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ASSESSING AND MITIGATING THE COST OF CLIMATE CHANGE

DRAFT REPORT*

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* Until this document has been approved by the Economics and Security Committee, it represents only the views of the Rapporteur.

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I. INTRODUCTION

1. Examples of what climate change entails are myriad. This autumn, Danish and US researchers reported that warm air and sea surfaces were likely to trigger record lows of sea ice at the North Pole in 2018. Air temperatures in the High North in November 2016 were 20°C higher than normal, with temperatures that would normally be at -25°C actually hovering above freezing - this at a time of year when the sun no longer shines above the horizon. Warmer waters take longer to freeze and sea ice is expected to remain exceedingly thin in 2017 (Vidal). This is the second year in a row that temperatures in the High North - what some characterise as the “canary in the mineshaft” of climate change - have risen to exceedingly high levels.

2. The spillover effects just of this recent event have been global in nature. The jet stream itself shifted profoundly as a result of this singular warming event, causing additional heat and moisture to move into the Arctic in what scientists characterised as a vicious circle. Lengthening jet stream waves emerged as the Arctic has been heating faster than the equatorial band, with wide spread, varying and dramatic climate impacts. The fluctuating jet stream has transported these impacts far beyond the Arctic.

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 are breached. 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 is becoming real, making the case posed by climate change skeptics ever less credible. Climate change is happening and human activity is primarily responsible for the phenomenon. Responsible governments, at the very least, need to acknowledge it, prepare for its consequences, and contribute to the global effort to move the world off the path it has been on. The challenge confronting humanity is not simply scientific in nature. It is rather about social, political, and economic mobilisation, and more specifically, the capacity of the international community to slow climate change, mitigate its impacts and manage its costs. 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. That political consensus is further eroded when the costs of climate mitigation enter the discussion. Oftentimes these costs are presented with little consideration of the costs of failing to act and so voters rarely have an opportunity to consider trade-offs and opportunity costs.

5. This draft report will seek to take stock of some of these costs and the kinds of trade-offs the international community confronts as it grapples with this exceedingly complex and important environmental change. It will do so by surveying some of the recent work environmental scientists and economist 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.

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

6. In 2016 in Paris, it seemed that a kind of consensus around climate action had 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 negotiated the language of the agreement, and it was adopted by consensus in December 2015 went 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 the treaty, which is the world's first comprehensive climate agreement, are essentially:

1) 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 preindustrial levels;
2) 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;
3) 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) which should be detailed, ambitious, and with a horizon out to 2030. These NDCs are submitted to the UNFCCC secretariat. They are not, however, enforceable by law and thus are likely subject to slippage depending upon prevailing economic and political conditions among signatory countries. A name and shame system is all there is to keep countries focused on following a path to emissions reduction. 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 of 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 Kyoto did. It has established a framework to govern international transfer of mitigation outcomes (ITMOs) and allows 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.

9. Unlike the Kyoto Protocol, the Paris Agreement also 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 developing countries make their contributions to global emissions reduction while developing in an environmentally sustainable fashion.

10. Although the world's wealthier countries, many of which industrialised early, 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 very harsh climatic conditions. Small low-lying island nations will be the first to suffer catastrophic losses as a result of sea rise. These poorer countries will see their growth rates seriously affected by climate change. These countries also lack the financial means 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.

11. The concept of Common But Differentiated Responsibilities (CBDR) recognises that while all countries have a responsibility to work to mitigate climate change, their capacity to do so varies. International law recognises that the capacity 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 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).

12. A central question, of course, is how all of this is to be financed, particularly in the developing world which faces acute challenges in this regard. 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 treaty will never be achieved. 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). 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. One problem here 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 incentivised. Of course, this raises problems of affordability for developing countries. This is a classical policy dilemma requiring careful trade-offs and innovative solutions (Jayaraman).

13. 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 although there is frankly little likelihood that financing at the USD100 billion will be raised. The availability of financing for adaptation is particularly 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 island nations that are highly vulnerable to sea rise.

14. The G7 has announced a plan for a USD420 million Climate Risk Insurance Program and the Obama Administration provided a USD500 million grant for a Green Climate Fund targeted on low emission and climate resilient development, which has so far been funded up to USD10 billion. Small and less developed countries have 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 or the lack thereof in meeting targets are monitored and published. Countries are obliged to report on any headway that they have made in mitigating emissions and need to do so in a peer review framework.

15. The Obama Administration did not 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 said that his administration would pull out of the Paris Agrement and withdraw all funding from the UN Framework Convention on Climate Change. The Trump Administration has made it very clear that it will not seek to fulfill the promises the Obama Administration, that it hopes to increase US oil and gas drilling and coal mining, and that it will pull out of the global pact to cut emissions. There is a legal discussion underway as to whether the United States would still be obliged to submit to its legally binding procedural commitments for a four-year period, although it could simply leave the UNFCCC altogether. Leaving the UNFCCC, however, would have diplomatic consequences and could undermine international cooperation in other areas (Chemnick).

16. 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). The degree to which this view will inform his policy is not yet clear, but it certainly does not suggest a great deal of leeway for dialogue on the issue between Europe and the United States. Indeed, the

new US position has triggered concerns in European capitals and in Canada, where the science surrounding climate change is generally accepted. A US withdrawal from the UNFCCC would likely become a source of both trans-Atlantic and North American tensions (Reuters).

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

17. 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 possible scenarios. Any attempt to come to grips with the potential costs of climate change, the cost of moving the planet off the pathway to catastrophic 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.

18. A number of economists have begun to think through 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.

19. Although difficult to quantify, the impacts of global 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 - like catastrophic incidents like super storms emerging over warmer oceans - while others, like desertification or sea rise, are likely to persist or 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, etc. It is interesting to note that most of the potential benefits accrue to developed countries in cooler 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. Severe weather events will become more frequent as ocean temperatures rise and these would likely become more lethal and destructive as sea levels rise. Scientific studies suggest that the sea level is likely to rise between 52-98 centimeters by 2100, which poses a serious threat to the lives of billions of people living along the world’s coast lines as well as to urban infrastructure, energy, agriculture and tourism.

21. The OECD conducted one of the more comprehensive efforts to begin to assess potential costs. 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 obviously have substantial economic costs. These are important caveats and they point to the sheer difficulty of coming to reasonable approximation of the impacts of climate change (OECD). 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 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 also 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 suggests that 23 of 25 regions of the world 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. For all the attention given to the Paris Agreement and in light of scepticism about signatories' capacity and/or willingness to meet the targets it establishes, there are concerns that the effort will not be anywhere near enough to keep global temperature rise below 2°C. A much-discussed study in the scientific journal Nature 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 likely warm from 2.6°C to 3.1°C by 2100 and could even warm more than this with a 10% chance of rising by 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 "stock take" foreseen in the Agreement will need to adopt substantial course corrections (Rogelj, et al., and Mooney).

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. 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. 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 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 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.

27. Climate change thus augurs a redistribution of global income favoring cooler countries which tend already to be wealthier (Maclay). Another study by the same three academics unearthed statistical data that linked increased human conflict - from murder to civil wars - to rising temperatures (Hsiang, Buke, and Miguel). Obviously civil conflict, war and the mass movement of refugees impose major costs and countries caught in these circumstances invariably suffer serious setbacks to economic growth and development.

IV. TRADE IMPACTS

28. It is also worth considering the multifarious connections between international trade and climate change. The WTO and 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 both a factor in climate change and will be impacted both by global warming and the effort to mitigate it.

29. 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.

30. Studying the precise relationship between trade and greenhouse gas emission levels is highly complex and tends to reveal variegated results. For example, trade openness for OECD countries seems to correlate with 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. But over the long term, there seems to be a positive correlation of trade and CO_2 emissions (WTO-UNEP).

31. 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 energy, are slated to rise substantially. More generally, petroleum products power 95% of world trade transportation so the expansion of trade could pose a challenge to the effort to mitigate the emission of greenhouse gases. 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 although the loss of Arctic sea ice has rather ominous implications for the overall health of the planet.

32. 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 of this particular technology. 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.

33. 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 which merely shift the locus of production without mitigating greenhouse gas emissions. On the other hand, insofar as trade can generate growth and 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 both because it is wealthier and has the means to cope with the problem and because that country has a serious and costly problem of general environmental degradation and is acutely vulnerable to climate change. In other words, China has now both the means and the motivation to begin to address the problem.

34. 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. In other words, an economic contraction linked to climate change in one country, could 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.

35. It is worth considering that 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 will be one way to offset the impact. 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.

36. Finally it is worth considering that 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. Societies that most successfully manage adaptation to climate change may also gain certain advantages in global commercial markets as will those countries that specialise in developing technologies that mitigate the use of CO_2.

37. Finally we need to 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 (WTO-UNEP).

V. POTENTIAL ECONOMIC GAINS FROM MITIGATION

38. Beyond the apparent economic gains to be had simply by averting or at least minimising global climate change, there are other advantages linked to the process through which this change might unfold. Since climate change is being driven by the expanding use of fossil fuel, and 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 development.

39. Markets 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 only accounts for 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 still employs 38% more people than solar 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. As the industry matures, it will require significantly less labor.

40. 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).

VI. OTHER IMPACTS

41. The World Health Organization has estimated that climate change linked to human activity is already 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. But 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.

42. To make this tangible, it could be helpful to consider one event—the inordinately hot summer in Europe in 2003. That summer, over 14,000 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.

43. 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.

44. Finally, social changes linked to climate change could include violent conflicts linked to declining food production or water shortages or economic crises linked to these phenomena. The pontential for conflict between regions affected by climate change should not be ruled out. The refugee crisis shaking political stability throughout much of the Middle East and posing serious problems 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 trigger mass movement particularly in regions which no longer have the water and agricultural resources needed to support life. It is impossible to even begin to affix numbers to the problem but 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.

VII. CARBON TAXATION

45. 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. Many of the wealthier carbon fuel intensive countries anticipate that they will invariably foot a high part 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 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.

46. 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 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 price paid reflects the total cost including the societal costs.

47. 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 meted out 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 help moderate consumption behaviour so that demand is conditioned by real prices reflecting the full spectrum of opportunity costs.

48. 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).

VIII. A POSSIBLE US WITHDRAWAL FROM THE PARIS AGREEMENT

49. The apparent intention of the Trump Administration to pull out of the Paris Agreement and even to prioritise carbon based fuel production and use over renewables represents a serious blow to the international effort to cope with the climate change challenge. Although the United States, like many other countries, faces both technical challenges and costs to meet the goal of reducing its greenhouse gas emissions as laid out in the Agreement, it cannot escape the costs associated with climate change. 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).

50. 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.

51. If the United States were to leave the international coalition working to mitigate climate change, the US policy position could also reduce the will of other states to address the challenge, making it all the more likely that costs linked to inaction would mount. 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 this particular study have grown more gloomy.

52. These events would hit 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 caused 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 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 nothing to mitigate climate change.

53. 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.

54. They argue 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 CO_2 emissions.

55. Secondly, they argue 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.

56. 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.

57. 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.

58. 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.

IX. CONCLUSIONS

59. 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.

60. 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.

61. 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.

62. The benefits of a successful effort to achieve the goals laid out in the Paris Agreement would far outweigh the substantial costs. This effort will 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 and eventually other carbon fuels will face similar competitive pressures as the cost of cleaner energy sources falls. Subsidising the use of carbon based energies is now understood as utterly regressive and will only postpone an inevitable transition and leave societies poorly positioned for the emerging economic order. Indeed 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.

63. Other incentives are 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 and technological advancements will create ever greater 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 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.

64. Properly pricing carbon will also make clean energies more attractive and accelerate their introduction into national energy mixes. Under-pricing carbon has distorted energy markets and here again, the state has a corrective role to play to make those markets better reflect real cost conditions. Thus, 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 Feldstein et al. are welcome and demonstrate that the goal of carbon reduction and economic efficiency are not mutually exclusive.

65. 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 there are now signs that it may reject its structures and even the science underlying it. This would represent a serious setback. The international community, including NATO allied countries, must continue to engage the United States so that it remains a leader in this important effort. International action becomes very difficult without US participation, and there needs to be a dialogue to keep the United States within the reigning political and scientific consensus.

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