacts	Sprawl; reduce parking area	Ambiguous

Figure 11 outlines the novel solutions of ICT implementation in the transport industry. These technological solutions can bring different effects that range from being beneficial by improving efficiencies to detrimental by causing disruptions.

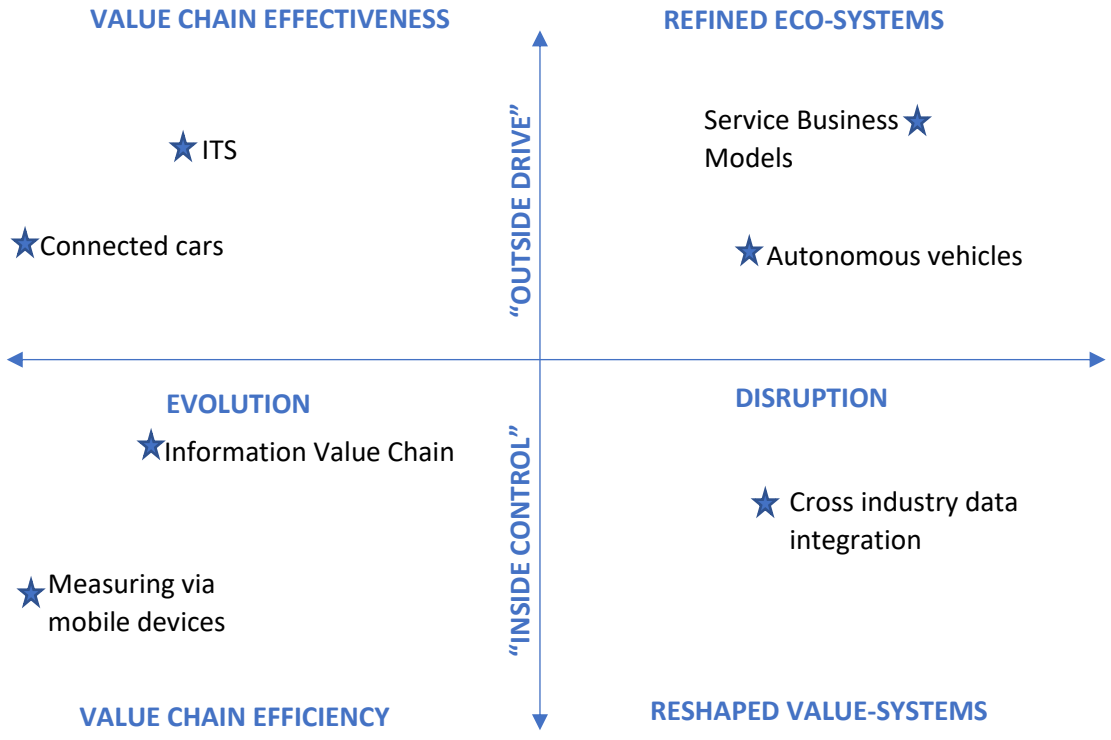

Figure 11. Novel ITC solutions for transport industry (based on Mulligan, 2014, p. 32)

ICT technologies are rapidly developing. Positive effect of these technologies is that such technologies can be implemented in different sectors and do not necessary require high costs of implementation. Solutions such as ridesharing or carpooling are very beneficial for society in terms of climate change mitigation and at the same time do not require high cost. Of course, there are innovation that might cost large amount of capital, such as autonomous vehicles, however there is flexibility in choice technologies.

Scientific literature discussed in this section provided sufficient basis for the research problem of this thesis. However, the empirical analysis of Lithuanian economic sectors, in particular the transport sector, is necessary in order to implement most suitable solutions for Lithuanian sustainable growth. Therefore, the next section presents methodology for empirical analysis.

1. METHODOLOGY OF ECONOMIC ASSESSMENT OF INNOVATIONS IN THE ROAD TRANSPORT SECTOR

Analysis of existing literature did not provide us with a specific method to study the innovative activities within Lithuanian economy and the transport sector in particular. In the absence of a precise method, it was decided to employ correlation analysis from secondary statistical data. Correlation analysis will allow us to examine mutual relationships between variables, even though we can only assume the direction of causality. Besides correlation analysis we will locate, analyse and illustrate topic related secondary data from www.stat.gov.lt and http://ec.europa.eu/ as well as from scientific literature.

Research question- how to assess innovations in road transport sector in terms of climate change and what can be done to promote responsible innovative behaviour of enterprises in this sector.

Object of the analysis - innovations in transport sector

Goals of the analysis:

- To demonstrate the impact of the transportation sector on climate change;
- To prove that innovations aimed at reducing GHG emissions which effect climate change do indeed provide positive results;
- To identify factors hampering innovative activities within firms and propose appropriate measures to overcome those factors.

Hypotheses:

Hypothesis 1 – That largest contributor to the greenhouse effect in the transport sector is road transport.

Hypothesis 2 - There is a positive relationship between R&D investment and GDP per capita, i.e. an increase in R&D investment will increase GDP per capita.

Hypothesis 3 - There is a negative relationship between R&D investment and GHG emissions, i.e. an increase in R&D investment will decrease GHG emissions.

Structure of the analysis:

Step 1. Use correlation analysis to analyse GHG emissions within the Lithuanian transport sector. Data for both passenger transportation and transportation of goods will be analysed. The time period to be analysed is from 2002 to 2014.

Step 2. Correlation analysis will be used to analyse the effects of R&D on GDP per capita and GHG emissions. The time period be analysed here is from 2005 to 2015.

Step 3. Analysis of innovative activities within all firms including those that are engaged in the transport sector. The goal of this step is to identify:

- The share of innovative enterprises compared to all enterprises for each sector of the economy, including the dynamics over the past few years;
- The share of environmental innovators compared to all other innovators in each sector of the economy;
- Factors hampering innovative activities of firms;
- Cooperation between enterprises in innovative activities.

Step 4. Proposal of measures to increase environmental innovativeness in the road transport sector to reduce to harmful consequences of road transport through the removal of obstacles to innovation. Both statistical data and scientific literature will be analysed.

In the next section, the analysis using this method is performed, using the results of the analysis solutions to the problems that were identified are proposed. After the analysis final conclusions were presented.

4. RESULTS OF ECONOMIC ASSESSMENT OF INNOVATIONS IN LITHUANIAN ROAD TRANSPORT SECTOR

4.1. Transport sector and GHG emissions in Lithuania

The transport sector of the Lithuanian economy consists of four types of transportation: air transport, railway transport, road transport and water transport. Correlation analysis was performed to identify which type of transportation is particularly important to meet climate change obligations. Our *Hypothesis 1* which states that the largest contributor to greenhouse gas emissions is road transport will be checked in this part of the analysis.

The transport sector of the Lithuanian economy can be divided into passenger transportation and transportation of goods. As such, in this analysis we discuss both areas of the transportation sector.

Passenger transportation:

To analyse how passenger transportation via all modes of transport affects the volume of GHG emissions, an attempt to prove that the number of passengers transported and GHG emissions (in CO2 equivalent) are positively correlated variables was made. Data taken into consideration for this analysis is for the period from 2002 to 2014. As a guideline to better interpret R^2 values that were calculated we refer to the work of Henseler et al. (2009) where the authors suggest using an interpretation of R^2 coefficients proposed by Chin (1998). This work interprets a coefficient of 0.19 as an indication of a weak relationship, 0.33 as evidence of a moderate relationship and 0.67 corresponds to a substantial relationship. As the exact value of the coefficients calculated in this work differ from those of Chin (1998) we will assume the closest value to our results. Results of the correlation analysis are summarised in Table 5.

Table 5. Passengers transported by all modes of transport compared to GHG emissions (in CO2 equivalent).

Type of the transport	**Relationship with GHG emissions**	**R^2 coefficient**
Air transport	Moderate positive relationship	0.38
Railway transport	No relationship identified	0.032
Road transport	Substantial positive relationship	0.654
Water transport	Very weak/no relationship identified	0.123

From Table 5 illustrated above we can observe that no relationship exists between the number of passengers transported by railway transport and GHG emissions. This suggests that increasing or decreasing the number of passengers transported by railway transport doesn't increase nor decrease GHG emissions. The R^2 coefficient, 0.032 in this case, reveals that only 3.2 % of the variation in GHG emissions data can be explained by the number of passengers transported by railway transport. Water

transport yields relatively similar results. The number of passengers transported by water transport has very weak or no effect on greenhouse gas emissions. The transport modes that do have an effect on greenhouse gas emissions are air transport and road transport, these modes have a moderate and a substantial relationship with GHG emissions respectively. The R^2 coefficient of 0.38 is interpreted as an indication that 38% of variation in the data of GHG emission can be explained by the number of passengers transported by air. The strongest positive relationship is observed between the number of passengers transported by land and greenhouse gas emissions, this relationship is illustrated in Figure 12.

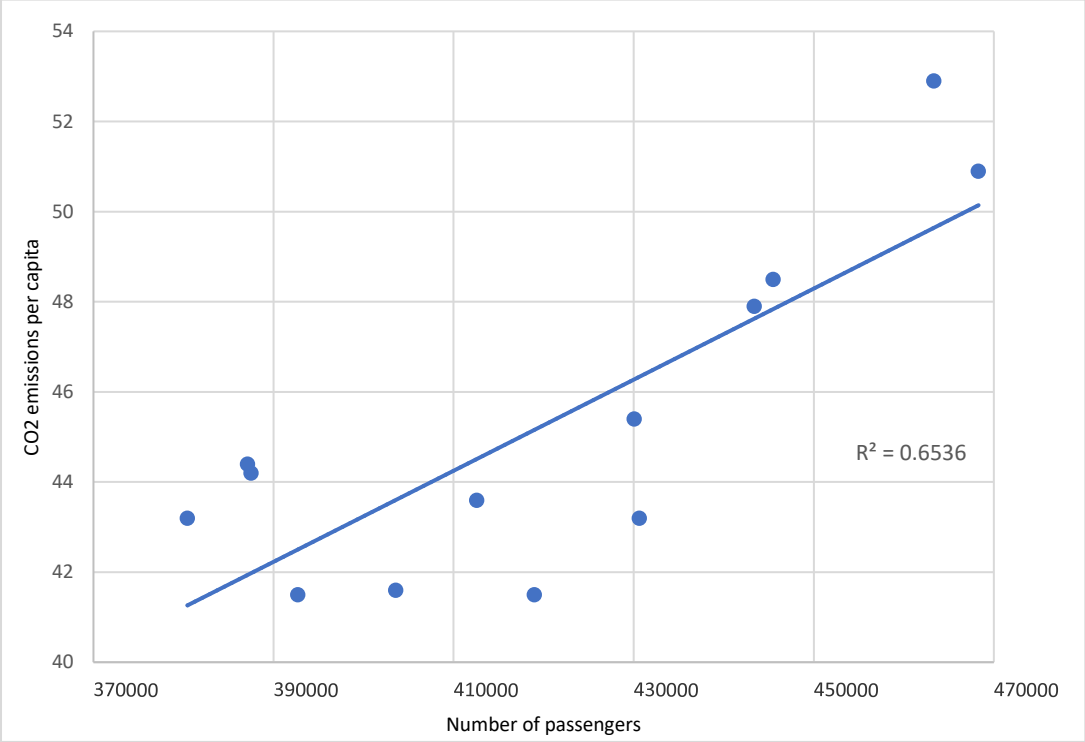

Figure 12. The relationship between the number of passengers transported by land and GHG emissions (in CO2 equivalent) for the period from 2002 to 2014 (based on the data from https://osp.stat.gov.lt and Eurostat)

Upwards slope of the line, illustrated in a Figure 12, indicates a strong positive relationship between the numbers of passengers transported by road transport and GHG emissions, suggesting that an increase (decrease) in the number of passengers transported by road transport will cause an increase (decrease) in GHG emissions. R^2 which in this case is equal to 0.654 tells that the number of passengers transported by road transport accounts for 65.4% of the variation in the dependent variable which is - GHG emissions.

Transportation of goods:

The transportation of goods is responsible for significant effects on pollution and climate change. The requirement to transport goods also increases rapidly with the growth of the economy. Therefore, in this

part of the analysis it was investigated which type of the transportation of goods has the largest effect on the GHG emissions. The approach applied in this part is identical to the approach used to analyse transportation of passengers.

Table 6. Goods carried by all modes of transport compared to GHG emissions (in CO2 equivalent).

Type of the transport	**Relationship with GHG emissions**	**R^2 coefficient**
Air transport	Moderate positive relationship	0.465
Railway transport	Moderate positive relationship	0.377
Road transport	Moderate positive relationship	0.498
Water transport	No relationship identified	0.053

In Table 6 presented above it could be observed that in the transportation of goods only water transport showed insignificant correlation with GHG emissions. The other three modes of transportation of goods have moderate correlation with GHG emissions, the lowest of which is observed in railway transportation ($R^2 = 0.377$), with air transport coming in second place again ($R^2 = 0.465$). GHG emissions are most highly correlated with goods carried by road transport ($R^2 = 0.498$) as illustrated in Figure 13.

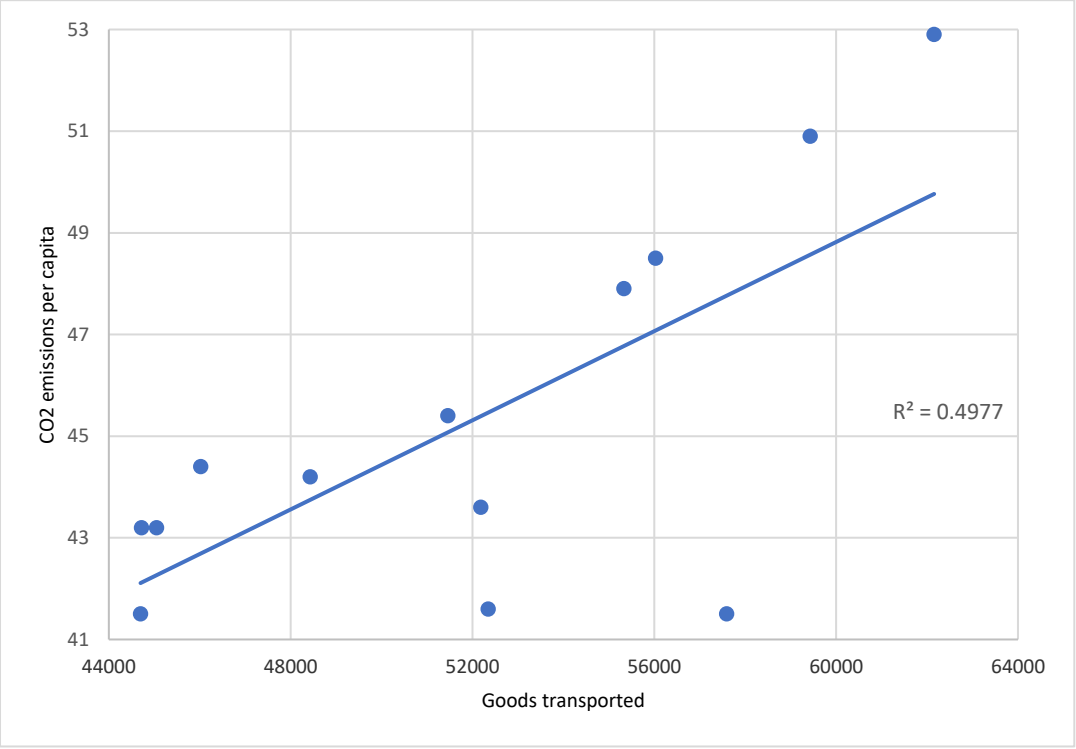

Figure 13. The relationship between goods transported by road transport and GHG emissions (in CO2 equivalent) for the period from 2002 to 2014 (based on the data from https://osp.stat.gov.lt and Eurostat)

The upwards slope of the trend line in Figure 13 indicates a strong positive relationship between the transportation of goods by road transport and GHG emissions, suggesting that an increase (decrease) in goods transported by road transport will increase (decrease) GHG emissions.

The main finding of the correlation analysis between transportation of passengers/goods and GHG emissions just conducted is:

- *Hypothesis 1* is confirmed: in the area of passenger transportation as well as goods transportation, the largest contributor to GHG emissions is road transport

4.2. R&D investment: increase in GDP per capita and decrease in GHG emissions

In this part of the analysis were tested next two hypotheses. First, intensive R&D investment leads to an increase in gross domestic product. Second, R&D investment leads to the reduction of GHG emissions. To prove these hypetheses we test the presence of a postive linear relationship between R&D investment and GDP per capita and the presence of a negative linear relation between R&D investment and GHG emissions respectively. Data on R&D investment (expenditures) and GHG emissions is selected from eurostat while the data on GDP per capita is taken from stat.gov.lt.

Results of the correlation analysis performed to prove *Hypothesis 2.* The results are illustrated as a linear relationship in Figure 14.

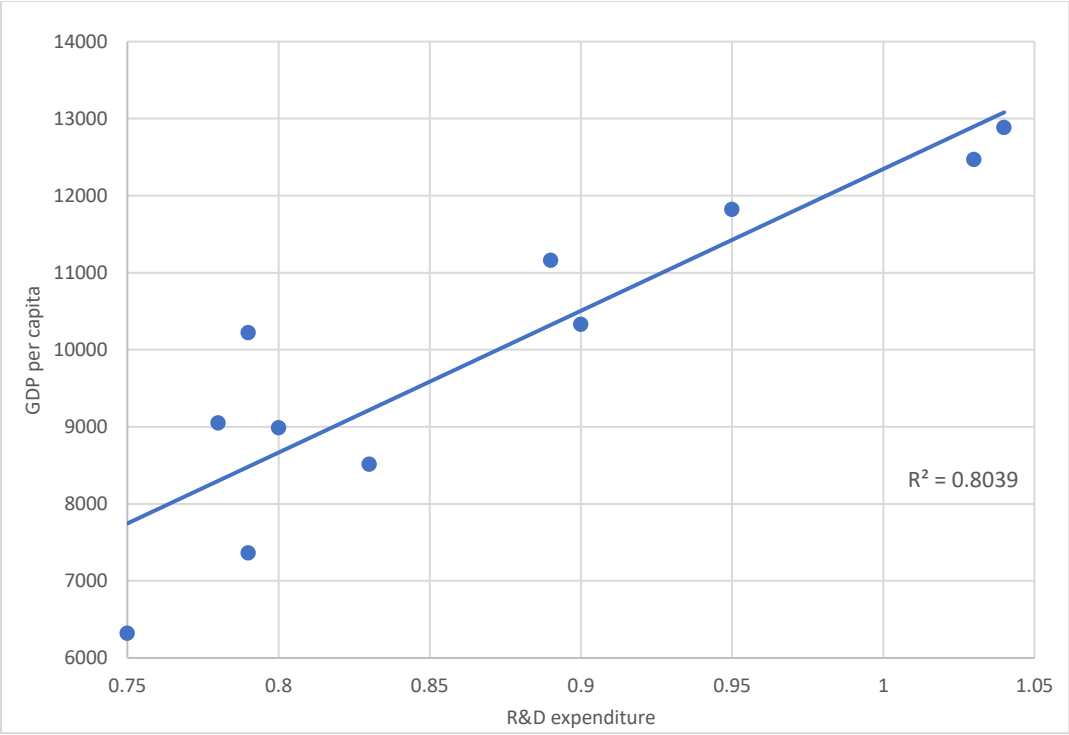

Figure 14. Relationsip between R&D expenditures and GDP per capita (from 2005 to 2015) (based on the data from https://osp.stat.gov.lt and Eurostat)

Upwards slope of the line in Figure 14 illustrates a strong positive relationship between R&D expenditures and GDP per capita. The R^2 coefficient, which is equal to 0.804, tells us that 80.04% percent of the variation in data for GDP per capita is attributable to R&D expenditures. The positive relationship between innovations and economic growth is not a novel finding. The positive impact of

innovations on domestic economic growth and the revenue of enterprises has actively been studied since the times of the industrial revolution and our analysis proves that the Lithuanian economy is no exception. Increasing attention to innovative activities positively affects the economic performance of a country. Unfortunately, due to the lack of data we are not yet able to perform correlation analysis within different sectors of the economy.

Further the *Hypothesis 3* was tested. The results of the correlation analysis are illustrated in Figure 15. In this figure can be observed downward slope of the trend line demonstrating a negative linear relationship between R&D investment and GHG emissions which suggests that an increase (decrease) in R&D investment leads to a decrease (increase) in GHG emissions. The R^2 coefficient in this case is 0.429, which is not quite as high as in the case of GDP, however it is significant and can be interpreted as moderate according Chin (1998), as cited by Henseler et al. (2009).

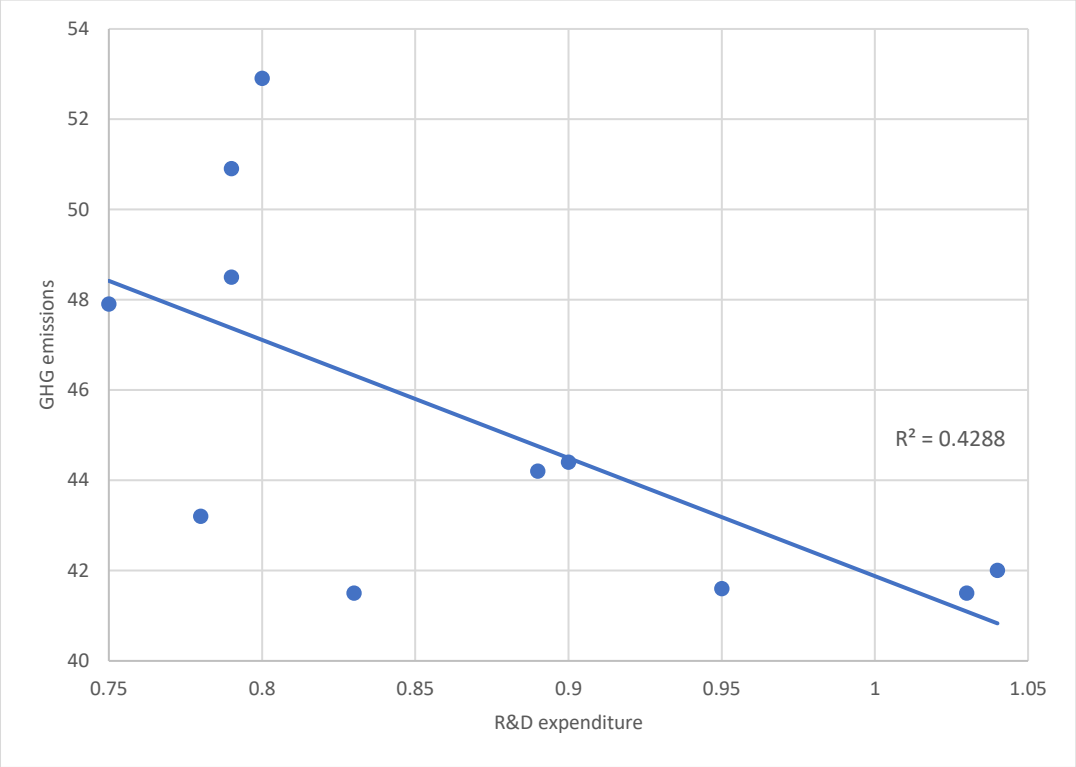

Figure 15. Relationsip between R&D expenditures and GHG emissions (from 2005 to 2015) (based on the data from https://osp.stat.gov.lt and Eurostat)

4.3. Innovative activities within all sectors of Lithuanian economy

In Figure 16(a) we observe that most innovative enterprises in the given time period have been those that are engaged in financial and insurance activities. Second place is occupied by enterprises related to electricity, gas, steam and air conditioning.

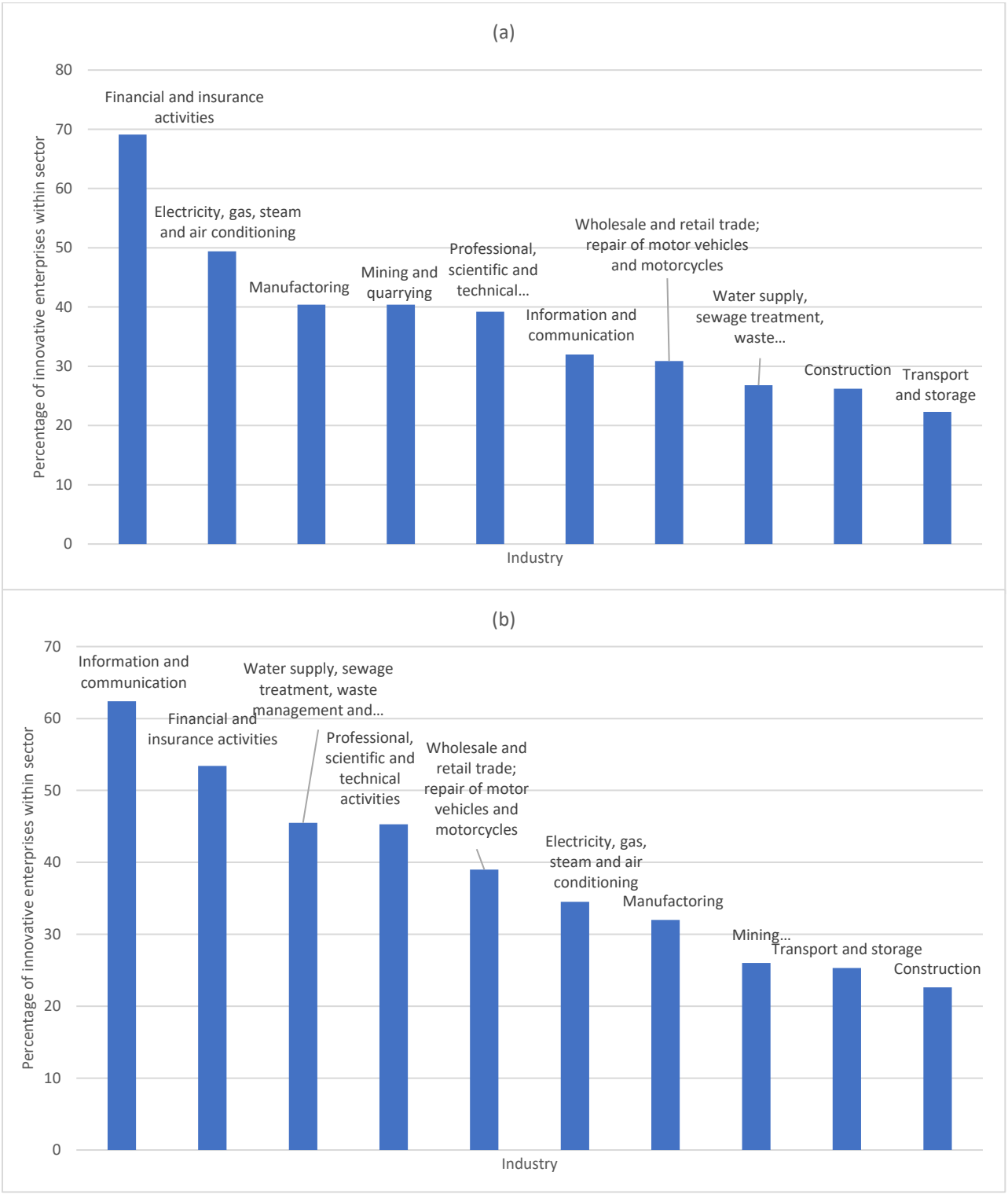

Figure 16. Innovative enterprises in Lithuania by sector compared to all enterprises. (a): Percentage of innovative enterprises during 2002-2004. (b): Percentage of innovative enterprises during 2008-2010 (based on the data from https://osp.stat.gov.lt)

Companies engaged in manufacturing, mining and quarrying as well as those engaged in professional, scientific and technical activities performed well. The enterprises with the least interest in innovative activities from 2002 to 2004 were those engaged in transportation and storage. In part (b) of this figure however, an increase of innovativeness in enterprises engaged in economic activities within transportation and storage sector can be observed. A very large increase in the proportion of innovative

enterprises compared to all enterprises can been seen in the information and communication sector. All other enterprises demonstrate negative results except for those that engage in wholesale and trade; repair of motor vehicles and motorcycles as well as those that operate in professional, scientific and technical activities.

As an approximate of the current performance of enterprises we view the latest data available from 2014. Figure 16 illustrates innovative enterprises in Lithuania by sector compared to all enterprises for the period from 2012 to 2014. In this figure positive changes in innovative activities in the transport and storage sector during this period compared to earlier periods (see Figure 16(a)) can be observed. 32.5% of enterprises in transport and storage sector are considered innovative. Positive tendencies towards innovativeness can be observed in almost all sectors. A small decrease can be seen in enterprises engaged in professional, scientific and technical activities. Enterprises engaged in financial and insurance activities are becoming less innovative, a fact that is observable across all analysed periods. Despite the positive tendencies observed in the transport and storage sector, this sector is still outperformed by almost every other sector with the exception of construction. Enterprises in information and communication are almost twice as innovative as those in the transport and storage sector.

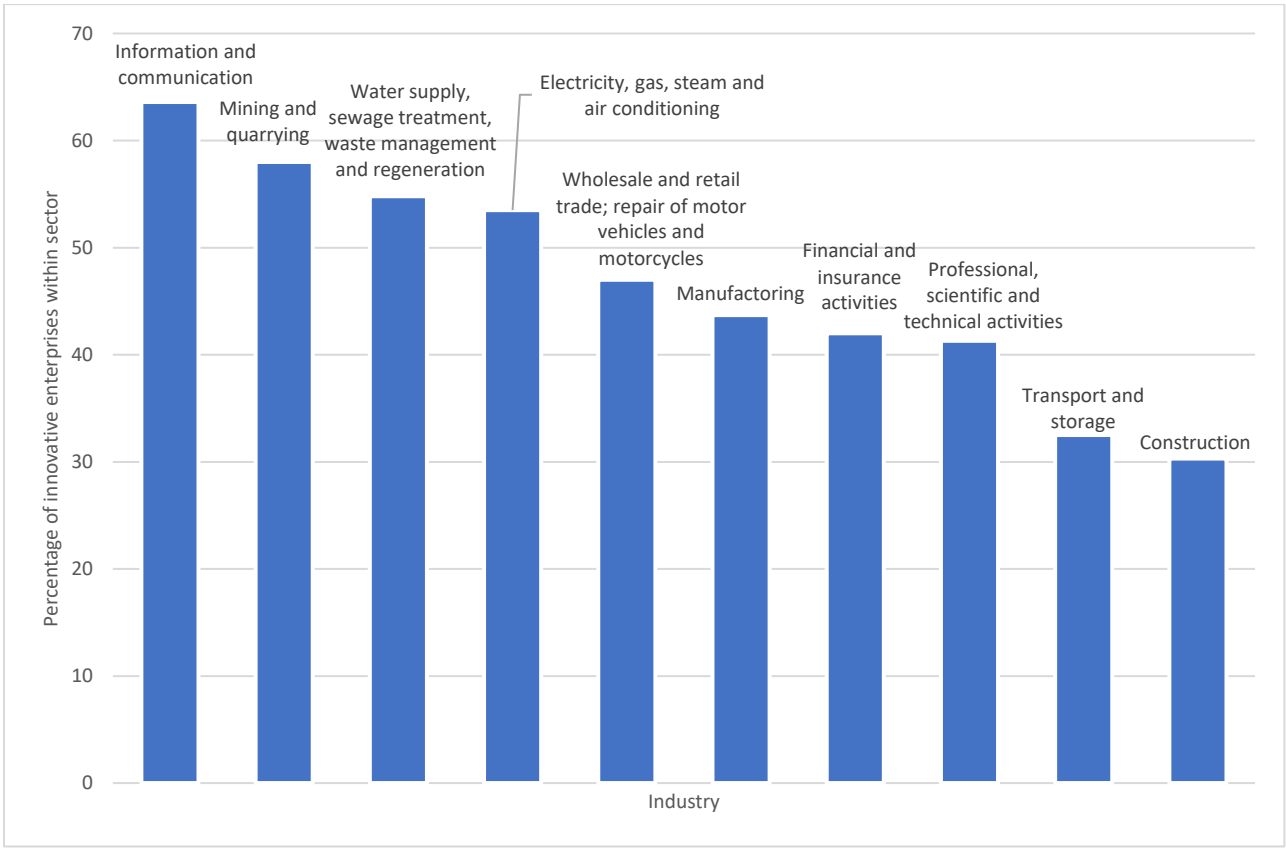

Figure 17. Innovative enterprises in Lithuania by sector compared to all enterprises. Percentage of innovative enterprises during 2012-2014 (based on the data from https://osp.stat.gov.lt)

Increasing innovativeness of enterprises doesn't necessarily have a positive impact on the environment. Firms can innovate to have higher revenue through costs reduction with the help of technological development, to meet customer demands, or to create a better public image of the company. Therefore, it is necessary to distinguish innovativeness aimed at environmental sustainability. This is done in the Figure 18 which demonstrates the percentage of innovative enterprises engaged in innovative activities for environmental sustainability in the period from 2012-2014. The leading enterprises in this case are those engaged in electricity, gas, steam and air conditioning as well as those that operate in water supply, sewage treatment, waste management and regeneration. Over 81% of innovations in these enterprises are introduced to address environmental issues within these economic activities. Enterprises engaged in financial and insurance activities afford the least attention to innovating for environmental sustainability. Above average performance compared to other sectors can be observed in transport and storage sector, where 61.7% of innovations in enterprises operating within this sector are introduced for environmental sustainability.

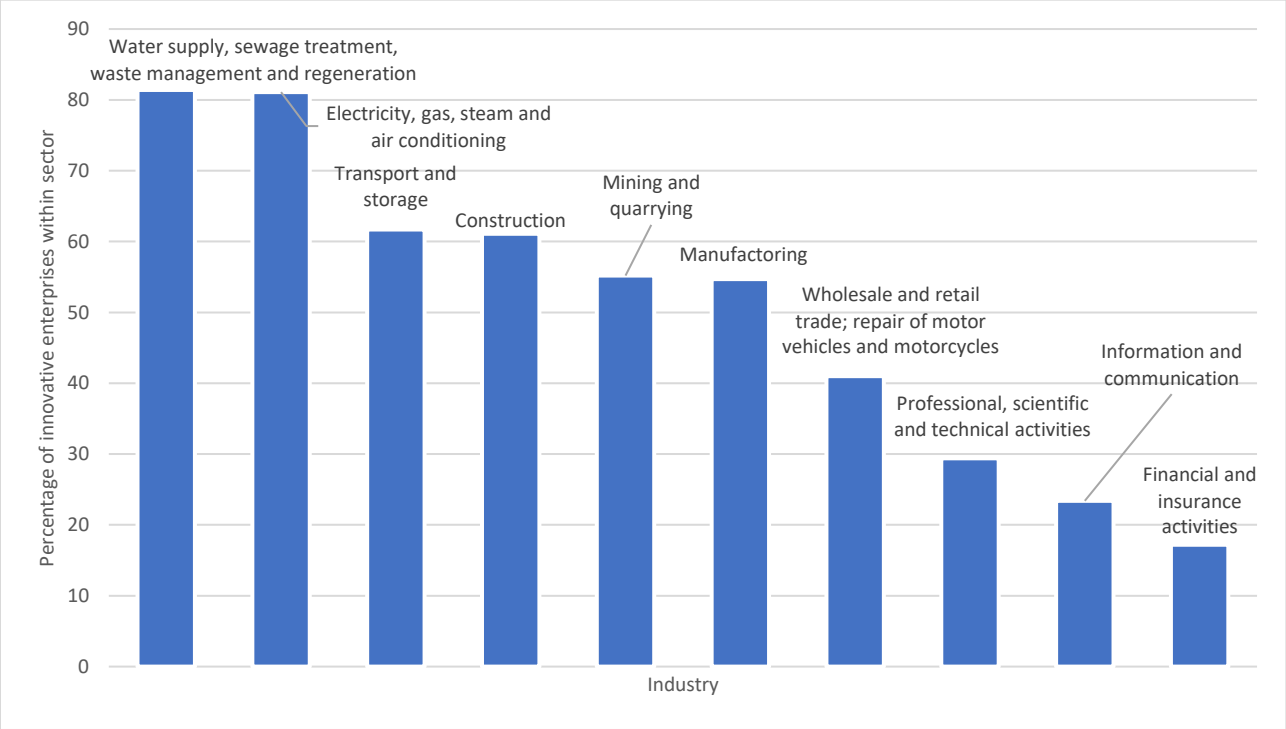

Figure 18. Environmental innovativeness in the period 2012-2014 (based on the data from https://osp.stat.gov.lt)

To better understand the reasons behind innovative stagnation of some enterprises it is important to identify factors hampering technological innovation activities. Once identified, measures could be taken to address these factors in order to promote innovation within all enterprises. Lithuanian statistical department has collected information within different enterprises to identify these factors. Data set are only available for the period from 2002 to 2010 as shown in Table 7. After the year 2010, data to identify factors hampering technological innovation was not collected.

From the data presented in Table 7 it can be observed that the major reason why firms do not engage in innovative activities is due to the lack of the financial resources. A large number of firms do not innovate due to the lack of funds in the company or group of companies. Another reason given is the high costs of innovation. Pressure from market leaders is also cited as an obstacle to innovation. One interesting fact is that concerns regarding the high costs of innovation have been increasing over time and lack of funding from other sources has become more prevalent in recent years. This could be the result of firms being ill-informed about projects supporting innovative activities or that they are not well informed about current innovations. For example, 20.8% of companies in the period from 2008-2010 did not innovate because old innovations met their needs and 16.5% did not wish to innovate because of the absence of demand. These two reasons could indicate that some companies are only interested in innovation for their own financial benefit and the environmental aspect is likely being completely ignored in such cases.

Table 7. Factors hampering innovation activities within all sectors of Lithuanian economy, % (based on https://osp.stat.gov.lt)

	2002-2004	2004-2006	2008-2010
Lack of funds in the company or group of companies	24,7	21,4	28,7
Lack of funding from other sources	15,5	12,5	21,0
Too high costs of innovation	23,4	24,6	29,6
Lack of qualified staff	10,7	20,0	14,2
Lack of information about technologies	3,9	4,8	7,2
Lack of market information	4,2	5,1	6,9
Difficulties in finding partners for innovation	7,8	10,4	14,4
The market is dominated by recognized companies	21,1	22,2	22,2
Low consumer demand for innovative goods and services	10,8	12,1	19,2
There was no need to innovate because previous innovations were enough for the company	11,2	16,7	20,8
There was no need to innovate because of the absence of demand	6,5	13,5	16,5

Over the past years, the number of companies expressing concerns about their inability to find partners has been increasing. This is cause for concern and should not be left unattended as in order to innovate responsibly, cooperation and openness between firms is necessary (see Table 7). Openness and cooperation between companies could also partly solve other problems that firms have, for instance the sharing of information about markets and technology or sharing costs of innovation. Given the high importance of cooperation between innovating firms, it is necessary to confirm the data from the survey presented in Table 7 against cooperation statistics before we propose possible solutions to this problem.

Figure 19 illustrates the percentage of enterprises which had cooperation partners in innovation activities analysed over the period 2012-2014. Enterprises that operate in financial and insurance activities are the most cooperative, despite the fact that these enterprises rarely engage in innovative activities that benefit the environment (as evidenced in Figure 18). These enterprises developed 65.7% of their innovations in cooperation with partners. The Second highest percentage (53.1%) of cooperation in period analysed was in water supply, sewage treatement, waste management and regeneration sector which is very close to the results for transport and storage sector (52.6%). Enterprises engaged in professional, scientific and technical activities as well as those engaged in wholesale, retail trade and repair of vechicles and enterprises operating in mining and quarrying have an average cooperation level compared to all other enterprises. Manufactoring and construction enterprises are cooperating in innovative activities less than all other companies, 37.3% and 37.4% respectively.

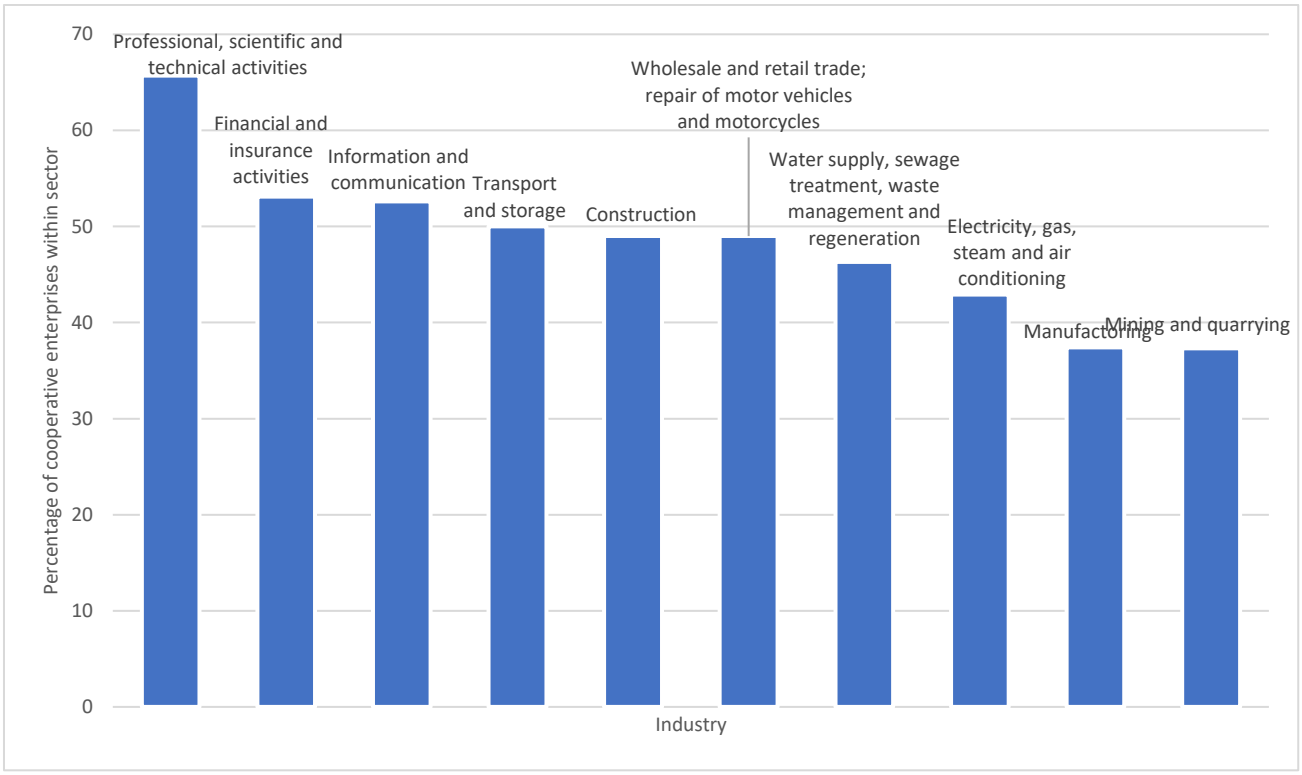

Figure 19. Enterprises which had cooperation partners in innovation activities by sectors for the period of 2012-2014, % (based on the data from https://osp.stat.gov.lt)

The cooperation of innovating enterprises has actually descreased over time (see Figure 19). The decrease in cooperation is not that drastic if we consider enterprises from all sectors without distinction, however the situation in the transport and storage sector is different. There was a significant deacrease in cooperation from the period of 2002-2004 to 2006-2008. After this period cooperation levels increased but never returned to the original levels. Currently, only 52.6% of enterprises in the transportation and storage sector innovate in cooperation with partners while in the period 2002-2004 this number was significantly higher. 78.2 percent of enterprises innovated in cooperation with partners.

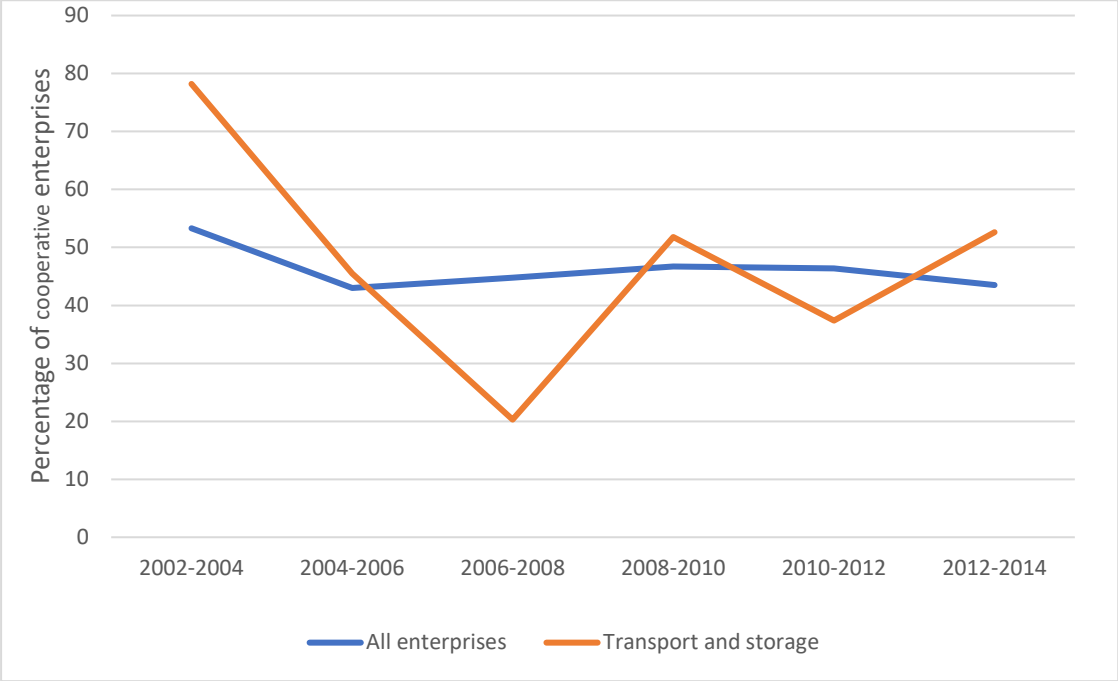

Figure 20. Dynamics of cooperative innovation from 2002 to 2014. *(*based on the data from https://osp.stat.gov.lt)

4.4. Measures to increase sustainability oriented innovative activities in Lithuania

Analysis of the outcomes of innovation revealed several reasons why some enterprises do not engage in innovative activities. Measures were proposed to increase innovativeness of firms taking into account the reasons identified:

- Lack of consumer demand disincentivizes the pursuit of environmental innovations;
- Lack of cooperation between innovating firms;
- Lack of external financial support;
- Lack of financial resources within the firm.

Environmental demand

Orientation of enterprises to meet customer demands regardless of what the environmental prospects are is not a favourable strategy for sustainable development nor for long term perspectives of business. Firms operating in the transport sector must understand that climate change will have a significant effect on their long term performance. As such, measures to reduce harmful activities triggering climate change as well as strategies to adapt to the consequences of climate change must be considered.

The transport industry must respond to the demands of an increasingly pressing climate change problem. This is an issue that can potentially bear dire consequences on the continued operation of the sector as a whole through various mechanisms including: rising sea levels, storms, rain, flooding and

higher temperatures. The National Climate Change Action Plan (NCCAP) outlines some of the major impacts on transportation businesses (Kepsa, 2014):

- Heavy storms and high seas have the potential to destroy port infrastructure.
- It is much more likely and already becoming commonplace for roads and bridges to suffer catastrophic damage during extreme weather events.
- Sudden torrential rainfall causes flooding leading to mass disruptions in all forms of transportation networks including maritime, road, rail and air.
- Extreme heat deforms pavement and tarmac creating irregularities such as ruts and potholes in addition to warping rail tracks. This necessitates repair work and the introduction of disruptive measures such as speed restrictions.
- Weather related causes can block supply chain, put drivers in danger, introduce delays and increase costs.
- Weather conditions can lead to scarcity of water or other raw materials. When these are not locally available, the operating costs of companies will rise as they need to be transported in.

As such, it is evident that climate change will drastically change the choice of goods being transported as well as the methods employed by modern transportation companies (Kepsa, 2014). It is surprising that even though transport is a vital part of any society it does not yet receive due attention in national and regional agendas. In order to bring transport perspectives to the forefront, the EU and member states must prioritise transport adaption plans at least as highly climate change mitigation. Progress on this front is impeded heavily by the lack of policy awareness of the necessity of transport adaptation. This means that adaptation action, which is currently still fixated on early stage knowledge acquisition and brainstorming, is lagging behind when it should already be in the stage of strategy development. Many countries have not begun implementing policies. It would therefore be prudent for governments and the EU to facilitate the process by providing access to expertise specific to the intricacies of transport development. One source of such knowledge is the research on climate-related projects conducted as part of the EU Seventh Framework Programme (FP7). Furthermore, the Horizon 2020 research programme offers resources and opportunities that could prove useful to sharing knowledge. Finally, transport companies and authorities should contribute realising change by cooperating with the scientific community to improve information exchange and ensuring their efforts are applicable in the real world (European Environment Agency, 2014).

The Copernicus Climate Change Service (C3S) could serve as a useful example for Lithuania to follow as a means of acquiring knowledge about the repercussions of climate change and how it can be combated. C3S, which is still under development, aims to incorporate global observations of the climate into cutting edge science to provide definitive and reliable information about “the past, current

and future states of the climate in Europe and worldwide". Upon completion, it will deliver several services:

- Informing policy such that it is ideally suited towards protecting citizens from the dangers of climate change.
- Improving measures currently in place to facilitate mitigative and adaptive practices in essential areas.
- Promoting continual advances that serve the best interests of society.

Cooperation between enterprises and formation of networks

As innovative activities become increasingly complex, successful outcomes require the coordinated efforts of a number of different bodies. For innovations to be realised, companies must endeavour to implement them through cooperation in order to overcome the limited human, organisational, technological and financial resources available. It is now commonplace for innovative activities to take the form of interactive processes within a diverse network of enterprises. Networks allow their members to make best use of pooled resources through partnerships, alliances and joint ventures. This tendency to combine expertise and the ability to draw competencies from other enterprises is credited with extending the scope of developmental studies. It is not unreasonable to think that innovations are in fact the direct result of identifying opportunities for cooperation between different entities and acting upon them. Success is often determined by connecting the appropriate resources with the necessary technology and knowledge. Enterprises that are brought together through mutual interest in innovative activities naturally form into interorganisational networks facilitating the process further (*Grabowska and Otola, 2016*).

Benefits that cooperation networks bring are illustrated in Figure 21.

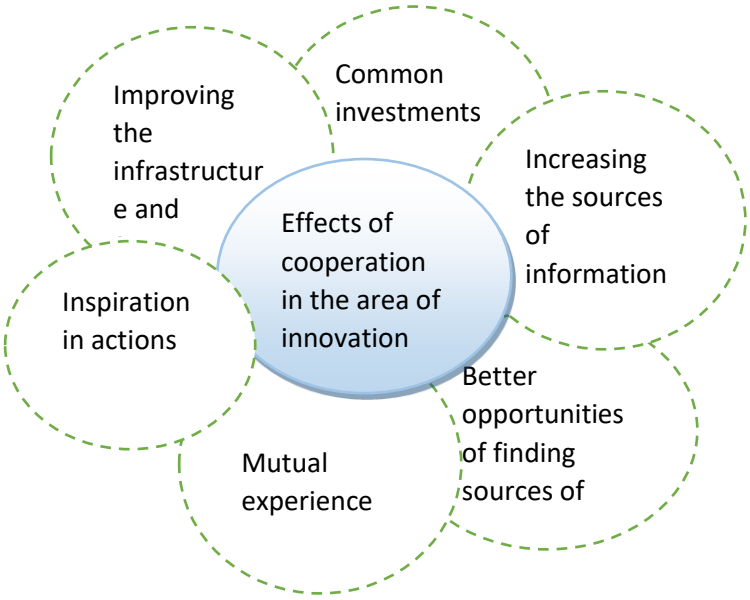

Figure 21. Effects of cooperation (based on Grabowska and Otola, 2016, p.)

Given the lack of cooperation in innovation between Lithuanian enterprises and the significant benefits that cooperation does bring, it would be reasonable to take measures to increase cooperation. Small and medium enterprises should be encouraged to create and join cooperative networks. The government could contribute to the creation of such networks by organizing forums and funded projects to support cooperative behaviour. Lithuania has cooperated in the past with different European countries, especially Sweden, with aims to increase European integration and development, including environmental development.

Sweden, a major donor to Lithuania (Regeringskansliet, 2002), has supported Lithuania on sustainable transitions and reformations since 1990. A total sum of up to SEK 985 million has been spent on bilateral development cooperation projects and programmes between 1990 and 2000. A major portion of this has been invested in efforts to transform Lithuania into a socially sustainable economy. Additionally, there have been significant contributions to sustainable environmental development, especially for securing Ignalina nuclear power plant. Other areas to receive attention include improving democracy, human rights and security in Lithuania.

At the moment most cooperation projects are of a cross country origin, such as cooperation programme Interreg V-A - Poland-Denmark-Germany-Lithuania-Sweden (South Baltic). The programme is particularly interested in implementing environmental measures targeting the reduction of pollutants dumped in the Baltic Sea. This is to be achieved through the development of green technologies. The programme also aims to promote the preservation of natural and cultural heritage encouraging sustainable tourism practices. There are hopes to facilitate cross-border labour mobility and innovation transfer through providing incentives to SMEs and aiding internationalisation. The programme will further develop transport services in the South Baltic region to increase efficiency and reduce damage to the environment. These endeavours are designed to complement cooperation between local actors in critical areas involving them in cross-border networks (Directorate- General for Regional and Urban Policy, 2017).

Funding priorities:

- Revitalising international efforts and innovation in South Baltic green economy.
- Optimal use of environmental and cultural resources in the South Baltic for green economy.
- Developing cross-border transport infrastructure to increase connectivity in a green area.
- Increasing human resource capabilities for the green economy area.
- Building cross-border networks to connect local actors in the South Baltic and increase involvement.

Expected impacts:

- Gaining exposure and a footprint in international markets for South Baltic green sector SMEs and developing their innovation capacity.
- Better utilisation of green technologies, reduction in pollutants dumped in the Baltic Sea, establishing a well-managed and highly accessible sustainable tourism industry to increase the number of visitors to the region.
- Development of passenger and intermodal cargo ship facilities in the Baltic sea to become more efficient and environmentally friendly.
- Improving access to labour of the required skill levels in all areas for green sector companies and lifting obstacles in the face of labour mobility.
- Encouraging active participation of local community actors in cross-border networks and increasing responsiveness to their demands.

However, we were not able to find any promising programmes/projects to increase cooperation within firms, which according to our point of view is of a particular importance for innovators. Higher cooperation could be attained through the creation and facilitation of networks. But in this case both positive and negative effects that arise from networks should be taken into account to avoid negative impacts on agents operating in networks. According to Grabowska and Otola (2016), the "network effect" is defined as "the positive or negative effect of the network on its individual members (organisations, enterprises)" and it is observable. Studies tend to focus on positive effects and they identify the following:

- Strategic dependence: concerned with establishing the strategic options of network actors.
- Network fit: matching suitable partners.
- Sharing of knowledge and management expertise within networks.
- Minimising technological risk as cooperation ensures easier access to the latest technologies.
- Positive feedback such as utilising economies of scale.

Despite the advantages, one should remain mindful of the risks introduced by networking. Economic disturbances can be contagious and spread to all actors in a network due to the market activities of a single partner. As such, networks can be unintentionally conducive to the propagation of catastrophic consequences across companies potentially resulting in bankruptcy.

Difficulties in obtaining external funding for innovative activities

A surprising finding from the analysis of Lithuanian enterprises was that approximately 21% of the companies do not engage in innovative activities due to the lack of external funding for innovation. This statement is could be controversial considering the fact that there are different projects developed

in the European Union to provide funding for innovative activities within the EU. The number of these projects has been increasing over time.

According to the UK Parliament (2016), funding for research within European Union is provided with five mechanisms:

- The Horizon 2020 programme;
- European Structural and Investment funds;
- Sectoral research and development programmes (programmes for research in space, coal and steel, nuclear research);
- Other connected programmes (Erasmus, COSME, connecting Europe etc.);
- Partnerships (Joint Technology Initiatives (JTIs), Innovative Medicines Initiative (IMI)).

The examples of Lithuania and other countries such as Malta, Latvia, Luxembourg, Slovakia etc., however demonstrate that the presence of these projects doesn't necessary guarantee support for innovation. This can be observed in a Figure 22 presented below.

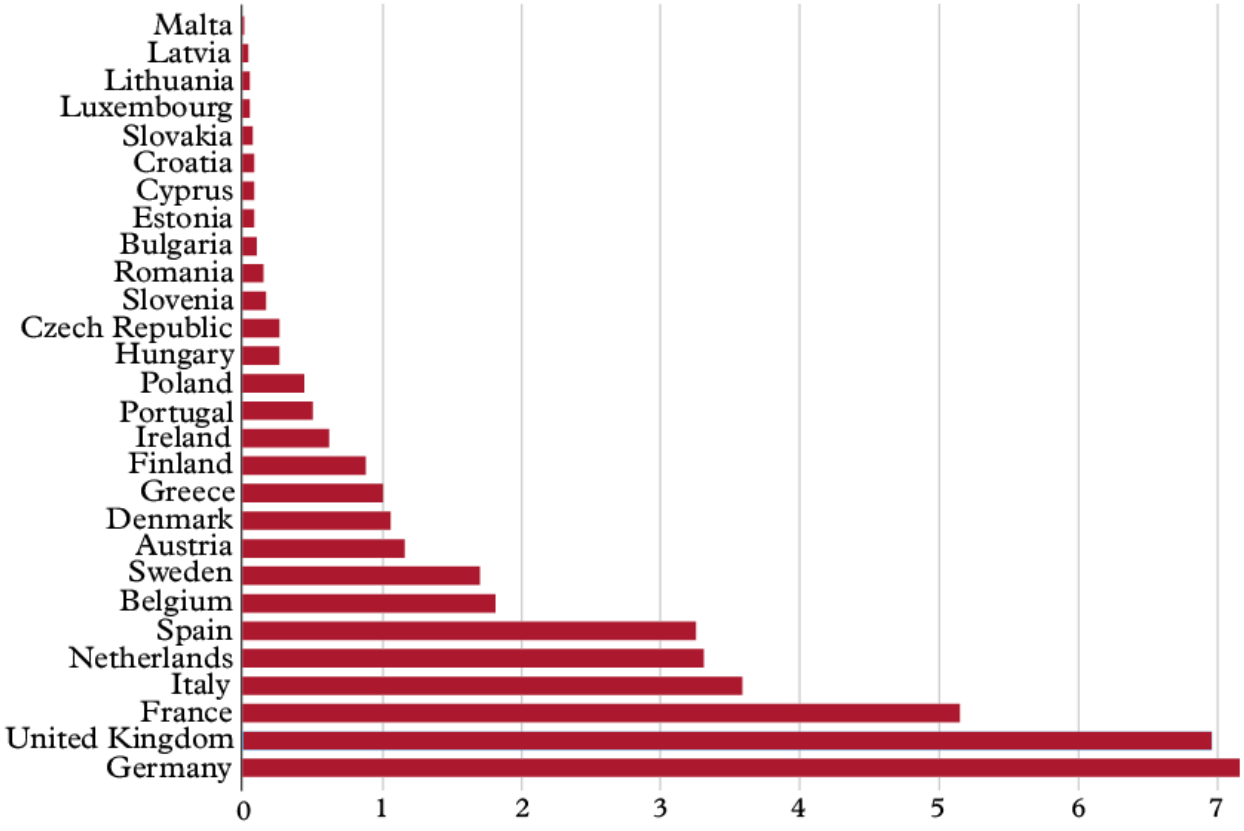

Figure 22. EU funding received (€ billion) (based on UK Parliament, 2016)

Lithuania is among those European countries that received lowest funding for innovative and research activities. Only Malta and Latvia were awarded with funding lower than Lithuania (see Figure 22). Of course, this finding might be partly explained by the relative size of countries. Countries like Germany

and the United Kingdom have higher populations and more companies engaged in innovation activities and research, consequently the absolute value of funding may not be best indicator. Therefore, Figure 23 negates scale factors and demonstrates proportional effects by illustrating per capita funding.

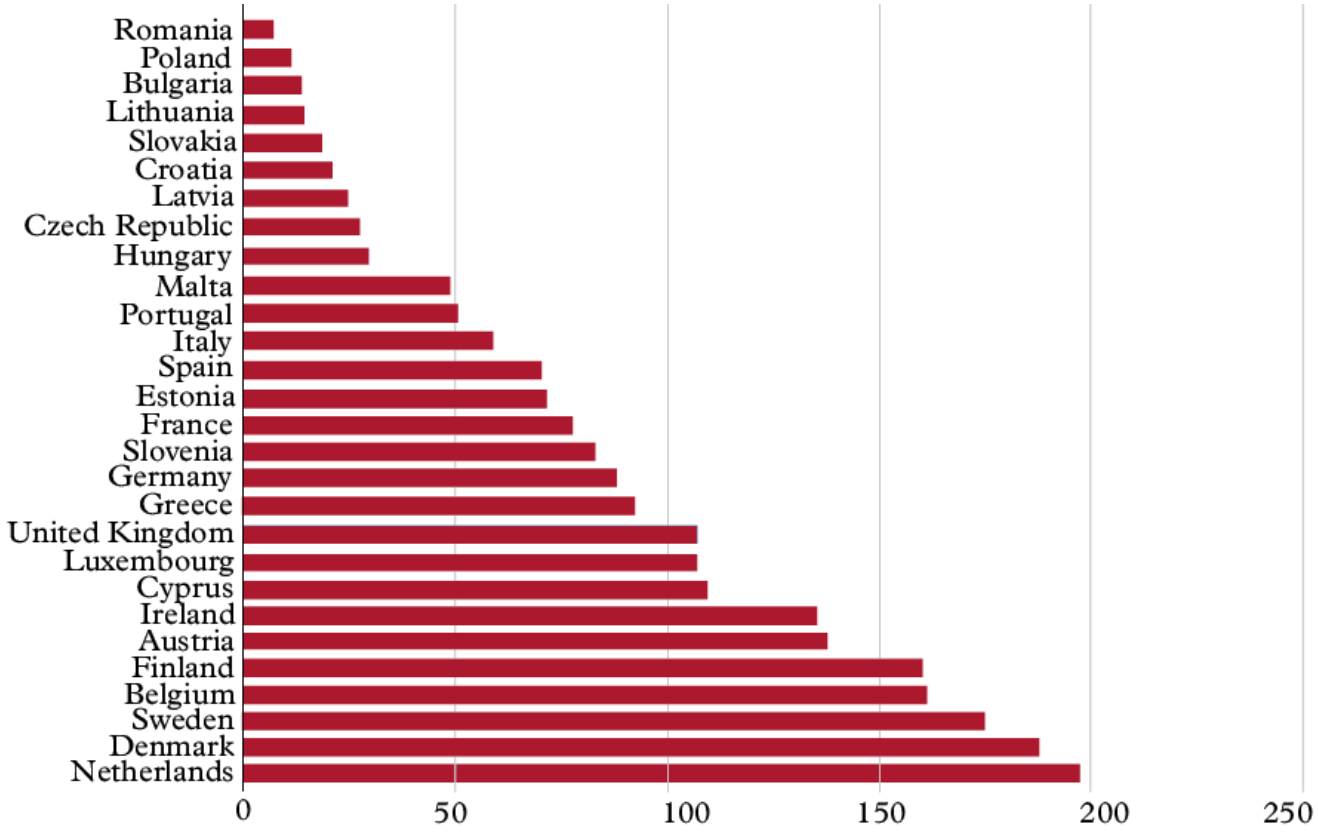

Figure 23. EU funding received per capita (€) (based on UK Parliament, 2016)

From figure 23 it can be observed that that Lithuania still occupies a similar position, being very close to the bottom compared to most of the countries. Funding received per capita is higher in 24 countries and only 3 countries received lower funding per capita (Bulgaria, Poland and Romania). This suggests that Lithuanian enterprises are indeed struggling with external funding.

Two reasons that might explain why firms are not receiving external funding are immediately evident:

- Firms are not well informed about the opportunities
- The funding systems are too complex and the procedures required to be eligible for funding are too intensive for smaller companies to dedicate resources to

The second reason is perhaps most relevant considering the fact that the scientific community often expresses concerns about the complexity of procedures involved in pursuing European research funding projects such as Horizon 2020. The European Parliament's Committee on Industry, Research and Energy (ITRE) for example, criticises Horizon 2020 for being too complex for SME's as well as for

start-ups due the limited information and guidance provided about participation in this programme. For instance, a glaring shortcoming of the programme is that no instructions are provided to help young companies claim funding. The member of the European Parliament representing Belgium has also expressed criticism for Horizon 2020 programme pointing out that procedures involved are too complex which makes it very difficult for small businesses to participate (Wonderlane, 2016).

To address the issues of EU funding on the national level is difficult, however the national government could negotiate with the EU funding authorities to address the difficulties that national companies experience. To do so, more detailed research is required to identify which procedures are considered the most complex for innovating firms that were not able to participate in such projects. Additionally, universities and the education community as a whole should consider adding into education programmes teaching oriented to prepare future employees to work with complex EU funding projects.

Low cost innovations – smart technologies

Despite the vital importance of capital needed to engage in innovative activities, there are innovations that can be implemented at lower costs that yield significant positive effects for society and the environment. The application of ICT technologies discussed in the theoretical part of this paper is just one such example.

Out of all the Baltic States, Lithuania boasts the most highly developed ICT industry with the greatest capacity to accommodate local and foreign companies. Of the 20 IT businesses with the highest market share in the Baltic region, 13 are headquartered in Lithuania. The IT sector has enjoyed remarkable growth complemented by a highly-skilled labour force. It is attracting ever increasing levels of foreign investment for the development of pioneering technologies including cloud computing, specialised solutions for financial services and engineering and medical firmware. This has placed Lithuania at the forefront of ICT sector growth (The Canadian Trade Commissioner Service, 2015). Therefore, it would be advisable to implement ICT solutions that have been discussed in the theoretical part within the Lithuanian transport sector. Implementing large-scale solutions will be a costly and complex process. In this case, the best solution could be the implementation of low cost small-scale solutions and those solutions that lead to industrial disruption. Small-Scale solutions such as car rental are already widely spread in Lithuania, therefore in this paper we will stick to the implementation of ICT solution that lead to industrial disruption and do not require high costs.

Measures that could be implemented within Lithuanian transport sector without incurring high expenses are:

- Ride Sharing
- Carpooling

The advantages and challenges associated with the implementation of these two measures are presented in a Table 8.

Table 8. ICT innovations that can be implemented in Lithuania

	Advantages	**Challenges**
Ride Sharing	• Reduction of GHG emissions through reduced number of individual vehicles • Opportunities to earn money (more self-employed population, and lower unemployment) • Opportunities to save on traveling costs for passengers	• Threat to taxi business • Effective security checks of drivers are necessary • Legal challenges • Insurance policies • Effective marketing strategy is required to make ride sharing widely spread
Car pooling	• Reduction of GHG emissions through reduced number of individual vehicles • Opportunities to save on traveling costs for both driver and passenger	• Security checks cannot be regulated • Low flexibility

As summarised in a Table 8 above, both these measures can contribute to the reduction of GHG emissions through decreasing the number of individual vehicles. However, there are challenges that have to be taken into account to produce the best results from the implementation of these ICT technologies.

From the analysis that was performed it is evident that to reach the goals of sustainable development the collective work is necessary. Cooperation between firms that are innovating responsibly for the sake of sustainable development as well as the efforts of governments, all together can contribute to the mitigation of climate change.

CONCLUSIONS

This work has endeavored to perform scientific research as originally set out in the aims. Initially, it is established that the world as a whole is indeed facing a climate change problem and that it is a direct consequence of human industrial activity. This is followed on by demonstrating the harmful effects of climate change not only on economic interests but also as an existential threat to continued human life on this planet. Consequently, the urgent need to combat this phenomenon is stressed, especially in light of the fact that current measures already in place are ineffective and fall drastically short of the intensity required.

The position that innovations in industrial activities provide the best solutions for sustainable transformations is adopted and a literature review is performed to provide the theoretical framework for this assertion and to evaluate the effectiveness of measures that are already being pursued. These are found to include the concepts of responsible innovation, green economy, international environmental agreements and the utilization of information and communications technology. The investigation leads to the conclusion that energy consumption is the single greatest contributor to climate change through GHG emissions and further identifies the transportation sector as the largest consumer of energy. The transportation sector is therefore considered an apt target for sustainable transformations as even small improvements could lead to significant mitigation of climate change.

With a solid basis in place, we turn our attention to formulating the methodological principles by which our study is to be conducted. This involves clearly setting out the research question, the objectives, our hypotheses and details on how they are to be tested.

Empirical data is collected and analyzed primarily using the method of correlation analysis. The results of analysis indicate 3 important facts. Firstly, road transport is the biggest culprit in the transport sector whether it involves the transport of passengers or goods. Secondly, the finding that R&D expenditure increases as a function of GDP per capita is confirmed as per other works in the literature and some reasons are offered for this positive relationship. Thirdly, it is confirmed using R&D expenditure as an instrument for innovation that a higher level of innovation does in fact contribute to a reduction in GHG emissions thereby mitigating climate change. Secondary statistical data is then analyzed in order to investigate the dynamics of innovation and cooperation in Lithuanian enterprises of the years. Furthermore, the factors hampering are also identified.

Using the results established from data analysis of all forms, an effort is made to propose measures to increase environmental innovativeness within the road transport sector. These include measures outlining environmental demands and increasing awareness in industry of the long-term risks posed by irresponsible practices. Additionally, the importance of both local and international knowledge and technology sharing programs is outlined. This is achieved through cooperation between enterprises

and the formation of scientific research networks. However, certain difficulties in this regard are identified and the need for the Lithuanian national government to address these issues is stressed. The problem is especially pertinent when it comes to securing EU funding for SMEs involved in innovative activities in Lithuania and efforts need to be expended in this area. Finally, low cost innovations that yield significant positive effects for society and the environment are presented as a very viable solution for the Lithuanian road transport sector. Despite being a relatively simple and perhaps "unimpressive" route to take, the benefits of ICT development must not be underestimated especially considering the already well established and proven ICT industry in Lithuania and the small amounts of further capital investment required for incremental benefits.

REFERENCES

1. Amaral Kaisa (2016) Effort sharing on the agenda.*Carbon Market.* Watch. *Carbon Market Watch*. [Retrieved 25.10.2017]. Accessible via https://carbonmarketwatch.org/2016/09/21/effort-sharing-on-the-agenda/
2. Ayres, Robert (2007). On the practical limits to substitution. Ecological Economics, vol. 61, No. 1, pp. 115-128.
3. Baptista, P. C., Azevedo, I. L., & Farias, T. L. (2012). ICT solutions in transportation systems: estimating the benefits and environmental impacts in the Lisbon. *Procedia-Social and Behavioral Sciences*, *54*, 716-725.
4. Barham R. (2014). Climate and Energy Impacts of Automated Vehicles. *Prepared for the California Air Resources Board*.
5. Blok, V., and Lemmens, P. (2015). The emerging concept of responsible innovation. Three reasons why it is questionable and calls for a radical transformation of the concept of innovation. In *Responsible Innovation 2* (pp. 19-35). Springer International Publishing.
6. Bock, B. B. (2012). Social innovation and sustainability; how to disentangle the buzzword and its application in the field of agriculture and rural development. *Studies in agricultural economics (Budapest)*, *114*(2), 57-63.
7. Burget, M., Bardone, E., and Pedaste, M. (2017). Definitions and Conceptual Dimensions of Responsible Research and Innovation: A Literature Review. *Science and engineering ethics*, *23*(1), 1-19
8. Center for climate and energy solutions (C2ES). Paris Climate Agreement Q&A. [Retrieved 01.12.2017]. Accessible via https://www.c2es.org/content/paris-climate-agreement-qa/
9. Chmelynski, H. (2008). National Economic Impacts per $1 Million Household Expenditures (2006); Spreadsheet Based On IMPLAN Input-Output Model, *Jack Faucett Associates*. Accessible via: http.// www.jfaucett.com.
10. CNN (2017). Kyoto Protocol Fast Facts. 24.03.2017. [Retrieved 01.12.2017]. Accessible via http://edition.cnn.com/2013/07/26/world/kyoto-protocol-fast-facts/index.html
11. de Coninck Heleen, Fischerc Carolyn, G. Newella G. Richard, Uenod Takahiro. (2008). International technology-oriented agreements to address climate change. *Energy Policy 36. pp.335–356.*
12. Directorate- General for Regional and Urban Policy (2017). Interreg V-A - Poland-Denmark-Germany-Lithuania-Sweden (South Baltic). [Retrieved 12.12.2017]. Accessible via http://ec.europa.eu/regional_policy/en/atlas/programmes/2014-2020/sweden/2014tc16rfcb013
13. Edber J. and Fagerberg J. (2017). Innovation policy: what, why, and how? *Oxford Review of Economic Policy*, Volume 33, Issue 1, 1 January 2017, Pages 2–23
14. EU ETS, Publications Office (2016). Green economy 2015. The EU Emissions Trading System (EU ETS). ISBN 978-92-79-62396-7 doi:10.2834/6083. [Retrieved 01.12.2017] Accessible via https://sustainabledevelopment.un.org/index.php?menu=1446
15. European Bank for Reconstruction and Development (2016). Strategy for Lithuania, As Approved ByThe Board Of Directors At Its Meeting On 10 February 2016. [Retrieved 06.10.2017]. Accessible via file:///C:/Users/Mountain%20Cliff/Documents/Lithuania%20Country%20Strategy.pdf
16. European Comission - Eurostat. [Retrieved 10.11.2017]. Accessible http://ec.europa.eu/eurostat/data/database
17. European Commission (2017). Bonn climate change conference (COP 23). [Retrieved 07.12.2017]. Accessible via https://ec.europa.eu/clima/events/articles/0118_en

18. European Commission (2017). Reducing emissions from transport. [Retrieved 01.12.2017]. Accessible via https://ec.europa.eu/clima/policies/transport_en
19. European Commission (2017). UN climate conference makes progress on Paris Agreement implementation. [Retrieved 09.12.2017]. Accessible via https://ec.europa.eu/clima/news/un-climate-conference-makes-progress-paris-agreement-implementation_en
20. European Environment Agency (2014). Adaptation of transport to climate change in Europe. Challenges and options across transport modes and stakeholders. EEA Report, No 8/2014. [Retrieved 13.11.2017]. Accessible via file:///C:/Users/Mountain%20Cliff/Downloads/08%202014%20Adaptation%20of%20transport%20to%20climate%20change%20(1).pdf
21. Europos Sąjunga (2014). Transportas: Patikima jungtis tarp Europos įmonių ir piliečių. Liuksemburgas: Europos Sąjungos leidinių biuras. ISBN 978-92-79-42786-2. [Retrieved 05.10.2017]. Accessible via file:///C:/Users/Mountain%20Cliff/Documents/transport_lt.pdf
22. Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (2016). Climate Action in Figures – Facts, Trends and Incentives for German Climate Policy 2016 edition., Building and Nuclear Safety. [Retrieved 09.12.2017]. Accessible via www.bmub.bund.de/en/service/publications
23. Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (2017). EU Climate Policy. [Retrieved 01.12.2017]. Accessible via www.bmub.bund.de/WS3634-1
24. Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (2017). International climate policy. Retrieved 03.12.2017]. Accessible via 2017 www.bmub.bund.de/WS201-1
25. Grabowska and Otola (2016). Networks of Enterprises as Innovation Drivers– the Real Cooperation Activities. *Journal of Advanced Management Science* Vol. 4, No. 2
26. Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The use of partial least squares path modeling in international marketing. In *New challenges to international marketing* (pp. 277-319). Emerald Group Publishing Limited.
27. IPCC (2014). Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)].
28. Jarašūniene A. (2007). Research into intelligent transport systems (ITS) technologies and efficiency, Transport, 22:2, p. 61-67
29. Jockus (2017). Lietuvai teks brangiai mokėti už transporto taršą. Lietuvos Žinos. [Retrieved 14.10.2017]. Accessible via http://lzinios.lt/lzinios/Ekonomika/lietuvai-teks-brangiai-moketi-uz-transporto-tarsa/252647/
30. Jordaan, S. M., Romo-Rabago, E., McLeary, R., Reidy, L., Nazari, J., & Herremans, I. M. (2017). The role of energy technology innovation in reducing greenhouse gas emissions: A case study of Canada. *Renewable and Sustainable Energy Reviews*, *78*, 1397-1409.
31. Kelemen, A., Munch, W., Poelman, H., Gakova, Z., Dijkstra, L., & Torighelli, B. (2009). Regions 2020. The Climate Change Challenge for European Regions. *Regions 2020 the Climate Change Challenge for European Regions*.
32. Kemp, R., & Pearson, P. (2007). Final report MEI project about measuring eco-innovation. *UM Merit, Maastricht*, *10*.
33. Kepsa (2014). Climate Change and the Transport Sector. Climate Change and Your Business Briefing Note Series. [Retrieved 11.12.2017]. Accessible via https://cdkn.org/wp-content/uploads/2015/04/Climate-Change-and-the-Transport-Sector.pdf

34. Konstantinavičiūtė and Byčenkienė (2017). Lithuania'S National Inventory Report 2017: Greenhouse Gas Emissions 1990-2015. *Lietuvos Respublikos Aplinkos Ministerija*. [Retrieved 05.11.2017]. Accessible via http://www.am.lt/VI/files/File/Klimato%20kaita/ataskaita/lt_nir_20170315_final.pdf
35. Lietuvos statistikos departamentas. [Retrieved 10.11.2017]. Accessible viahttps://osp.stat.gov.lt/statistiniu-rodikliu-analize#/
36. Lithuania's Second Biennial Report under the United Nations Framework Convention on Climate Change (2015). Ministry of Environment and Aplinkos Apsaugos Agentura, Vilnius. [Retrieved 05.10.2017]. Accessible via https://unfccc.int/files/national_reports/biennial_reports_and_iar/submitted_biennial_reports/application/pdf/final_2nd_br_lt.pdf
37. May S. (2017). What Is Climate Change? *National Aeronautics and Space Administration.* [Retrieved 06.11.2017]. Accessible via https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-climate-change-k4.html
38. Moraglio M. (2015). Final Report Summary - RACE2050 (Responsible innovation Agenda for Competitive European transport industries up to 2050). Community Research and Development Service. [Retrieved 01.12.2017]. Accessible via http://cordis.europa.eu/result/rcn/173372_en.html
39. Mulligan (2014). ICT and The Future of Transport. Part 2/8 Industry Transformation – Horizon Scan. Telefonaktiebolaget LM Ericsson.
40. Owen, R., Stilgoe, J., Macnaghten, P., Gorman, M., Fisher, E., & Guston, D. (2013). A framework for responsible innovation. *Responsible innovation: managing the responsible emergence of science and innovation in society*, 27-50.
41. Regeringskansliet (2002). Country Strategy for development of cooperation with Lithuania. Jaunary 1 2002- December 31 2014. *Ministry of Foreign Affairs*. Article no: UD 02.077
42. Roos, I., Soosaar, S., Volkova, A., & Streimikene, D. (2012). Greenhouse gas emission reduction perspectives in the Baltic States in frames of EU energy and climate policy. *Renewable and Sustainable Energy Reviews*, *16*(4), 2133-2146.
43. RRI Tools (2016). A Practical Guide to Responsible Research and Innovation. Key Lessons from RRI Tools. [Retrieved 11.12.2017]. Accessible via https://www.rri-tools.eu/documents/10184/16301/RRI+Tools.+A+practical+guide+to+Responsible+Research+and+Innovation.+Key+Lessons+from+RRI+Tools
44. Šliupas A. (2016). Lietuvos Transporto Sektoriaus Perspektyvos 2016 m. *Lietuvos Respublikos Susisiekimo Ministerija.* [Retrieved 04.11.2017]. Accessible via http://www.lsta.lt/files/events/2016-03-02%20Ekonomikos%20konf/Arijandas_Sliupas.pdf
45. Stilgoe, J., Owen, R., & Macnaghten, P. (2013). Developing a framework for responsible innovation. *Research Policy*, 42(9), 1568-1580.
46. The Canadian Trade Commissioner Service (2015). Information and Communications Technologies Sector Profile Estonia, Latvia, Lithuania. [Retrieved 10.12.2017]. Accessible via https://www.enterprisecanadanetwork.ca/_uploads/resources/Information-and-Communications-Technologies-Sector-Profile-Estonia-Latvia-Lithuania.pdf
47. The European Parliament and The Council of The European Union (2003). DIRECTIVE 2003/87/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 October 2003: establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC. *Official Journal of the European Union.* [Retrieved 01.12.2017]. Accessible via http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32003L0087

48. Tyre-shopper (2016). The Rise of Ridesharing. [Retrieved 11.12.2017]. Accessible via https://www.tyre-shopper.co.uk/the-rise-of-ridesharing
49. UK Parliament (2016). The EU funding system supporting science and research. EU membership and UK science Contents, Chapter 4: Funding**.** [Retrieved 13.12.2017]. Accessible via https://publications.parliament.uk/pa/ld201516/ldselect/ldsctech/127/12708.htm
50. UNEP (2011). Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. [Retrieved 02.12.2017]. Accessible via https://web.unep.org/greeneconomy/sites/unep.org.greeneconomy/files/field/image/green_economyreport_final_dec2011.pdf
51. UNFCCC (2011). Fact sheet: the Kyoto Protocol. [Retrieved 01.12.2017]. Accessible via https://unfccc.int/files/press/backgrounders/application/pdf/fact_sheet_the_kyoto_protocol.pdf
52. UNFCCC (2014). First steps to a safer future: Introducing the United Nations Framework Convention on Climate Change. [Retrieved 05.12.2017]. Accessible via http://unfccc.int/essential_background/convention/items/6036.php
53. United Nations (2013). World economic and social survey 2013: sustainable development challenges. *United Nations, Department of Economic and Social Affairs,* New York.
54. United Nations (2015). Green Economy. Sustainable Development Knowledge Platform. [Retrieved 09.12.2017]. Accessible via https://sustainabledevelopment.un.org/index.php?menu=1446
55. United Nations Environment Programme (2011). Green Economy – Transport – Investment in energy and resource efficiency. Version -- 02.11.2011 (pp. 389-397). [Retrieved 03.12.2017]. Accessible via http://web.unep.org/greeneconomy/sites/unep.org.greeneconomy/files/field/image/10.0_transport.pdf
56. United Nations ESCAP (2015). Intelligent Transportation Systems for Sustainable Development in Asia and the Pacific. Working Paper by the Information and Communications Technology and Disaster Risk Reduction Division.
57. United States Environmental Protection Agency (EPA) (2017). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015. [Retrieved 07.11.2017]. Accessible via https://www.epa.gov/sites/production/files/2017-02/documents/2017_complete_report.pdf
58. Voegtlin, C., and Scherer, A. G. (2017). Responsible innovation and the innovation of responsibility: Governing sustainable development in a globalized world. *Journal of Business Ethics*, *143*(2), 227-243.
59. Wilkinson P. (2009), Close R. and Crabbe H. (2016). The effects of global warming and climate change. Health Knowlegde. [Retrieved 13.10.2017]. Accessible via https://www.healthknowledge.org.uk/public-health-textbook/disease-causation-diagnostic/2f-environment/global-warming-climate-change\
60. Wonderlane (2016). H2020 'too complex' for some SMEs. *Horizon 2020 Projects*. [Retrieved 13.12.2017]. Accessible via http://www.horizon2020projects.com/il-smes/h2020-too-complex-for-some-smes/