ESC

167 ESCTER 17 E bis
Original: English

NATO Parliamentary Assembly

ECONOMICS AND SECURITY COMMITTEE

ASSESSING AND MITIGATING THE COST OF CLIMATE CHANGE

REPORT

Lilja ALFREDSDOTTIR (Iceland)
Acting Rapporteur
Sub-Committee on Transatlantic Economic Relations

TABLE OF CONTENTS

I. INTRODUCTION

1. This report explores a range of challenges linked to climate change and considers recent international efforts to cope with the problem. It seeks to take stock of some of the potential costs climate changes will induce and explores several of the important trade-offs the international community confronts as it grapples with this exceedingly complex and important set of environmental changes. It will do so by surveying some of the recent work environmental scientists and economists have undertaken to assess the potential costs to the global economy of climate change, the costs of undertaking efforts to mitigate that change and the possible price tag of failing to do so. The report will also look at new economic opportunities adaptation and mitigation create and suggests that first movers may derive outsized economic advantages. It finally explores the special challenges faced in the High North and explores several of the security implications of climate change and how this might shape the security environment in which NATO member countries operate.

2. Examples of the ways climate change are becoming apparent are myriad. To take one example, in the autumn of 2016, Danish and US researchers reported that warming air and sea surfaces were likely to trigger record lows of sea ice in the High North. Air temperatures in the High North in November 2016 were 20°C higher than what had been the "normal temperatures of -25 °C between 1981 and 2010, suddenly hovering near freezing - this at a time of year when the sun no longer shines above the horizon. Warmer waters naturally take longer to freeze and not surprisingly sea ice remained exceedingly thin in 2017 (Vidal). This shocking development, however, reflected a broader long range trend. The rate of warming in the Arctic from 1981 to 2001 was eight times greater than the rate of Arctic warming over the last 100 years. Not surprisingly, the Arctic's sea ice maximum extent has fallen by an average of 2.8 % per decade since 1979. The summertime minimum extent losses are nearly five times larger: 13.5 % per decade. As the sea ice cap thins, it becomes more vulnerable to the action of ocean waters, winds and warmer temperatures (Earth Observatory).

3. The problems of Arctic warming and dramatically thinning Arctic ice illustrate the kind of tipping points of which environmental scientists have long warned. In other words, these phenomena demonstrate how global warming might accelerate to a point of no return once certain levels of warming have been breached; there is thus a risk that climate change could reach a point at which no concerted human action could reverse warming trends. What has recently transpired in the High North could well be the onset of one of these tipping points. If not, it at least illustrates the kind of complex and worrying linkages between climate phenomena that can be expected over coming decades if the international community is unable to move off the current path of greenhouse gas production.

4. Recent and dramatic changes in the High North also unambiguously illustrate the degree to which climate change has become a reality. Climate change is happening and human activity is the primarily driver of change in the current era. The US National Aeronautics and Space Agency (NASA) has pointed out that 97% or more of actively publishing climate scientists agree that climate warming trends over the past century are extremely likely due to human activities. In addition, most leading scientific organisations have issued public statements endorsing this position. The NASA webpage lists a selection of these including: the American Association for the Advancement of Science, The American Chemical Society, the American Geophyyscial Union, the American Meterological Society, the American Physical society etc. (NASA).

5. Forward looking and responsible governments need to acknowledge what is transpiring while understanding and preparing for its consequences, many of which have important economic dimensions. Indeed, the challenge confronting humanity is not simply scientific in nature. It is also social, political, and economic in nature and will thus require the international community to address climate change, mitigate its impacts, and manage its costs while constructing a more

environmentally sustainable economy out of this effort. This would be a daunting task in itself, but it is made all the more so given the elusiveness of political consensus regarding the nature of the threat and the apparent costs involved. Indeed, any political consensus on the nature of the challenge could well be eroded when the costs of climate mitigation enter the discussion. Oftentimes these costs are presented with little consideration either of the costs of failing to act or the economic opportunitites that moving to new forms of energy and energy saving might afford, and so voters rarely have an opportunity to consider trade-offs, opportunity costs and dynamic paradigm changes shaping the economy itself.

II. THE FRAMEWORK CONVENTION ON CLIMATE CHANGE: CONTENT AND PROSPECTS

6. In 2016 in Paris, it seemed that a global consensus around climate action had finally been achieved. After years of discussion, the international community agreed to directly address greenhouse gas emission mitigation, adaptation and finance. In so doing, they launched a global effort to deal with all three of these challenges. One hundred and ninety-five countries (out of 197) negotiated the language of the agreement. It was adopted by consensus in December 2015 and put into effect on 4 November 2016. As of December 2016, 194 countries had signed the Paris Agreement within the United Nations Framework Convention on Climate Change (UNFCCC) and 127 had ratified it.

7. The goals of this first comprehensive climate agreement, are essentially:

- to hold the increase in the global average temperature to below 2°C above pre-industrial levels and to undertake efforts to limit temperature increases to 1.5°C above pre-industrial levels;
- to increase the international community's ability to adapt to the adverse impacts of climate change and to foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production;
- to make financial flows consistent with a pathway towards lower greenhouse gas emissions and climate-resilient development (UNFCCC).

8. The exact contributions countries make to achieve the goals laid out in the Paris Agreement are set by nationally determined contributions (NDCs). These NDCs are submitted to the UNFCCC secretariat. They are not, however, enforceable by law and thus are ultimately dependent upon prevailing economic and political conditions among signatory countries. The signatories established a name and shame system to encourage all countries focused on following a path to emissions reduction.

9. In 2018, signatory countries will assess the degree to which the NDCs will move the world toward the goal both of halting the rise of global emissions and ultimately achieve zero net emissions by the second half of this century. At this point, the NDCs will be revalued. The structure of the Paris Agreement is thus bottom up, voluntary and seeks to build consensus broadly rather than impose highly specific obligations as did the Kyoto Protocol. While the agreement is ambitious, such ambition is necessary to cope with the challenge. The Paris Agreement also established a framework to govern the international transfer of mitigation outcomes (ITMOs) while allowing countries to use emissions reductions beyond their borders through a carbon accounting and trading system. The agreement then links up emissions trading schemes into a global accounting framework so that net global outcomes of emission reductions are registered.

10. Unlike the Kyoto Protocol, the Paris Agreement makes no formal distinction between developed and developing countries and accepts the notion that countries will do what they can to achieve the core goals of the agreement. It also establishes the principle of a Sustainable

Development Mechanism to assist parties on a voluntary basis to make their contributions to global emissions reduction while developing in an environmentally sustainable fashion.

11. Although the world's wealthier countries, many of which industrialised in the 19th century, have emitted most of the greenhouse gases driving climate change, it is the poorer countries that are likely to suffer the worst consequences. Many of the hotter and dryer countries in the global south will confront the challenge of sustaining life in ever more harsh climatic conditions. Small low-lying island nations will be the first to suffer catastrophic losses as a result of sea rise while arid countries could well see water levels fall. Countries in these conditions will undoubtedly see their economic growth affected by climate change. Many of these countries also lack the financial resources to counteract proactively the impacts of climate change. There is thus a serious responsibility on the primary generators of greenhouse gases to move now to counteract the impacts of the past and to help poorer countries cope with the challenge.

12. The concept of Common But Differentiated Responsibilities and Respective Capabilities, (CBDR-RC) recognises that while all countries share an interest in addressing climate change, their capacity to do so varies. International law recognises that the ability to finance contributions to mitigate climate change should factor into the expectations of developing countries to contribute to the effort. There is also a second principle of cost sharing suggesting that wealthier countries should support the efforts of developing countries to mitigate climate change. Finally there is a merit principle by which the greater the effort of a country to contribute to solving the problem, the more it should be rewarded. The challenge lies in squaring these three principles to find equitable and effective ways to lower carbon emissions (Bretschger).

13. A central question, of course, is how all of this is to be financed, particularly in the developing world which faces acute economic challenges. At the 2010 Cancun Climate Summit, leaders agreed a goal of mobilising USD100 billion in private and public funds to help developing countries finance both adaptation and mitigation in roughly equal measure. Without finance for the effort to limit climate change, the goals of the Paris Agreement will never be successfully reached. The International Energy Agency (IEA) recently estimated that the international community will need to spend USD16.5 trillion on climate action by 2030, which is the equivalent to approximately USD1.1 trillion a year. An important share of this will be invested in energy innovation (Geronimo and Wright) and this should be considered as much an economic as an environmental investment. Technology transfer remains key to empowering developing countries to lower greenhouse gas emissions, improve energy efficiency and mitigate the most adverse consequences of climate change. Beyond the daunting costs involved, an additional challenge is that developed countries continue to worry about intellectual property rights for green technologies and see the preservation of these rights as a way to ensure that those undertaking research in this field are properly incentivized to do so. Of course, this raises problems of affordability for developing countries. This is a classical policy dilemma which has emerged in many trade negotiations in recent years and which has required carefully balanced trade-offs and innovative solutions (Jayaraman).

14. In Paris, developed countries pledged to mobilise USD100 billion a year to help developing countries make progress in achieving both emissions reduction and adaption to climate change. A recently-produced roadmap projects that public climate finance could reach USD67 billion by 2020 so using public finance effectively to leverage increased private finance will be essential. The availability of financing for adaptation remains worryingly low even though the Paris Agreement calls for greater adaptation support for those countries most likely to suffer the consequences of climate change. These include the least developed countries and small island states that are highly vulnerable to sea rise.

15. The G7 has also announced a plan for a USD420 million Climate Risk Insurance Program. A UNFCCC Green Climate Fund targeted on low emission and climate resilient development has so far been funded to USD10 billion. Small and less developed countries have also pushed for a loss

and damage programme to help compensate for devastating losses linked, for example, to single catastrophic events or for phenomena such as land loss linked to sea rise. But developed countries have been reluctant to create a separate category for these types of events and so the focus remains on averting and minimising the impacts of climate change rather than compensating countries for losses incurred. The agreement also includes a Transparency Framework to ensure that progress in meeting targets is monitored and published. Countries are obliged to report on any headway that they have made in mitigating emissions, adaptation, finance, technology development and transfer and capacity building and they need to do so in a peer review framework.

16. The Obama Administration never put the Paris Agreement to a ratification vote in the US Senate. Because there are no legal action-related or financial obligations pertaining to the Paris Agreement and because the US Senate had ratified the 1992 UNFCCC Treaty, it legally fell under the guise of an executive agreement rather than a treaty. During the presidential campaign in the United States, Donald Trump announced that if he were elected, his administration would pull out of the Paris Agrement and withdraw all funding from the UN Framework Convention on Climate Change. This has now come to pass. The Administration has announced that terminate US payments into the Green Climate Fund, which had been created in advance of the Paris Agreement, to support climate change related projects in developing countries (Kotchen). These funds were to help fund infrastucture needed to develop and deploy clean energy or to encourage investment for the same ends. Because many of these projects were to pay returns that would then be plowed back into other projects, the impact could be extensive (Worland). The Trump Administration has also made it clear that it will not seek to fulfill the promises the Obama Administration had made to move toward an energy mix in which the importance of renewable energy would steadily increase. Indeed, the new administration has announced that in addition to pulling out of the Paris Accord, it also hopes to increase US oil and gas drilling and coal mining, reduce subsidies for renewable energy (Cohen) and even impose retroactive tariffs on imported solar panels which have helped make the industry competitive (Cardwell). A legal discussion is now underway as to whether the United States would still be obliged to submit to its legally binding procedural commitments under the Paris Agreement for a four-year period, although it could simply leave the UNFCCC altogether (Chemnick).

17. President Trump had previously suggested that he believed climate change is a “hoax” foisted on the world by the Chinese “in order to make US manufacturing non-competitive” (Jacobson). This view does not suggest a great deal of leeway for dialogue on the issue between Europe and the United States and indeed, in the wake of the Administration’s decision to withdraw from the Paris Agreement, the issue has unfortunately become a source of trans-Atlantic diplomatic and political tension. Indeed, the new US position has triggered concerns in European capitals and in Canada, where the science surrounding climate change is widely accepted and the Paris Agreement has been strongly embraced as a key step to coping with the challenge (Reuters). But there is no doubt that the effort to carry out that dialogue will continue as the issue is not going away and the current disagreement will not be allowed to undermine allied solidarity in the broader sense. For example,the issue came up in the 14 July meeting President Trump had with French President Macron in Paris.

III. THE EXPERT COMMUNITY COMES TO GRIPS WITH THE ECONOMIC CONSEQUENCES OF CLIMATE CHANGE

18. Climate science is obviously highly complex and dependent upon many variables. Although there is a near consensus among scientists, if not among politicians, that the global climate is changing rapidly and that human activity is the main driver of these changes, all the consequences of a warming planet are not fully understood. Scientists and economists, however, have developed a range of scenarios to facilitate climate and economic forecasting. Any attempt to come to grips

with the potential costs of climate change, the cost of moving the planet off the pathway to significant warming, the price tag of failing to do so and the cost of adjustment to a warmer planet is dependent on these climate change models.

19. A number of economists have begun to think through potential environmental outcomes and the stakes and costs of various policy options aiming to cope with these outcomes. It is essential that this work be done; societies need to make informed critical judgements about possible trade-offs in a setting of scarce resources. Although difficult to quantify, the impacts of climate change on the global economy are likely to be significant. Some of these costs will be direct, while others will be indirect. Some of the impacts will be one off – such as catastrophic incidents like super storms emerging over warmer oceans - while others, like desertification or sea rise, are likely to persist or even worsen over time. Some costs will be evident in the short run while others will only reveal themselves over the longer term. It is expected, for example, that the number of people exposed to episodes of extreme rainfall will quadruple over the next century while the number of those exposed to drought will triple. The exposure of older people to drought will rise 12 fold according one study led by Peter Cox at the University of Exeter (Tavernise). And of course, there could also be economic benefits, for example, from new possibilities to navigate Arctic waters, mining and agricultural opportunities arising from retreating ice, longer growing seasons in northern climes, and lower heating costs in regions where these costs have traditionally been daunting. It is interesting to note that most of the potential benefits accrue to developed countries in cooler northern locations.

20. More quantifiable economic consequences will likely include developments such as falling crop yields, loss of land due to sea rise, altered fisheries, storm related damages, increased energy required for cooling, and public health challenges requiring new health expenditures. There is substantial evidence that in global terms a warming planet will reduce yields of critical commodities like maize. The yield of African maize, for example, has fallen in direct correlation with rising temperatures on that continent as has US maize (Presentation by Marshall Burke, NATO PA Spring Session 2016, Tbilisi, Georgia). Severe weather events will become more frequent as ocean temperatures rise and these would likely become more lethal and destructive. The Intergovernmental Panel on Climate Change (IPCC) projections forecast a sea-level rise of 52-98 cm by 2100 if greenhouse emissions continue to grow, or of 28-61 cm if emissions are strongly curbed. The former would imply a sea level rise of 5-110 meters which would threaten the survival of coastal cities and island nations ("Climate Change 2013: The Physical Science Basis," IPCC, Fifth Report, Chapter 13). This would threaten the lives of billions of people living along the world's coast lines and would obviously have devastating impacts on urban infrastructure, energy, agriculture and tourism.

21. The OECD conducted one of the more comprehensive efforts to begin to assess potential costs of climate change (OECD) . The study looked at matters such as changes in crop yields, loss of land and capital due to sea level rise, changes in fish catches, capital damages from hurricanes, labor productive changes, alteration in health care expenditure arising from the spread of disease and heat stress, altered tourism patterns and shifting energy demand for heating and cooling. Other potential impacts were not considered including phenomena such as moving beyond irreversible tipping points at which point environmental impacts become far more dramatic than currently assumed. It also excludes consideration of non-market factors like the potential for political instability related to climate change, which itself could have substantial economic costs. These are important caveats, and they point to the sheer difficulty of coming to reasonable approximation of the likely economic impacts of climate change. The OECD study, however, importantly deduces that there is still time and policy space to affect positive changes.

22. The OECD forecasts that market damages across a selected set of impacts are likely to rise gradually over time, although these costs will increase more quickly than will global economic activity. The complex economic models employed by the OECD suggested that if no further climate

change action is taken and the world remains on its current warming trajectory, the impact will undermine global growth and could result in global economic damages ranging between 1% and 6% of GDP by the end of the century, even if emissions were to fall to zero in 2060. If temperatures, however, were to rise to 4°C above pre-industrial levels by 2100, GDP would fall between 2% and 10% by the end of the century relative to a no change baseline. Higher temperatures could lead to damages as high as 12% of GNP by 2100, with the largest negative impacts on crop yields and labor productivity. The OECD study suggests that over time, sea level rises will likely become an increasingly important generator of costs and damage to the world economy. The study also notes that 23 of 25 regions of the world modelled in the analysis would likely suffer negative effects because of climate change at the levels described above. Africa and Asia would be particularly vulnerable in this regard.

23. If the Paris Agreement is to reach its goal of holding the global average temperature increase to below 2°C, countries will need to further ramp up the ambition of their commitments. A much-discussed study in the scientific journal *Nature* (Rogelj et al.) suggests that the commitments so far made by signatories of the Paris Agreement are not sufficient to achieve the global temperature target and that much more has to be done, and done sooner rather than later. The Nature piece surveyed current national pledges and argued that even if these are fully implemented, the planet would temperature increases from 2.6°C to 3.1°C by 2100 and could even warm more than this with a 10% chance of an increase 4°C. This study argues that the goal of limiting temperature rise to 1.5% is well-nigh impossible given current and promised levels of climate action. For this reason, the 2018 facilitative dialogue to take stock of the collective efforts of the parties foreseen in the Paris Agreement could well request substantial course corrections (Rogelj, et al., and Mooney, 2017).

24. The Nature study notes that there are important bonuses to acting early and that the longer climate action is delayed, the greater the reliance will be on negative emissions—or technologies that actually remove CO_2 from the atmosphere like carbon capture and storage—a far more problematic and expensive approach to the problem.

25. Another challenge relates to the global distribution of burdens arising out of climate change. According to a second Nature study, if climate change is unmitigated, average income in the poorest 40% of the world's countries would fall by as much as 75% by 2100, while the richest 20% of the world might experience slight gains (Burke, Hsiang and Miguel). That study states that:

> "*Overall economic productivity is non-linear in temperature for all countries, with productivity peaking at an annual average temperature of 13°C and declining strongly at higher temperatures. The relationship is globally generalisable, unchanged since 1960, and apparent for agricultural and non-agricultural activity in both rich and poor countries. These results provide the first evidence that economic activity in all regions is coupled to the global climate and establish a new empirical foundation for modelling economic loss in response to climate change, with important implications. If future adaptation mimics past adaptation, unmitigated warming is expected to reshape the global economy by reducing average global incomes roughly 23% by 2100 and widening global income inequality, relative to scenarios without climate change*" (Burke, Hsiang and Miguel).

26. The projected per capita income fall is five to ten times greater than reported in most other models. Fourty-three percent of the world's countries would likely be poorer in 2100 than they are today as a result of climate change, even when standard projections of technological progress are incorporated in the model. This stunning result is based on hard data exploring the relationship between economic activity and temperature rise. It does not even consider other climatic impacts beyond temperature changes. The complex statistical analysis of historical economic data separated out temperature as it relates to growth and demonstrated strong shifts in growth when temperature changes.

27. Based on past data, very cold countries like Canada and Sweden tend to grow faster as they warm while warmer countries in Africa and South Asia tend to undergo slower growth as temperature rises (Burke). The study also found economies operate optimally at roughly 13°C - the average temperature for both New York City and Palo Alto in Silicon Valley. Above and below that figure, economic performance tails off. Twenty percent of the world's countries that are now cooler than this optimal average temperature could therefore theoretically benefit from climate change (discounting, of course, the negative shocks that might be transmitted from adversely affected countries, for example, through their declining demand for imports). But 80% of countries that are currently at the optimum temperature level or above it could find their economies harmed as a result of warming. This includes key global players like Japan and the United States. The statistical study found that even wealthy countries do not escape the consequences of this logic even though they have more resources than developing countries to mitigate the impacts. Climate change could therefore augur a continual redistribution of global income favoring cooler countries which tend already to be wealthier (Maclay).

IV. CLIMATE CHANGE AND SECURITY

28. Climate change could also be a factor in triggering violent conflicts linked to declining food production, water shortages or economic crises linked to these phenomena. Indeed, the potential for conflict between regions affected by climate change cannot be ruled out. The refugee crisis shaking political stability in the Middle East and posing serious challenges in Europe could be a harbinger of things to come. The huge economic and social costs linked to mass movements on this scale are self-evident. It is distinctly possible that global climate challenges could become a trigger of mass movements of people, particularly in arid regions where agriculture and food supplies are vulnerable to drought. The potential problems here are very much worth considering and could certainly emerge as a key element in the economic fallout of unmitigated climate change.

29. Another study by the above cited three academics unearthed statistical data that linked increased human conflict to rising temperatures. That study reviewed 60 rigorous quantitative studies and unearthed striking causal evidence linking climatic events to human conflict in different regions of the world and at different times. That statistically convincing study suggested that climate has a strong influence on the level of violence: "For each standard deviation (1σ) change in climate toward warmer temperatures or more extreme rainfall, median estimates indicate that the frequency of interpersonal violence rises 4% and the frequency of intergroup conflict rises 14%." The effect of temperature change is greater than the impact of rainfall change and the effect on intergroup violence like civil war is greater than the effect of interpersonal violence like assault. (Hsiang, Buke, and Miguel) In Africa, violent conflicts increase by between 5 and 20% during hot years. Not surprisingly the numbers also suggest that hotter temperatures also correlate with increased migration. Asylum applications to the EU rise when temperatures in source countries are high and a +1°C higher temperature increases applications by roughly 10% (Presentation by Marshall Burke, NATO PA Spring Session, Tbilisi, Georgia). Civil conflict, war and the mass movement of refugees also impose major costs, and countries caught in cycles of violence invariably suffer serious setbacks to economic growth and development.

30. The impact of climate change on water supplies alone could constitute a global emergency and could generate new cylces of instability. More than 30 countries in the Middle East are expected to experience serious water stress over the next 25 years, and this could exacerbate social and political tensions throughout the region[1]. Warming will also melt high mountain glaciers with a corresponding impact on Asian rivers and water supplies although similar impacts will also be apparent elsewhere in the world.

[1] See the 2017 STC report on « Food and Water Security in the Middle East » [176 STC 17 F]

31. Climate change is thus a risk multiplier and poses a particular threat to fragile states. Along these lines, it is not surprising that terrorist groups like ISIS in the Middle East and Boko Haram in Nigeria have begun to use water and access to water as a weapon of war in vulnerable countries. It is worth considering that the breakdown of order and security in Syria was preceded by one of the worst water crisis in that country's history—an event that gravely effected food supplies and led to a sharp degradation of living conditions for millions of people. Drought and food shortages had already compelled thousands to flee their homes even prior to the beginning of the conflict and were likely an important factor in ratcheting up political tensions and possibly pushing the Syrian society over the edge. It is worth considering here that there is clear evidence that human civilization arose in a period of climate stability (NATO PA, Joint Special Seminar in Svalbard).

V. TRADE IMPACTS

32. There multifarious connections between international trade and climate change. The World Trade Organization (WTO) and UN Environnment Programme (UNEP) published a major survey of the literature in 2009, which explored many of the linkages established by experts studying the issue. Trade, of course, remains a key driver of the global economy and has been a critical factor of global economic growth. The volume of trade is also correlated to increased use of carbon-based energy. It is thus worth noting that the average share of exports and imports of goods and commercial services in global GDP rose from 20% in 1995 to 30% in 2014 (in value terms) (WTO). Trade has thus been a critical agent of economic development and growth and has also been a factor in climate change. It will undoubtedly be impacted both by global warming and the effort to mitigate it.

33. Trade has had three broad effects on global warming:

- a **scale effect** insofar as trade has increased energy intensive economic activity and, by extension, greenhouse gas emissions, for example through increased use of transport or by making affordable automobiles more accessible to more people;
- a **composition effect** or the way trade changes the composition of national production either to become more or less carbon energy intensive;
- a **technique effect** by which technologies are transmitted that might reduce the emission intensity of goods and service production (WTO-UNEP).

A potential fourth impact might be that because trade is wealth producing and because mitigating climate change is a costly endeavour, trade can help generate resources to fund adaptation and mitigation efforts.

34. Studying the precise relationship between trade and greenhouse gas emission levels is highly complex and tends to reveal variegated results depending, in part, upon assumption. For example, trade openness for OECD countries seems to correlate to reduced CO_2 emissions as it improves access to energy efficient technologies, whereas trade for non-OECD countries seems to correspond with higher emissions as both scale and composition factors predominate. In a globalised economy, there has also been a degree of industrial off-shoring so that emissions once produced by factories located in the West, are now offshored to developing countries. As a result, a degree of industrial pollution has also been offshored as developed countries become more service oriented.

35. Over the long term, there nevertheless seems to have been be a positive correlation of trade and CO_2 emissions (WTO-UNEP). Transport represents a primary reason why trade might be contributing to greater CO_2 generation. Goods can be transported by ship, road, rail, air and pipeline with maritime transport accounting for the largest volume and value of trade. Aviation is a highly polluting form of transport and the share of traded goods carried by air has been rising. Shipping is the most energy efficient mode of transport, but CO_2 emissions from shipping,

particularly from diesel based fuels, are slated to rise substantially. More generally, petroleum products power 95% of world trade transportation so the expansion of trade could weaken the effort to mitigate the emission of greenhouse gases unless this trade-energy relationship is not altered. Finally it is worth mentioning here that melting sea ice in the Arctic is likely to open new trade routes that will shorten the routes for trade between Europe and Asia. This could well confer certain commercial benefits and reduce energy use required, for example, to ship goods from Europe to Asia. It it difficult, however, to assert at this juncture that costs associated with the loss of Arctic sea ice would outweigh the benefits of shortened trade routes in the summer months.

36. On the other hand, trade helps diffuse energy saving technologies and energy efficient practices that reduce carbon fuel use. An example here might be the export of relatively inexpensive solar panels exported from China to the rest of the world — a development which has helped trigger the rapid transmission and use of a technology seen to be a key to a sustainable energy future. As these technologies develop and become cost effective, trade will play a critical role in their diffusion and will also help drive down their cost. These technologies, in turn, will likely further delink economic growth with carbon energy use — a critical step toward finding sustainable solutions to the carbon energy challenge.

37. It is also important to consider other factors such as the phenomenon that highly polluting industries operating in free trade regimes might tend to concentrate in those countries that have the least regulation. This, in turn, lends credence to the argument that a certain level of environmental regulation needs to be globalised to prevent “beggar thy neighbour” environmental policies or environmental dumping, which merely shift the locus of production without mitigating overall greenhouse gas emissions. But insofar as trade can generate growth and act as a catalyst to development, it can encourage countries that previously could not afford to undertake regulation to begin to do so. Thus a country like China which imposed few environmental restrictions on firms producing in the country during its initial industrialisation, has now begun to do so because it has generated so much national wealth through trade and thus has the means to begin to cope with the problem. Moreover, that country confronts a problem of general environmental degradation, and there is mounting domestic pressure to begin to address the problem in a systematic way. Finally, because China’s northern and western regions are suffering from very acute and ever worsening water shortages, the country is vulnerable to the effects of climate change and its leaders recognise that it must do its part to address the problems. In short, China has now both the means and the incentive to begin to address the problem.

38. As suggested earlier, trade is also a primary vehicle through which macro-economic shocks are transmitted internationally. In an open trading world, a contraction in demand in one or a number of countries can be transmitted to other countries through the trading system. Following this logic, an economic contraction linked to climate change in one country, could theoretically be transmitted abroad through a reduction of demand for imports in that country or even through a reduction of exports—both of which would impinge on the economies of its trading partners.

39. Climate adaption strategies will invariably have a trade dimension as well. If there are supply shocks in vulnerable countries that are directly or indirectly linked to climate change, trade offers one way to offset the impacts. Trade will be a critical tool of adaptation particularly in sectors like agriculture which are most sensitive to warming and drought. Not only can the trading system move food to where it is most needed, but it can also diffuse technologies and practices that help countries cope with drought conditions or rising waters.

40. Climate change could also trigger changes in national comparative advantages which, in turn, would generate new patterns of trade. This will be particularly true for countries specialising in climate sensitive products like food, but there could also be impacts on service exporters, particularly in areas like tourism. Of course, countries that master renewable energy technologies will particularly stand to benefit as the world’s economies looks to wean themselves off of carbon based energy. Societies that most successfully manage adaptation to climate change may also

gain certain advantages in global commercial markets as will those countries that develop technologies that mitigate the use of CO_2 because they will also benefit by exporting these technologies.

41. Finally one should also consider that climate change could also leave international supply chains vulnerable because of increased storms, sea level rise and the threat this poses to critical port and coastal infrastructure that represent critical nodes in the global trading system (WTO-UNEP).

VI. POTENTIAL ECONOMIC GAINS FROM MITIGATION

42. Beyond the apparent economic gains to be had simply by averting or at least minimising global climate change, there are other potential advantages that might be derived as countries begin to adjust. Since climate change has essentially been driven by the expanding use of fossil fuel and as governments are committed to move away from their use, the market for renewable energy sources is bound to grow. Indeed, this market is expanding rapidly, aided not only by increasing demand but also by technological innovation that is driving down costs, increasing supply and opening whole new vistas of economic opportunity. The Paris Agreement is often characterised simply as a large cost, but it is also an opportunity as those countries dedicated to adhering to its strictures are likely to move quickly to embrace new energy producing and saving technologies that could define new avenues to productivity increases and growth.

43. In 2015, the world invested $350 billion in renewable energy or more than double the amount invested in coal and gas fired power generation. The explosion of demand for renewables, the entrance of large companies enjoying scale economies and the flood of investment in relevant technology has driven down the costs of solar and wind power to the point where they are now competitive with fossil fuel power generation despite the limits of intermittency and their dependence on weather conditions. The march of technology will continue and the cost of renewables will invariably fall further. Better solutions to the intermittency problem, for example, are likely to emerge out of this research. All of this will eventually produce a paradigmatic shift that will drive future economic growth. Some countries will be better poised than others to establish leads in this future economy and most likely, they will be early movers both in adaptation and in technology development.

44. Indeed, markets now seem increasingly poised to move into high technology solutions to the carbon energy challenge including the development of renewable technologies but also energy saving technologies that lower energy/GDP ratios. Even though solar power currently accounts for only 1.3% of US electricity generation, it employs roughly 260,000 people in that country and this number is growing, with the industry accounting for one of every 50 new jobs in 2016. Most of these jobs are in the installation field and provide a median wage of nearly USD26 per hour. The solar energy industry currently employs slightly more workers than natural gas, twice as many people as coal, three times the number of people employed in wind energy and five times the number working in nuclear energy. The oil/petroleum sector, by comparison, still employs 38% more people than the solar industry in the United States. One reason that solar energy is employing so many people is that it is a new industry and much of the work involves installation of fixed capital projects. These numbers also suggest that solar remains relatively labor intensive and this is one of the reasons it is still more costly than gas and oil. But job creation has a certain political appeal and the solar lobby, which heretofore has not been terribly consequential, could begin to throw around its weight in US energy policy discussions. It has, after all, become something of a job creating machine (Plumer). As the industry matures, it will likely require significantly less labor, but over the medium term, it will continue to be a job creating engine.

45. China has become one of the global leaders in the renewable energy sector and in related technology development. Reducing pollution has become a top priority, and this has led to a significant slow down in coal plant construction and massive investments in renewable energy including very large investments in research and development. China has started to develop a lead in a sector that could eventually become one of the foundations of the global economy. According to Bloomberg New Energy Finance, China invested USD102 billion in renewable energy in 2015, which is twice as high as US investment in that sector that year.

46. It is also investing abroad globally. China Light and Power, for example, invested USD1.1 billion in Austria to purchase power from wind and solar farms. In Chile, Tianqi Lithium purchased 25% of a lithium mining and processing operation. Lithium is a key input in batteries used in electric cars and home energy storage systems. China currently owns five of the world's six largest solar module manufacturing firms, the largest wind turbine manufacturer, the largest lithium ion manufacturer and the largest electric utlity (Slezak). As a first mover that has mobilised signifant capital for these ventures and that enjoys the benefits of scale, China has put itself into a good position to reap long-term rewards in this renewable sector. A new industrial paradigm could well be emerging as a result of climate change and a near global consensus to work to mitigate its worst impacts. It is worth noting that India is also now getting into the game and has recently begun to move away from coal generated electricity precisely because of persistent pollution problems.

VII. OTHER IMPACTS

47. The World Health Organization has estimated that climate change linked to human activity is currently causing the deaths of 150,000 people each year. The Climate Vulnerability Monitor puts this figure at 400,000, which, based on the US Environmental Protection Agency (EPA)'s Value of Statistical Life, exacts a cost of USD3 trillion (Tago and Thom). The disparity between the two studies is revealing insofar as it illustrates the methodological challenges associated with this kind of estimate. They nonetheless point to the scale of the human costs of climate change which are linked to extreme weather, eco system changes and related shocks to human health and society. To make this tangible, it could be helpful to consider one event — the inordinately hot summer in Europe in 2003. That summer, over 19,000 people died in France due to the heat according to a range of public studies. That single event provides an indication of the kinds of shocks to human health and well being that can be expected as a result of global warming.

48. A second threat to human life arises out of related changes to biodiversity and changing conditions for flora and fauna. An obvious example here is represented by the rise of disease spread by mosquitoes like the Zika virus or by waterborne disease including malaria. A warming planet exposes previously sheltered regions to these types of diseases.

49. Climated induced phenomenon such as drought, desertification and land degradation, could also be a factor leading to socio-economic problems and even instability due to declining food production or water shortages. Desertification could be a factor in compelling people to leave their homes and livelihood and thus could be one of many factors triggering mass movements of migrants.

VIII. THE CHALLENGE TO THE ARCTIC

50. There are unique challenges confronted by the Arctic as a result of global warming. The Arctic is warming twice as fast as the rest of the planet. In Svalbard, Norway for example, the temperature has been rising for the past 37 years with the annual temperature at four meterological stations there increasing by 2.7–4.0°C, and winter temperature rising by 4.8–6.5°C over that period (Forland, Eirik J. et. Al.). The last two years have been the warmest ever registered in the Arctic and the past 73 months have registered higher than average temperatures. Winters are warming more than summers and this is consistent with current climate change models. The region's reflectivity has begun to dissipate as sea ice melts, and this is accelerating the warming trend. Antarctica is naturally much colder so the warming trend there, although well underway, is less apparent. Scientists working in Antarctica, for example, recently documented a massive melt event as well as unprecedented rainfall in the Western part of that continent. Green moss is also appearing on rocks for the first time according to scientists. Both of these phenomena could be a harbinger of more rapid change in a region of that continent that contains over 10 feet of potential sea level rise. One influential study published last year suggested that there could be a major ice loss on that continent in this century that alone could account for four feet of sea level rise. A British Antarctic Survey recently indicated that Antartica had warmed by 2.5° C since the 1940s. Ice shelves on both the eastern and western sides of the Peninsula have retreated since 1995 and the annual melt season has increase by 12 days over the last 20 years. The shelves are weakened by meltwater on the surface and thus become more susceptible to fracturing (Union of Concerned Scientists, "Early warning signs of global warming: Arctic and Antarctic Warming").

51. The equatorial regions of the world absorb far more energy than the polar reaches of the planet. This energy is partly transferred to the north through weather fronts and the Gulf Stream. Likewise, cold air and water from the north also moves southward, thereby acting as a natural air conditioner for the planet. The High North's cooling role, however, is now threatened as the region heats up. Other feedback loops could be accelerating climate change in ways that exceed expectations expressed in earlier climate change models. For example, permafrost is melting and as it does, it releases more carbon into the atmosphere, which, in turn, further accelerates warming thereby releasing even more carbon etc. These feedback loops help explain why the Arctic is changing so precipitously.

52. The retreat of sea ice is only the most apparent change in the region, but there are many more. Indeed ice retreat is having an amplified impact on global climate change. As white ice is replaced by dark water, the earth absorbs and retains more solar heat and this feedback loop could be accelerating climate change in ways that exceed expectations expressed in earlier climate change models. Climate change, however, is altering these weather bands, and far more heat appears to be moving northward. This is accelerating sea level rise as ice around Greenland and in Svalbard, among other High North locations, begins to melt. This is also opening new sea routes through the North East and North West passage. Fish stocks are shifting as many species are following water temperature trends and rapidly moving northward. Melting ice and warming water is thus having a significant impact on the fishing industry and is leading to a reassessment of economic opportunities in the High North in sectors such as shipping and mining.

53. The Arctic's natural heritage is now at grave risk. A significant migration of fish is underway from the North Atlantic to Arctic waters. Shrimp and Snow crab are now fished in far northern waters and cod and haddock are being caught north of Svalbard. This migration has unfolded very quickly, and has changed how littoral and more distant countries look at these waters. At the same time, polar bear hunting grounds are rapidly diminishing, permafrost is melting, and the glaciers are retreating rapidly. Perhaps most worrisome of all is that there is now little predictability as these changes have never been observed and their impacts are highly complex. It is, in essence, nearly impossible to fathom where all of this is leading although the general trend line is very worrying

(NATO PA-Joint Special Seminar in Svalbard , Comments by Kim Holmenan, Vidar Helgesen, and Sverre Engeness).

54. A report that the Arctic Council recently issued suggests that the Arctic as a whole is shifting into a new state that will have a profound impact on the rest of the world. The Arctic is currently heating up at a rate that is twice that of the rest of the world. Its temperature is on a pace to increase by 5-9 degrees Celsius by the end of the century and could rise possibly as high as 12 degrees. This would have a dramatic impact on sea level rise, which in turn, would gravely affect low lying coastal regions of the world such as Bangladesh. A 1.5 meter rise in the sea level would erase 16% of that country's territory and 17 million people would be displaced. It is important to recognise that in the last ice age, sea levels were 25 meters lower than today so the amount of ice on land profoundly impacts sea levels.

55. Warming temperatures in the Arctic, for example, could theoretically render an important swathe of the Middle East uninhabitable, trigger draught in parts of Europe and North America and cause flooding in other parts. The Director of the National Snow and Ice Date Center in Colorado, Mark Serreze, are predicting an ice-free Arctic summer by 2030 (Borenstein). Insofar as the Arctic is one of the world's primary cooling systems, the impact of this change would be dramatic, enduring, and global in nature. It would affect everything from sea level to storm patterns. Change in the Arctic is thus amplifying the impact of global warming, and if this transformation continues unabated, it could well produce extreme weather, effect bio diversity, trigger crop failures, wild fires, new and unexpected pandemics, infrastructure break downs, and mass migration among many other impacts.

56. There are important economic opportunities implicit in some of these changes. The melting of sea ice holds out the opportunity for navigation in the high Arctic and the shipping industry is poised to exploit this opportunity although with a modicum of caution. The melting of permafrost makes road transport across Arctic tundra increasingly problematic so the shipping industry will likely shoulder the burden of transporting goods across the region. The opening of the North-Eastern passage, for example, would cut the shipping distance between Europe and Asia by a third, although the industry believes that the use of this passage is many years down the road. The North West-passage is likely to remain a more difficult option as ice blockage there is more substantial.

57. It is also important to recognise that the High North is no longer an isolated and depopulated region. It is growing more dynamic and the population has been rising. For example, 10% of Norway's population lives above the Arctic circle, and the Arctic plays a critical role in the national economy as it does, for example, in Russia. The Arctic Council has become an important vehicle for member and observer countries to discuss how the changing climate is shaping economic opportunity and how this is to be managed. Sustainable development of the region will be essential, but this will only be possible if it is done in a cooperative international framework. The Law of the Sea plays a vital role in regulating how countries approach the region. Updated regulations will be needed to resolve outstanding disputes arising out of new opportunites linked to climate change that could threaten the broader comity that characterises relations in the region. Shifting fish populations is an example but there are many others. Although the Arctic Council began as a forum that was largely focused on the region's environment, the range of issues that it addresses has expanded substantially. One of the most important of these issues is how to manage economic development cooperatively in that fragile and environmentally changing region (NATO PA-Joint Special Seminar in Svalbard Seminar, Presentation by Marit Berer Rosland).

58. Shipping in the High North represents another particularly compelling challenge. Currently the support systems needed to sustain shipping in the Arctic simply are not present. New industrial standards are needed as well as critical support infrastructure. Responsible shipping requires accurate weather forecasts, proper navigation charts, search and rescue support, and resupply

centres. Presently there are gaps in all of these and this too operates against extensive commercial exploitation of Arctic passages.

IX. CARBON TAXATION

59. Decisions about how to mitigate the impact of global climate change require consideration of optimal economic policy responses, the burdens those responses impose and who exactly ought to shoulder which burdens. This becomes a process of considering trade-offs between equitable and efficient solutions. There is little doubt that both climate change and the response to it involve very important questions of income distribution. As suggested above, there is growing evidence that poorer and hotter countries will likely suffer harsher economic impacts as a result of global climate change which has largely been induced by the world's more advanced economies. Many of the wealthier carbon fuel intensive countries recognise that they ought to foot a higher share of the overall bill to cope with the challenge. The Paris Agreement, however, has created an expectation that developing countries, particularly major emitters like China, will also have to do their share (Bretschger). The Kyoto Protocol had largely exempted developing countries from its most burdensome strictures. Paris makes it incumbent upon all carbon emitters to take action to bring down the level of carbon based energy to levels consistent with overall targets.

60. It is important to recognise that the costs of using carbon energy are often not reflected in the price of these commodities. The externality costs of using carbon based energy includes the costs to the environment, health and even national security costs that are not adequately captured in the market price of energy. This is a classic market failure. An externality, in this case, is the cost that affects the entire society linked to the use of a commodity by those who did not fully incur that cost. Economists often urge governments to adopt policies that "internalise" externalities so that the price actually paid reflects the total cost including the societal costs.

61. There is thus a sound economic efficiency justification for taxing carbon so that the price at the pump reflects the real opportunity costs of using that energy. These real costs need to be reflected in those prices so that business and consumers possess the full cost information needed to make efficient energy use decisions. In 2011, coal generated power plants charged only USD 3.2 cents per kilowatt/hour but the actual costs were estimated to be 170% higher as each kWh of coal generated electricity resulted in 5.6 cents of damage including 3.4 cents of adverse health impacts, and 2.2 cents in climate related damages (Greenstone and Looney). Externalities reflect market failures that states can correct through tax policies that actually render markets more efficient. These taxes, in turn, help moderate consumption behaviour so that demand is conditioned by real prices reflecting the full spectrum of opportunity costs.

62. This is the essential justification for taxing carbon based fuels. A number of countries have implemented carbon tax systems which invariably reduce the price differential between carbon and renewable energy sources. Carbon taxes, however, are not the only reason that carbon energy use has begun to fall. In the United States, the growing use of natural gas instead of coal in electricity generation has had a dramatic impact on carbon emissions. The Obama Administration's efforts to boost fuel efficiency standards for automobiles and to impose higher efficiency standards on household appliances have helped reduce the energy intensity of the economy and, by extension, lowered the component of carbon based fuels used in it. All of this was accomplished without a tax on carbon although the results would likely have been even more dramatic had one been established in the United States (Komanoff). Carbon taxation represents a highly efficient and powerful tool to properly price carbon and encourage clean fuel use and for this reason, many free market advocates now embrace it including a group of influential US Republicans including former Secretary of State James A. Baker, former Secretary of State George P. Schultz and former Secretary of the Treasury Henry M. Paulson Jr. Major oil companies, including Exxon Mobil have also favored the idea (Schwartz).

X. THE US WITHDRAWAL FROM THE PARIS AGREEMENT

63. The Trump Administration's 1st June 2017 announcement to pull out of the Paris Agreement has been broadly understood as a serious blow to the international effort to cope with the climate change challenge and that it has become a source of discord between the United States and it Allies. But dialogue on this issue will have to continue as climate change will remain an enduring problem the consequences with which all countries will have to cope. Under the accord, the United States can only formally submit its intention to withdraw after November 2019 and the process of withdrawal would likely take a year to consummate. In any case, the international reaction to the decision has been decidedly negative and has a potential to weaken trans-Atlantic political solidarity. The initial reaction from a number of government leaders both within and beyond NATO, has also included an express determination to respect the terms of the agreement and a refusal to contemplate any renegotiations of its terms (Sengupta).

64. Although the United States, like many other countries, would have faced both technical challenges and costs to meet the goal of reducing its greenhouse gas emissions as laid out in the Agreement, it will not escape the kinds of costs associated with climate change outlined in this report. One study conducted in 2008 when cost estimates were far lower than current estimates, laid out only four impacts — hurricane damage, real estate losses, energy costs and water costs and suggested that just these alone could cost the United States 1.8% of GDP or roughly USD1.9 trillion annually in current dollars by 2100 (Ackerman and Stanton).

65. In a recent peer reviewed EPA study (*Climate Change in the United States: the Benefits of Collective Action*), experts estimated the various savings that would accrue to the United States if goals for greenhouse gas limits were achieved by 2100. These include: an estimated 57,000 fewer deaths from poor air quality in 2100; an averted increase in electricity demand of 1.1%-4.0% in 2050, an estimated USD10-USD34 billion in savings on power systems; in 49 major US cities, an estimated 12,000 fewer deaths from extreme temperature in 2100; an estimated 720-2,200 fewer bridges made structurally vulnerable in 2100; an estimated USD4.2-USD7.4 billion in avoided adaptation costs in 2100; approximately USD110 billion in avoided damages from lost labour due to extreme temperatures in 2100; an estimated USD2.6-USD3.0 billion in averted damages linked to poor water quality; in 50 US cities, an estimated USD50 million-USD6.4 billion saved in adaptation costs in 2100; approximately USD3.1 billion in averted damages and adaptation costs from sea level rise and storm surge in 2100; savings of as much as USD2.8 billion in damages averted from land flooding; an estimated USD6.6-USD11 billion in averted damages to agriculture in 2100; an estimated USD520 million to USD1.5 billion in averted damages to forestry in 2100; an estimated 40%-59% fewer severe and extreme droughts in 2100; an averted loss of approximately 34% of the US oyster supply, 37% of scallops, and 29% of clams in 2100; an estimated 6.0-7.9 million fewer acres burned by wildfires in 2100; an estimated USD11-USD180 billion in avoided damages from water shortages in key economic sectors in 2100; an avoided loss of approximately 35% of current Hawaiian coral by 2100, with a recreational value of USD1.1 billion; an estimated 230,000-360,000 acres of cold water fish habitat preserved in 2100; an estimated 1.0-26 million fewer tons of carbon stored in vegetation in 2100. A study conducted by Frank Ackerman and Elizabeth Stanton of Tufts University, predicted that in an inaction scenario, temperatures in most of the United States would rise by an average of 13 ° F and 18 °F in Alaska. High costs would also be inflicted through more frequent and severe heat waves, hurricanes, droughts and other abnormal weather events. It is worth noting that studies conducted since the publication of this particular study have grown decidedly more gloomy.

66. Climate change would thus strike many sectors including state budgets, tourism, agriculture and a range of other weather dependent industries. Households would see water bills rising due to water scarcity in dryer parts of the country. Higher sea surface temperatures would generate stronger hurricanes along the Atlantic coastline and these storms would interact with higher seas to trigger highly damaging storm surges, erosion and flooding. Hurricanes have recently generated an

average cost to the United States of USD12 billion and cause 120 deaths a year. If climate change is not slowed due to a lack of international action, this figure could rise to USD422 billion and 720 deaths per year according to the Tufts study. Sea rise would also cause very serious property destruction and damage and by 2100 could generate costs of USD360 billion per year. Energy costs in the United States would also likely rise as demand for air conditioning and refrigeration would soar. There would be some offset costs for reduced winter heating demands in the north. Cooling demand would generate an extra USD200 billion in electricity and air conditioning costs, while there would be an USD80 billion reduction in heating costs, netting out to an additional USD141 billion per year in costs. Finally, the study foresees an additional USD95 billion per year in water costs, as drought conditions worsen in many regions of the United States. Again, just within these four categories, the additional costs to the United States of remaining on the current climate change path is USD1.9 trillion per year according to this model, and this does not even factor in many other potential costs in areas like health and other environmental damages. These could raise the cost from 1.8% of GDP to 3.6% per year if the international community as a whole does fails to mitigate climate change.

67. As suggested above, some of the most interesting solutions to the challenge in the United States are now being offered by free market economists who both recognise the nature of the environmental threat but who are wary of traditional regulatory approaches. Martin Feldstein, Ted Halstead and Gregory Mankiw have played a particularly prominent role in this discussion. They lament that the two major political parties in the United States have sought to cope with the problem of reducing carbon emissions through executive orders which subsequent administrations abandon. This has fostered regulatory inconsistencies and created great uncertainty for businesses that need a degree of certainty to engage in long term planning. This is precisely the logic behind the carbon tax-carbon dividend proposed by former Secretary of State James A. Baker described above.

68. These free market advocates argue that carbon emissions reduction efforts should also seek to mitigate regulatory intrusion promote economic growth, benefit working class people and should be acceptable to a broad political spectrum of US voters. They have accordingly laid out a four pillar plan in which the federal government would gradually impose an increasing tax on carbon dioxide emissions, beginning at USD40 per ton but rising over time. This would send a powerful pricing decision that would encourage a reduction in CO2 emissions. They also maintain that the proceeds from this tax should be rebated to US voters through a quarterly dividend check. At USD40 per ton, this would mean a USD2,000 rebate to a family of four. The dividend payments would rise as the tax increases.

69. US companies exporting to countries without comparable carbon pricing would receive rebates on the carbon taxes they have paid producing these goods, while imports from such countries would be charged fees on the carbon content of their products. This would protect the competitiveness of domestic firms and discourage carbon free riding. Finally, because pricing signals are so powerful in shaping behaviours, the government would be able to eliminate a number of regulations currently shaping emissions policy, including the Clean Power Plan, which many conservatives have claimed is very inefficient and burdensome.

70. The plan is interesting not only in the context of US politics but in any society seeking to balance environmentally sound policies with liberal market solutions. It offers a way to forge a broad political agreement over an issue which has been heavily divisive in US politics. The authors suggest that the pricing approach would be far more effective than regulations, less burdensome, more efficient and would encourage long-term investments in cleaner technologies. There would also be a redistributive impact as the bottom 70% of Americans would come out ahead if all elements of this plan were implemented (Feldstein, Halstead and Mankiw). Were the US Administration and the Congress to move in this direction, they would together chart out an

innovative way to cope with a serious global environmental challenge while championing free market principles and competitiveness.

XI. CONCLUSIONS

71. Although the cost of mitigating global climate change will be substantial, the failure to act will exact even higher costs not only in terms of lost economic and agricultural assets, budgetary burdens, additional energy and water costs but also in terms of human lives lost, species and ecosystem damage, social conflict and political instability.

72. There is growing evidence that the adverse economic impacts of climate change could be far more substantial than originally envisioned. This suggests that the benefits of mitigation could far outweigh the costs of the measures needed to achieve mitigation. Put another way, the cost of inaction increasingly seems prohibitive. The problem is the gap between the evidence and the political will needed to act on that evidence - or even to accept the evidence. Democratic politics tends to focus on the short run and is biased against planning for longer term dynamic economic, social and environmental phenomena. Not surprisingly, on the environmental front there is a built-in bias against undertaking mitigation strategies. The costs are up front and short term while the benefits - or the pay back on the initial investment - are only made apparent over the long term.

73. Understanding longer term economic dynamics is critical here. It is essential to recognise that decisions made today will alter the very structure of future economies and the energy that powers them. As the international community leans toward renewable energy over carbon based fuels, investment in the former will continue to increase. This will drive down the costs of clean energy technology, make it increasingly competitive and an ever more important generator of new jobs. Insisting that there is no alternative to dirty coal use, for example, is belied by the fact that far cleaner natural gas has already begun to replace coal as has even cleaner solar and wind power. The world has not yet entered a post-carbon energy order, but it is moving in this direction. Governments now have a blue print to ensure that this effort is ramped up to such an extent that the worst impacts of climate change can be averted.

74. The benefits of a successful effort to achieve the goals laid out in the Paris Agreement would outweigh the substantial costs. This effort will likely involve a degree of creative destruction by which older and obsolete forms of energy production will invariably have to decline unless cleaner ways to employ these energies are found. Coal use is already in decline in many parts of the world including in China and India. Eventually other carbon fuels may be expected to face similar competitive pressures as the cost of cleaner energy sources falls. India recently abandoned a huge expansion of coal fired electricity plants in favor of solar panel arrays both because the cost of solar had become highly competititve and because India is suffering serious pollution problems from coal burning. Subsidising the use of carbon based energies is now understood as utterly regressive and will only postpone an inevitable transition while leaving societies poorly positioned for the emerging economic order.

75. Properly pricing carbon will make clean energies more attractive and accelerate their introduction into national energy mixes. Under-pricing carbon has distorted energy markets. The state has a corrective role to play to make those markets better reflect real cost conditions. Serious carbon pricing schemes are needed so that consumer decision making reflects the true price of the energy that they consume. Innovative market oriented schemes like those recently proposed by James Baker and George Schultz are welcome and demonstrate that the goal of carbon reduction and economic efficiency are not mutually exclusive. Carbon needs to be priced to reflect its real costs, including environmental and security costs (through carbon taxation), while cleaner technologies (e.g., carbon capture) and renewable energy should be subsidised so that the environmental and societal benefits are better reflected in those prices. Such policies might appear

costly, but they would help move energy prices to accurately reflect opportunity costs associated with their use.

76. Market economies advance, in part, through the discovery of interruptive technologies which literally shift the foundations of economies and define new patters of growth and development. In this manner, renewable energy “may become the greatest opportunity for wealth creation of the 21st century” (Stoiljkovic). Some industries and workers will lose in this process. That is the very nature of creative destruction. But it is hard to argue that it is worth holding the world economy hostage to the false notion that coal jobs are coming back. They are not and that is why China and India have decided to look for other ways to produce energy. On the demand side, investments in far more efficient appliances, cogeneration, and green buildings will also characterise this new economy and environmentally sensible regulatory standards will provide focus for these investments. Undoubtedly these new energy industries will create millions of jobs. The explosion of employment in the US solar industry is likely just the tip of the iceberg. Seen this way, climate targets can actually be understood as elements of long term growth strategies (Stoiljkovic).

77. To build this future economy, incentives will be needed to encourage far greater levels of energy efficiency in everything from building codes, appliance efficiency and mileage standards for automobiles. Enormous progress has been made on these fronts as well and continued technological advancements will create new economic opportunities. Governments and business need to work in partnership to ensure that higher efficiency standards are constantly pursued and made mandatory. These efficiency standards will lower costs and can foster tremendous growth opportunities for firms and for national economies. Indeed, first movers will be rewarded, and this is precisely why climate action should be seen as an investment in a dynamic growth opportunity and not simply, and misleadingly, as simply a deadweight cost. Building the support infrastructure essential to making renewable energy widely available remains a major challenge for governments, but it also offers a substantial opportunity for innovation, enhanced security and economic growth. Transmission capacity, which facilitates the integration of intermittent energy sources like solar and wind, is particularly important in this regard. There is a great deal of room for innovation here as well, and international cooperation will be essential to push out the technological frontier.

78. The Paris Agreement marks an important advance and suggests that the international community has begun to come to terms with the challenge and recognised that action must be undertaken by both the developed rich and developing poorer countries. The United States played a leading role in pushing for the Paris Agreement, but the Trump Adminstration has now announced its intention to leave that agreement. This undoubtedly represents a setback given the historic importance of US leadership on global envirionmental challenges. The international community, including NATO allied countries, must continue to engage the United States on the issue of climate change. US society itself remains deeply engaged in these issues and local and state governments, businesses and civil society as a whole will continue to work for positive change.

79. Generating and sustaining consensus on coping with this monumental set of challenges will thus be critical to coping with the problem and new ways of reaching out to sceptics will be essential. Although the Administration in Washington has expressed scepticism about climate change and the Paris Agreement, it might be fruitful to find new ways to conduct a dialogue on these matters. The future of world agricultural markets, food security, and the military-security implications of climate change represent a series of potential entry points. The risks of sea rise to property and insurance markets might be another way to talk about this issue with US leaders. The Governor of the Bank of England, for example, has warned that climate change could ultimately upend insurance markets as more and more property becomes uninsurable. This is already underway in the United States and the problem could lead to all manner of financial breakdowns while undermining existing business models and asset pricing (Haufler). These are real and

contemporary challenges that will be hard to ignore and they have implications for all allied countries regardless of their position on the Paris Agreement.

80. The hard security implications of climate change needs to considered by the defense and security establishments of all NATO countries and should be a subject more closely taken up within the Alliance. The challenges here are myriad and include everything from the future of coastal bases, to emergency response, to the prospects of long-term instability in the Middle East as a result of drought.

81. Finally, special attention needs to be paid to the Arctic, the importance of which seems to be on the rise. Some have argued, in fact, that climate change is essentially placing the Arctic at the centre of the world rather than on its periphery. The stake here are extraordinarily high as stability will not be possible in a world characterised by rising temperature, far more extensive drought, and unpredictable food supplies. A paradigmatic shift will be essential, and this will have broad cultural and political implications. A shared outlook on environmental matters in the Arctic has lain at the root of cooperation in the region and this will have to continue particularly as the international community comes to better appreciate how central the Arctic is to the planet's delicate environmental balance and to critical security issues like future food supplies.

82. On the other hand, the Arctic is also increasingly seen as a zone of economic exploitation and international rivalry. There are signs of militarisation or perhaps remilitarisation in that delicate region, but this avenue should be resisted. Managing these challenges will only be possible in a cooperative framework, and this represents a critical challenge for the international community as a whole. This cooperation will have to be rooted in new understandings and a broader knowledge of how these various systems are interacting (NATO PA-Joint Special Seminar in Svalbard, Comments by Lassi Heininen).

83. For several centuries, the world has been in an Anthropocene era in which humankind is exercising tremendous influence over the natural world and its environment. The question today is whether the world will manage to exercise the kind of restraint needed to maintain critical planetary balances that make life itself possible. In the coming years, the Arctic states will move from the periphery to the very core of international discussions about security and sustainability simply because of their location in this rapidly changing and highly exceptional region and their own vital role in protecting it.

BIBLIOGRAPHY

Ackerman, Frank and Stanton A., Elizabeth, "The Cost of Climate Change: What we'll pay if Global Warming Continues Unchecked," Natural Resources Defense Council, May 2008.

Bretschger, Lucas "How do we share the costs of climate change," World Economic Forum, 16 October 2015.

Borenstein, Seth, "Sea ice in Arctic shrinks to second lowest level on record, Phys.org, 15 September 2016 https://phys.org/news/2016-09-sea-ice-arctic-lowest.html

Burke, Marshall; Hsiang, M. Solomon; and Miguel, Edward "Global non-linear effect of temperature on economic production," Nature, 527, 21 October 2015.

Burke, Marshall, "The global economic costs from Climate change may be worse than expected," Planet Policy, Brookings Institution, 9 December 2015.

Cardwell, Diane, "Solar trade case, with Trump as Arbiter, Could upend Market, The New York Times, 30 June 2017, https://www.nytimes.com/2017/06/30/business/energy-environment/solar-energy-trade-china-trump.html?_r=0.

Cohen, Steven, "Trump's Attack on Renewable Energy," HUFFPOST, 19 June 2017, http://www.huffingtonpost.com/entry/trumps-attack-on-renewable-energy_us_5947c072e4b024b7e0df4db1 .

Chemnick, Jean, "Could Trump simply withdraw U.S. from the Paris Climate Agreement?" Scientific American, 10 November 2016, https://www.scientificamerican.com/article/could-trump-simply-withdraw-u-s-from-paris-climate-agreement/

Climate Change 2013: The Physical Science Basis, Intergovernmental Panel on Climate Change, Fifth Report, Chapter 13, http://www.ipcc.ch/report/ar5/wg1/#.UlvpNH_Ix8E

Climate Change in the United States: the Benefits of Collective Action, https://www.epa.gov/sites/production/files/2015-06/documents/cirareport.pdf

Dougherty-Choux, Lisa, "The Costs of Climate Adaptation, Explained in 4 Infographics," 23 April 2015.

Earth Observatory, "Evidence of Arctic Warming," https://earthobservatory.nasa.gov/Features/ArcticIce/arctic_ice3.php

Feldstein, Martin; Halstead, Ted and Mankiw, N. Gregory "A conservative case for Climate Action," The New York Times, 8 February 2017.

Forland, Eirik J. et. al, "Temperature and precipitation development at Svalbard:1900-2100," Advances in Meterology, 2011, https://www.hindawi.com/journals/amete/2011/893790/

Framework Convention on Climate Change, United Nations, FCCC/CP/2015/L.9, 12 December 2015, https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf

Geronimo, Lorenzo and Wright, Thurstan, "One year After the Paris Climate Summit, we are we now?" IMC, 6 February 2017, http://www.imcworldwide.com/news/one-year-after-the-paris-climate-summit-where-are-we-now/

Haufler, "Insurance and Reinsurance in a Changing Climate" paper presented at the conference on Climate Change Politics in North America, Woodrow Wilson international Center for Scholars, May 18-19 2006.

Greenstone, Michael and Looney, Adam, "The real costs of U.S. Energy," Brookings Institution, 15 June 2011, https://www.brookings.edu/opinions/the-real-costs-of-u-s-energy/

Hsiang, Solomon M.; Burke, Marshall and Miguel, Edward, "Quantifying the Influence of Climate on Human Conflict," Science, 13 September 2013.

Jacobson, Louis, "Yes, Donald Trump did call climate change a Chinese Hoax," Politifact, 3 June 2016, http://www.politifact.com/truth-o-meter/statements/2016/jun/03/hillary-clinton/yes-donald-trump-did-call-climate-change-chinese-h/

Jayaraman, Thiagarajan, "The Paris Agreement on Climate Change: Background, Analysis and Implications," 6 January 2016 https://www.researchgate.net/publication/289470031_The_Paris_Agreement_on_Climate_Change_Background_Analysis_and_Implicattions

Kotchen, Matthew, "Green Climate Fund. He has no idea what it is," The Washington Post, 2 June 2017.

Komanoff, Charles, "The Good News: A clean electricity boom is why the clean power plan is way ahead of schedule," The Carbon Tax Center, December 2016, http://www.komanoff.net/fossil/The_Good_News.pdf

Maclay, Kathleen, “Study finds climate change will reshape global economy,” Berkeley News, 21 October 2015, http://news.berkeley.edu/2015/10/21/study-finds-climate-change-will-reshape-global-economy/

Mooney, Chris, "The world has the right climate goals — but the wrong ambition levels to achieve them," The Washington Post, 29 June 2016.

Mooney, Chris, "Scientists stunned by Antarctic rainfall and a melt area bigger than Texas," The Washington Post, 15 June 2017.

Mufson, Steven, “These titans of industry just broke with Trump’s decision to exit the Paris Accords, Washington Post, 1 June 2017.

NASA, GloBal Climate Change: Vital Signs of the Planet, “Scientific Consensus: Earth’s climate is warming,” https://climate.nasa.gov/scientific-consensus/

NATO PA, DSC/ESC/PC, Report, Joint Special Seminar in Svalbard, Norway 10-12 May 2017 [132 JOINT 17 E] http://www.nato-pa.int/

NATO PA Economics and Security Committee Meeting, Tbilisi, Georgia Presentation by Marshall Burke, 27 May 2017.

OECD “The Economic Consequences of Climate Change, 2015, http://www.keepeek.com/Digital-Asset-Management/oecd/environment/the-economic-consequences-of-climate-change_9789264235410-en#page4

Plumer, Brad, “There are now twice as many solar jobs as coal jobs in the US,,” Vox, 7 February, 2017, http://www.vox.com/energy-and-environment/2017/2/7/14533618/solar-jobs-coal

Reuters, “President Trump Prepares to Withdraw from the Groundbreaking Climate Change Agreement,” 30 January 2017.

Rogelj, Joeri et al. "Paris Agreement climate proposals need a boost to keep warming well below 2C". Nature. 534, 2016.

Schwartz, John, “A Conserative Climate Solution: Republican Group Calls for Carbon Tax,” The New York Times, 7 February, 2017, https://www.nytimes.com/2017/02/07/science/a-conservative-climate-solution-republican-group-calls-for-carbon-tax.html

Seaman, Laura, “Stanford researchers’ calculations reveal higher-than-expected global economist cost of climate change,” Stanford News.

Sengupta, Somini, Melissa Eddy and Chris Buckley, “As Trump Exits Paris Agreement, Other Nations are Defiant,”The New York Times, 1 June 2017.

Slezak Michael, “China: Cementing global dominance of renwable energy and technology,” The Guardian, 6 January 2017.

Stoiljkovic, Nena, “The Paris Agreement is a $23 trillion investment opportunity. How can we unlock it, World Economic Forum, 31 January 2-17, https://www.weforum.org/agenda/2017/01/unlocking-23-trillion-of-climate-investment-opportunities-is-mission-possible/

Tago, Damian; Thom, Alban, “Failure to address global warming will cost many lives,” The Economist, 10 December 2015.

Tavernise, Sabrina, “Risk of Extreme weather from climate change to rise over next century, Report says,” The New York Times, 22 June 2015.

Union of Concerned Scientists, “Early warning signs of global warming: Arctic and Antarctic Warming,” http://www.ucsusa.org/global_warming/science_and_impacts/impacts/early-warning-signs-of-global-1.html#.WW8hn4iGMdU

Vidal, John, “Extraordinarily hot Arctic temperatures alarm scientists,” The Guardian, 22 November 2016.

Worland, Justin, “How Trump Could Slow Climate Change Projects around the World,” Time Magazine, 13 June 2017, http://time.com/4813115/paris-agreement-climate-change-trump-green-climate-fund/

WTO (World Trade Organization), United Nations Environment Programme (UNEP) Report, “Trade and Climate Change,” 2009, https://www.wto.org/english/res_e/booksp_e/trade_climate_change_e.pdf

WTO, International Trade Statistics 2015, https://www.wto.org/english/res_e/statis_e/its2015_e/its2015_e.pdf

_____