

RE-CITY

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RAPPORTEURSHIPS "FACING CLIMATE CHANGE"

"HOW NATIONS CAN COOPERATE TO MEET THE CLIMATE-CHANGE CHALLENGE?"

SESSION WITH **JOHN ROEMER.**



How nations can cooperate to meet the climate-change challenge

Invited Speaker: Prof. John Roemer. Yale University, United States

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This report is a synthesis of the debate carried out with Prof. John Roemer in the conference series “Facing climate change” organised by Catalunya Europa Foundation in the context of the Re-City project. This session, entitled "*How nations can cooperate to meet the climate-change challenge*" consisted of a public lecture, a seminar with participants from the academic sector of Catalonia and a lunch-debate that brought together personalities from the economic, social, political and business sector of Catalonia. The mentioned activities were held in Barcelona at the Antoni Tàpies Foundation on December 2018. The content order along the report is thematic and does not represent the order in which it was exposed by John Roemer. The conference series “Facing climate change” is developed in collaboration with BBVA, Generalitat de Catalunya, Àrea Metropolitana de Barcelona and Barcelona City Council.

Biography

Dr. John E. Roemer is the Elizabeth S. and A. Varick Stout Professor of Political Science and Economics at Yale University, United States. He is a Fellow of the Econometric Society and has been a Fellow of the Guggenheim Foundation and the Russell Sage Foundation. His research has concerned political economy, distributive justice, theory of socialism, climate change, human welfare, and cooperative economics.

In 1966, Roemer obtained his Bachelor of Arts (B.A.) degree in Mathematics (*summa cum laude*) at Harvard College, Massachusetts. Then, he started as a Mathematics teacher from 1969 to 1974 at Lowell High School and Pelton Jr High School, San Francisco. In 1974, he obtained his Ph.D. in Economics at the University of California, Berkeley. After this, he was a professor of Economics and the Director of the Program on Economy, Justice & Society at the University of California-Davis until 2000, when he moved into Yale University. He is currently teaching Political Competition and a Workshop in Political Economy.

Roemer has obtained awards and honours from around the world, including Catalonia. His latest prizes were obtained for the paper “Kantian Equilibrium” (2010), which received the Scandinavian Journal of Economy prize in 2010 as the best paper of the year, and for the book “Sustainability for a Warming Planet” (2015), written along with Humberto Llavador and Joaquim Silvestre, which received the X Catalan Economic Society Award in 2016. Further, he holds doctorates *honoris causa* from the University of Athens, Queen Mary University of London, and University of Louvain-la-Neuve.

Some Roemer’s high-impact publications include: “Equality of Opportunity” (2000), in which Roemer proposes a normative criterion of equal opportunity and advance opportunity dominance as an alternative criterion for the evaluation of policies; and “Theories of Distributive Justice” (1998), in which he critiques economists’ conceptions of justice from a philosophical perspective and philosophical theories of distributive justice from an economic one.

Summary

"Denying the existence of climate change is the main problem to find a solution," warned John Roemer, Professor at Yale University, in his lecture "The ethics of climate change" in the conference series "Facing Climate Change" organised by Re-City.

The American economist referred to those who, like President of his country Donald Trump, have questioned the existence of climate change and have opposed to cooperation between countries to fight together against their effects. According to Roemer **cooperation is the key to success. Without cooperation, it will be very difficult to comply with the Paris Agreements and reduce the emission of greenhouse gases (GHG).**

John Roemer, who also teaches Political Science at Yale, described the Paris agreement as "a very important but insufficient co-operation exercise. We have no way of checking the degree of compliance with the countries, but assuming that they all accomplished, would not be enough to mitigate the consequences of global warming."

John Roemer explained his theory to make compatible the fight against climate change with economic growth, helping to reduce the inequalities between countries in a sustainable way and with the least ecological impact on the world population and future generations. Roemer proposed two systems, corresponding to a normative and a positive approach, respectively. The normative perspective responds to the principle of sustainability and allocates our remaining carbon budget between the developed and developing countries so that convergence of standards of living will still occur in the same date as if we wouldn't curve GHG emissions. This means that carbon emissions are limited in the global North and the global South to achieve the convergence date in 3 generations (75 years).

Along Roemer's model, the reduction in GHG emissions is more marked in the global North. The model also shows that the standard of living of the north grows at approximately 1% per year, which is lower than its average growth in the 20th century, as it was closer to 2% per year. On the other hand, the GDP of China, India, Brazil or Indonesia grows faster than 1% during the convergence period (Llavador *et al.* 2015).

The second approach by Romer is based on a joint project with Humberto Llavador ("Global Unanimity Equilibrium in the Global Budget", Cowles Foundation Working Paper 2019). The proposal calls for an agreement on total emissions, or temperature, and a global price on carbon that would decentralize the allocation of permits, setting a cap on emission of carbon dioxide and greenhouse gases. The money raised would be collected in a global fund and allocated among regions proportionally to their damages from climate change, resulting in a compensation to the poorest countries that would help to develop them, given that they would be the most affected by climate change. The proposal designs a mechanism that would yield all countries unanimously agreeing on a total emission limit for GHG that would not exceed 1,5°C of global warming established by the IPCC group in its latest report, while the price on

carbon would be set by the global market on emissions. Therefore, the objective of the tax is to induce companies to abandoning the use of carbon and evolving towards renewable energies, while the funds raised would help mitigation and adaptation, specially for the less developed regions. Like this, Roemer estimates that in 50 or 75 years the use of carbon could be reduced by 95%.

In this study, he estimated that the average tax for the next 40 years would be about 135 dollars per tonne of carbon and the global fund would add up over a trillion dollars per annum, which would result in the regions with less resources (namely, Africa, India and small less-developed countries in Asia) receiving around 500 billion dollars a year, five times more than the funds established in the Paris Agreements under the Green Climate Fund. Countries with higher emissions are the ones that will contribute the most. While on the other side, the ones that suffer greater climate change impacts, such as African countries and India would receive money from the fund.

Roemer and Llavador have simulated a projection of his system but have not foreseen a starting date. "The sooner we start, the better. There is no alternative," says Roemer.

Cooperation among countries is key to control global warming

Roemer stated that cooperation among countries of the world is absolutely necessary in order to limit greenhouse gas (GHG) emissions and to control global warming.

The standard concept of equilibrium among players in economics, which is called Nash equilibrium, is a non-cooperative concept. Roemer argued that people failing to cooperate in several cases would lead to disastrous outcomes in many economic situations. In fact, a lack of cooperation in the climate change issue will lead to what is known as the Tragedy of the Commons. In this theory, the “commons” is the global biosphere which we want to keep at a reasonably cool level, and lacking cooperation of a country by simply pursuing their own interests will make it unfeasible.

According to Roemer, economic theory has paid little attention to recipes for cooperation. Some conceptual innovation is required to describe precisely how cooperation could be organized in this particular problem. For this reason, **Roemer’s model does consider cooperation between countries and provides a Pareto-efficient solution.** A solution where there is no way of improving the welfare of one country, without making that of another country worse off.

The **2015 Paris Agreement was a first exercise in international cooperation**, where 194 nations agreed to intended nationally determined contributions (INDCs) to reduce GHG emissions. However, Roemer as many other specialists highlighted that there is no enforcement mechanism to require countries to actually implement what they promised in 2015. Furthermore, even if every country did implement what it promised, the reduction of GHG emissions would be insufficient towards keeping the global temperature below an increase of 1.5°C above preindustrial temperatures. Therefore, much more efforts have to be done with respect to increasing the contributions of countries and regions of the world to reduce their emissions.

In this context, Roemer remarked that **the main purpose of that meeting in Paris was to build trust and solidarity among the participant countries without which cooperation is not possible.**

For this reason, he was very critical of Donald Trump and his decision, when he arrived at the White House in 2017, to withdraw the United States from the agreements signed in Paris for 195 countries, just three years ago, on December 2015. A decision that Roemer deeply regrets because "since then, the US has done nothing against climate change. Trump also denies the existence of climate change. In November 2018, 13 federal agencies published a report outlining the problems that the country is going to face over the next 50 years due to climate change –for instance, that their GDP will decrease by 10% per year if they do not act radically to face climate change (USGCRP, 2018). According to Roemer, this is a good action, but Trump stated that he did not believe the results.

Luckily, some states, like California, are taking steps forward with specific legislations, on their own, outside the federal government of the White House. "But while the

voters keep Trump at the oval office, the rest of the countries will have to put more pressure on the United States not to completely disassociate themselves from this struggle, because we are facing a global problem", Roemer said.

Besides US, it is also unlikely that Brazil wants to cooperate now that Bolsonaro has been elected, and similar case is found in Hungary and some other countries. Roemer believes that this situation is due to the fact that people's economic situation is now much more precarious than it was 50 years ago in many parts of the world. Building the necessary kind of political cooperation is going to require getting rid of the thought that the country itself can solve the problem, because climate change is a global problem. Further, facing climate change will require changes in democratic countries, like France, in terms of improving the economic situation of the bottom-half of the population, so that they will be not attracted by far-right political leaders that deny climate change. Until this problem is not solved, Roemer is pessimistic about international cooperation.

At a lower scale, there are non-cooperative behaviours among different firms regarding a framework of sustainability and corporate law. In this context, it is important to know how to make countries cooperate, but also to encourage firms to cooperate among themselves as well.

Roemer does not know exactly how long it will take for the population to get organized to put pressure on the politicians to solve the climate change issue. It largely depends on how rapidly the climate catastrophes develop and get worse. Lately, they seem to be developing pretty rapidly, and the temperature keeps increasing. Moreover, we keep increasing the amount of carbon that we emit into the atmosphere every year, so the carbon blanket of the atmosphere which holds in the heat of the Sun is only getting thicker and thicker. Therefore, the number and frequency of catastrophes will increase. Further, while the Paris Agreement aims to converge to a temperature increase of 1.5 °C above preindustrial levels, the temperature has already increased about 0.8 °C globally since 1850. Roemer stated that we have to hope that human beings are going to see that they have to get organized to fight this. The sooner we organize, the better. He compared the relevance of facing climate change to the European Black Death of the 13th century, which killed about a third of the European population, and stated that these may be the two most important events that our specie has needed to fight.

Overall Roemer is confident, he stated that our huge successes as a species are due to our ability to cooperate with each other. "We just need to extend this ability to an even larger level –we have to learn to cooperate to the extent that we can solve the climate change problem" Roemer said.

Two principles of international cooperation to control greenhouse gas emissions

During the last decades, most people have been aware of the need to reduce GHG emissions as a main measure to mitigate climate change. According to Roemer, the big question is how permits to emit GHG should be assigned to different regions (eventually, countries) of the world in order to converge to a temperature increase of 1.5 °C above preindustrial levels.

A few years ago, a 2 °C increase was considered to be a sufficient target for avoiding real catastrophes with respect to climate, but the most recent IPCC's report exposes that 2 °C is too dangerous. Therefore, we really have to aim at holding the total increase in temperature to 1.5 °C. As stated by Roemer, this means that we have a certain carbon budget –i.e. a certain budget of emissions– left that we can implement before hitting this limit. Roemer pointed out that this will not be possible in a decentralized, voluntary and disorganized way. Instead, there have to be assignments of permits to individual countries and individual producers in countries eventually, so that this can be maintained. Consequently, cooperation is going to be necessary. Roemer's concerns, as an economist and a political scientist, are the cooperative principles that might guide the international negotiations. He wants to determine how political cooperation can be organized in order to meet the necessary level of emissions to preserve a decent climate for our civilization and for the rest of nature.

Roemer proposed two principles to decide on the allocation of total emissions, 1) to allocate our remaining carbon budget between the advanced and developing world according to a sustainability principle, so that convergence of standard of living will still occur in the same date as if we wouldn't curb GHG emissions (Llavador *et al.*, 2015) and 2) an international unanimity in a cap and trade system (Llavador and Roemer, 2019).

The first principle: TO MAINTAIN CONVERGENCE

How can we keep growing economically and save the planet simultaneously? What is the fair way to share this scarce resource across present and future generations, and across different regions of the world? In the book "Sustainability for a Warming Planet" (2015), John Roemer together with Humberto Llavador and Joaquim Silvestre proposed a solution that would allow growth in welfare to occur. To achieve this, the atmospheric concentration of carbon must be capped at some level not much higher than exists today, and investments in education and research should be higher than they currently are.

Many large countries (China, India, Brazil, Indonesia) are growing, in GDP per capita, much faster than the developed countries (US, Europe, Australia). These countries would eventually converge to Europe and North America in their levels of GDP per capita, as a proxy for the standard of living. Such convergence would be a major accomplishment for humankind. In this context, the first principle that Roemer presented is that all nations of the world should cut back their GHG emissions in such a way that we do not slow down the rate of convergence of the developing countries to the developed countries. Can we improve future generations while constraining the increase in temperature and reduce the divergence of welfare levels between developed and developing countries? According to their estimations, the answer is positive, but not at high rates of growth.

Roemer gave the example of China. If the growth rate continues in China the way it has been going for the last decades, and if there were no climate change problem, the number of years in which China would eventually converge to the European and North American standards of living would be 60 or 70 years. In this case, as enunciated by the first principle, China, Europe and US should cut back on their rates of growth in a way that China should still converge to the global north in terms of standard of living per capita in 60 or 70 years. Same approach has to be applied to India, Indonesia, Brazil, etc.

Roemer defended that this is a very important political principle, as no country should feel that they are being unjustly retarded in the degree to which they can converge to a decent standard of living. As he mentioned, we should make economic development available to everyone in the world.

Achieving that convergence –i.e. bringing China, India, Brazil, etc. up to the European and North American levels– will eventually occur, whether climate change problem would be considered or not, as these countries are growing much faster. However, the climate change problem will require that all countries grow more slowly than they would have in its absence. For this reason, Roemer stated that it is not possible to solve climate change challenge without affecting economic growth.

The model sets that convergence has to take place while following the pathway of emissions that keeps the global temperature below an increase of 2°C above preindustrial temperatures. They chose the Representative Concentration Pathway 2.6 (RCP2.6) and then they modelled the world as consisting of a global south and a global north, which looked roughly like China and US in terms of productive capacities. Afterwards, they performed a social-welfare maximization, in which the allocation of emissions to the two regions is determined via bargaining along the RCP2.6 path. Investment in research and development to lower the emissions-output ratio and the consumption allocation emerge endogenously. The solution is Pareto-efficient subject to the given initial path of global emissions. A solution where there is no way of improving the welfare of one country, without making that of another country worse.

If their model is followed, the temperature path that would occur follows very closely the recommended path by the IPCC. Both paths converge at about 1.6°C over the preindustrial temperature (Figure).

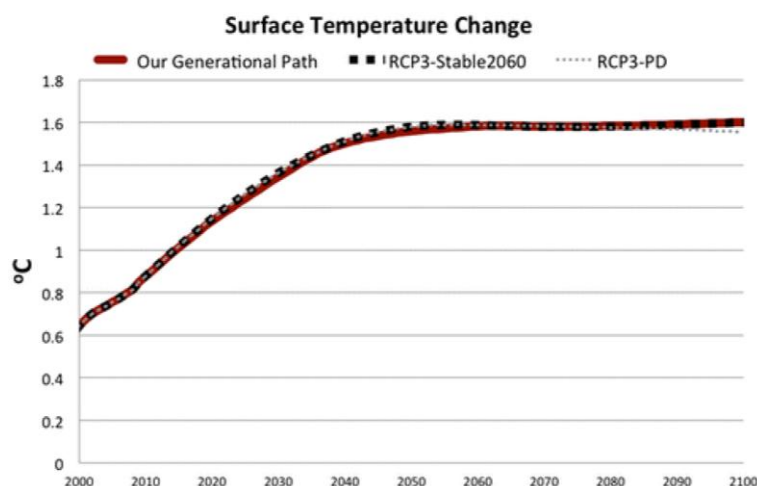


Figure 1. Surface temperature change with respect to 1850, from 2000 to 2100. The graph plot together three pathways: the original Representative Concentration Pathway 3 - Peak and declines before 2100 (RCP3-PD); the RCP3-stable2060, which only differs from RCP3-PD by stabilizing emissions after 2060; and Roemer's Generational Path, which assigns to each generation its average annual emissions according to RCP3-stable2060.

Extracted from: Llavador *et al.* (2015).

The results obtained showed that it is possible to maintain dates of convergence to the advanced countries' standards of living considering the remaining carbon budget. The model places the date of convergence in three generations (75 years). To achieve so, the global North should reduce the total carbon emissions from 3,86 GtC (Giga tons of Carbon) to 0.19 GtC, while the global South should reduce it from 5.18 GtC to 1.28 GtC, which represents a decrease in carbon emissions of 95% and 75%, respectively in 3 generations.

In their calculations, the path that we would implement in order to maintain convergence of the countries in the global south to the global north in terms of carbon emissions per capita is shown in Figure . In 2010, the global north was emitting 3.11 tC per capita and the global south 0.91 tC per capita. Roemer remarked that here we are considering tons of carbon, not tons of carbon dioxide –to do this transformation, one has to multiply the tons of carbon by about 3.7. In the first 25-year generation (2035), the global north will continue to produce more tons of carbon than the global south, but they will both go down. By generation 2 (2060), emissions would be very low globally, being 0.34 tC per capita, and global south would be emitting more than global north. In generation 3 (2085), emissions would be the same throughout the world, with a value of 0.15 tC per capita.

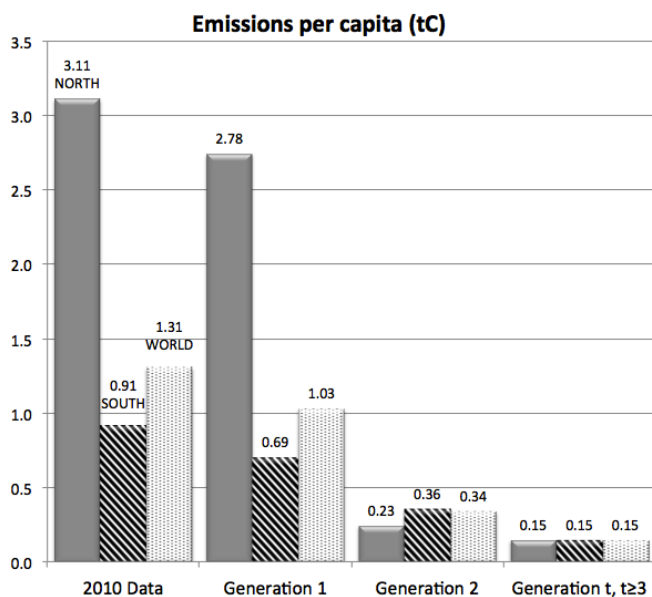


Figure 3. Emissions per capita in tons of carbon (tC) that should be allocated in each generation and each region. tC, tones of carbon. Generational time is considered to be about 25 years. Extracted from: Llavador *et al.* (2015).

An international team of economists would have to work out the details of how to assign these permits to different regions. Roemer believes that we must underscore the importance of establishing the goal that would guide this team. To agree upon that goal would itself require careful international regulations. Furthermore, the implementation would require a system of monitoring and penalties. According to Roemer, this goal is not achievable with the present US administration.

Roemer remarked that their proposal does not look backward at how much countries have emitted in the past, thus being forward-looking. On the other hand, many other researchers state that the developed world has already used up its carbon budget, and thus it actually should get a very small allotment of carbon, whereas almost all of the emission rights should be given to the developing countries. This is what Roemer calls a backward-looking proposal. However, he does not believe that it is politically feasible, as global north would need to cut back extremely on their emissions. Moreover, nobody knew the existence of global warming until 1988, when the first paper stating that the global warming was occurring was published (Hansen *et al.*, 1988). Before 1988, there were even arguments that it may be occurring a global cool. Thus, Roemer argues that blaming developed countries for the damages they have done from their emissions when people did not know what they were causing may not be fair, besides it would be useless if it did not result in a higher welfare level for the developing countries. Roemer believes that their principle is much more acceptable for most countries in the world.

Can the Earth sustain so much growth continuously? It is growing more an obsession than a real need? As mentioned by Roemer, there is a socioenvironmental movement defending that we have to stop growing and even to reduce the standard of living. However, the outcomes obtained from careful computations are optimistic. Roemer highlighted that a positive growth is compatible with the limitation of carbon emissions –we do not have to experience neither a negative nor a stationary growth.

Nevertheless, he pointed out that to continue growing at the same rate as before is not feasible. Along Roemer's path, the standard of living of the north grows at approximately 1% per year, thus being 28% per 25-year generation, which is lower than its growth in the 20th century as it was closer to 2% per year. On the other hand, the GDP of China, India, Brazil or Indonesia and other developing nations would grow at a faster rate during the convergence period, but still lower than current objectives, until both economies converge.

Roemer believes that the limitation of the growth of the global north has not been the problem with growth in the last 30 or 40 years. Instead, the real problem has been that the growth of the advanced capitalist countries has been extremely unequal. Therefore, most of the benefits of economic growth have gone to the very top of the income distribution. For instance, in the US, the total income (GDP) growth was 61% from 1980 to 2014 –even including the financial crisis, thus being 1,8% a year. However, the fraction of this economic growth that went to the bottom-half of the income distribution was little –their growth was close to zero, approximately 0.33% in average. In fact, the bottom 20% of the income distribution had a negative growth. On the other hand, the top 1% of the income distribution captured 48% of total growth. In this context, Roemer stated that having a 1% per year growth rate, if evenly distributed over the population, would hugely improve the situation of the bottom half of the income distribution in US. It would not be so dramatic in Europe as it would be in the US because the growth in US has been more unequal, but similar results would be obtained.

Again, Roemer recalled that the unequal distribution of the GDP within a country is what has driven the increasing irruption of far-right parties, as people's economic situation is now much more precarious than it was 50 years ago in many parts of the world including the US. Therefore, a lot of people are desperately looking for alternatives to what it is happening with their economic situation. This explains the attraction for Trump, as the Democratic Party has not solved this economic problem and people are looking for alternatives. Trump has given three explanations to what has happened to them –Chinese production is taking away jobs from American workers, illegal migration from Mexico to US is taking away jobs from American workers, and black people are taking away Government transport payments from white people. Building the necessary kind of political cooperation is going to require the improvement of the economic situation of the bottom-half of the population, so that they will be not attracted by far-right political leaders that deny climate change.

Roemer stated that these low emissions planned for 2085 are possible because of technological progress, which reduces the amount of carbon emissions per thousand dollars of output. In other words, there has been a steady improvement in efficiency of production in the sense of reducing the amount of carbon pollution that we produce per unit of output. Further, improvements in **renewable energies make possible to produce energy and keep growing without destroying the global commons**. In fact, Roemer mentioned that their results are in conservative estimations, and that they do

not assume the discovery of a “magical” highly-efficient technology. He also remarked that there would be costs during the transformation process. Energy companies based on oil and coal must be aware that they have to reinvent themselves and undergo the transition. In this context, some kind of compensation will be required for countries that will be affected by this transformation. This is the case of Saudi Arabia, which has large amounts of oil and they will not be allowed to mine it. This compensation will be feasible if people of the world are organized. However, without state coercion, the fossil fuel industry will not stop mining their product.

All in all, Roemer highlighted that to meet the goals set in the Paris Agreement we have to reduce GHG missions and, hence, to slow down growth, but we do not have to shrink the standard of living.

The second principle: INTERNATIONAL UNANIMITY IN A CAP AND TRADE SYSTEM

Roemer proposed this second principle because he believes that there are lots of ways of designing cooperation. This second approach is described in Llavador and Roemer (2019) and differs from the idea of preserving the rate of convergence. It proposes a way to decide upon what global emissions should be by international unanimity –this is achieved by a cap and trade system, a tax on firms for the emission of each ton of carbon. Every major region of the world would come to agree on what global GHG emissions should be over the next 75 years. Regional emissions would not be assigned but decentralized in such a way that the agreed-upon global emissions limit would be satisfied.

In the application, the world is divided in 12 regions, following Nordhaus’ RICE model (Nordhaus and Yang, 1996; and BOX 1), each of which operates a market economy. Apart from the usual prices of the production of commodities, wages and capital, there will be a price that each firm must pay for each ton of carbon that emits. Firms in the regions will set their production plans in the usual way, trying to maximize profits, but one of the costs that they must consider is the cost of carbon emissions associated with production. These carbon fees are paid to an international fund, a central clearing house that will eventually return the total revenues collected to countries according to pre-specified proportions. Therefore, countries are going to receive back payments from the fund according to agreed-upon proportions.

The model does not address how countries distribute the funds among their citizens. In that sense, it focuses on between country rather than within country wellbeing. Countries should decide whether they distribute the funds among the citizens, invest in repair the damages caused by climate change, invest in the transition, etc. The model neither does talk about compliance or transparency. These issues are common to any cap-and-trade or tax policy and, although they are very relevant, they are assumed to be solved for simplicity of the analysis.

It is assumed that each country will be interested in maximizing its own welfare, which is here defined as the GDP per capita minus the damages implied by climate change induced from the cumulative global emissions of carbon. Climate change affects every person in the world, but it affects differently depending on the region where the person is living. For example, Bangladesh is going to suffer much more a given level of global emissions than Russia, because Russia is far north and the climate change is maybe going to be beneficial to agriculture in Russia, whereas it is going to induce massive flooding in Bangladesh. Consequently, each country will have its own damage function, which describes the damages that the country will suffer monetized into costs of repairing those damages. Besides, each country will be interested in setting the production function, which describes the production process considering the emissions that a firm emits as an input.

The **damage function** is the function that relates the total cumulative level of emissions with the damages that the country sustains because global temperature is rising. This cost includes the cost of moving away people from the shore, as sea level is increasing; the cost of repairing the damages of hurricanes, droughts and heatwaves; and, on the top of costs, the cost of the increasing diseases, such as malaria. Damage functions depend not only on a country's emissions but on total emissions, and they vary among countries. Economists and other scientists are trying to estimate these damages as a function of mean global temperature. There is a thick asymmetry between emissions produced in one place of the world and the damages created somewhere else. The temperature rise may be more marked in some parts of the world than in others, but in any case, they are a function of global emissions. For instance, the temperature increase in Arctic will be much larger than in New York for a given amount of global emissions.

The **production function** is a function that transforms inputs into output. Roemer and his co-author made two grossly simplifying assumptions, common in these aggregate macroeconomic models. First, that commodities being produced are aggregated in one representative good. The second one is about how this good is produced in a country using three inputs –capital, labour and emissions. Therefore, emissions are seeing as an input into the production process.

These two functions are not constant over time. In the case of the production function, technological improvement is considered in the model using a time-period of 40 years. Roemer and his partner preferred to develop a static model because it reflects a one-time negotiation, like the Paris agreement, and because it is more useful for policy recommendations thanks to its “simplicity”. A dynamic version of this theory would be much more complex. The method of abstraction in economics simplifies the representation of the world in order to obtain a manageable mathematical model that still captures the essence of the question under study. A very detailed model that showed all the complexity of the real world would be like a 1:1 scale map and would not allow us to derive any understanding. Roemer hence compares the situation to a map –if a map not only has the highways and the topography but it is as detailed as

reality, it will be a very complex and realistic map but will prove useless for understanding and finding the right way. This justifies the use of models in making estimations and forecasting.

The global level of emissions that all countries will agree upon can be understood as the supply of permits to emit carbon, and those permits will be sold to the individual firms or countries that have a demand for permits which is the consequence of the profit maximization of the firms in their region. Taxes will be paid by the producers but, as is well-known in economics, both producers and consumers will bear the burden of the tax, as producers will shift part of the tax to consumers by increasing prices to partially cover the costs of carbon taxes. The proposal in Roemer and Llavador research sets a mechanism to determine the proportion of the global emissions fund that is returned to each region, so that all regions will unanimously agree on the global level emissions (Figure 4). The price of a permit will be determined by the combination of the supply and demand of emissions.

Region	a	a/Pop.share	a per million person	REVENUES		
				billion \$	\$ p.c.	%GDP
US	0.077	1.70	0.21	168.5	458.63	0.66
EU	0.112	1.60	0.20	246.6	431.60	0.91
Japan	0.015	1.07	0.13	32.7	288.18	0.57
Russia	0.006	0.43	0.05	14.4	114.71	0.45
Eurasia	0.010	0.43	0.05	22.3	114.70	0.74
China	0.182	1.05	0.13	402.4	283.22	1.80
India	0.130	0.74	0.09	287.8	199.45	2.47
MiddEast	0.056	1.60	0.19	124.1	428.27	1.82
Africa	0.220	1.15	0.14	483.9	309.36	3.99
LatAme	0.063	0.74	0.09	138.3	201.10	0.96
OHI	0.030	1.86	0.23	66.9	500.47	0.96
OthAsia	0.099	0.63	0.08	220.7	169.91	1.93

Figure 1. Allocations of permits' claims and revenues for each region. *a* is the share of the total fund that would be remitted to each country, between 0 and 1. OHI, other high-income countries including Canada, Australia, Singapore, Israel, Hong Kong, New Zealand, etc; LatAme, Latin America; OthAsia, other developing and poor countries of Asia.

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The citizenry of each region has a trade-off to consider in terms of setting the global level emissions: the higher the global emissions are, the more damages they suffer, but the more they get back as their share of compensation from the global fund, and the cheaper they can produce. Therefore, the citizenry of each region will have an optimal level of total emissions. The advantage of this proposal is that there is always a way of setting the shares that countries get back of the fund so that all regions agree on what that global level of emissions should be –Roemer called this an unanimity equilibrium. In equilibrium, the carbon market clears –i.e. the total carbon permits demanded by the countries will be equal to the total supply of permits. The demand of emissions should be provided by the national profit-maximizing firms, whereas the supply for emissions should be unanimously agreed upon by all national citizenries.

At the solution to this problem, the share of the global fund that a particular country gets is proportional to the marginal damages that it sustains at this global level of emissions. The marginal damages mean the rate at which their damages are changing at that level of global damages.

The solution entails a decentralized allocation of regional carbon emissions that is the result of firm profit-maximization in each region. The total allocation of goods and emissions which occurred following this model is again Pareto-efficient –i.e. there is no other allocation of emissions level that could make all countries better off in welfare terms, where welfare is measured by GDP minus climate change damages.

As in the first principle, the solution must be calculated by an international team of economists. The unanimous supply is going to require the organization of committees with experts that are able to consider the trade-off properly between the damages that the country suffers from emissions and the gains obtained from the fund. The cooperation entailed among countries is that all countries will agree on what the global level should be and to participate in this scheme.

Figure 4 shows Roemer and Llavador's latest calculations about the size of the carbon tax, and how much different countries would receive back from the international fund. In this model, a country's share of the emissions fund is proportional to its marginal damages. Thus, the shares reflect the conditions that the countries suffer from the global emissions. For example, countries less affected by climate change like Russia, Japan and US would get about 0.6%, 1.5% and 7.7% of the fund respectively, whereas countries more affected by climate change like Africa, China and India would get 22%, 18.2% and 13% of the fund, respectively.

Region	consumption		net payment billion(10 ⁹) \$
	trillion \$	thousand \$ per capita	
US	25.53	69.48	175.2
EU	27.04	47.33	14.7
Japan	5.720	50.43	19.8
Russia	3.15	25.10	64.1
Eurasia	2.97	15.25	46.6
China	22.22	15.64	136.9
India	11.77	8.16	-121.5
MiddEast	6.79	23.45	18.5
Africa	12.45	7.96	-331.2
LatAme	14.42	20.96	4.4
OHI	6.94	51.93	52.3
OthAsia	11.55	8.89	-79.9

Figure 2. Consumption and net cost of emissions for each region. OHI, other high-income countries including Canada, Australia, Singapore, Israel, Hong Kong, New Zealand, etc; LatAme, Latin America; OthAsia, other developing and poor countries of Asia.

Retrieved from: <https://www.re-city.net/admin/assets/uploads/files/96adb-conferencia-john-roemer.pdf>

Figure 5 shows the net payment that would go to each region of the world, that is the difference between the payment made by firms of each region of the world for emitting carbon and the amount received as its share of the fund. The important matter is whether the share that the country receives back is greater or less than its contribution to the fund. As we can see, the most polluting countries are the ones that will most pay the price of this pollution. As an example, the US net contribution to the fund would be \$175 billion; China, \$136 billion; Japan, \$19 billion; and Europe, \$14 billion.

On the other hand, the net beneficiaries of this procedure would be exactly the developing countries because they contribute less to climate change and suffer more of its consequences. Indeed, India, Africa and other Asian poor countries would get

back 121.5, 331.2 and 79.9 billion dollars per year net, respectively. Together, it means a total of more than 500 billion dollars per year net.

The promise accorded in the Paris Agreement was that by 2020, the developed world would contribute with 100 billion dollars a year to these countries. According to Roemer, we do not even see that this is going to happen. Furthermore, under his procedure, more than 500 billion dollars a year would be contributed to the developing countries. Therefore, his approach is hugely more compensatory than what was being proposed at the Paris meetings.

However, how can we convince particularly the US and China to pay out such a high amount each year, especially if we compare it to the EU? Roemer argued that the main advantage of this model is that the global cap and trade system is not determined externally by the UN or any other institution. Instead, every region will unanimously agree on what the global emissions should be. In fact, these shares are calculated so that both a unanimous agreement and Pareto-efficiency occur. The proposal also requires that the regions agree upon their damage functions –there is going to have to be an international team of economists, epidemiologist, sociologist, etc. involved in calculating what these damages functions are, and then the regions will have to agree with them.

One may think that the task of reaching international unanimous agreement on shares and emissions is likely to be very hard and difficult. Nevertheless, Roemer said that the trick is the clever choice of the shares of the global fund, which would be remitted to countries. It turns out that the way to set these shares is the one in which you set the shares equal to what the marginal damages for the country will be at the equilibrium level of emissions. The problem that we have now is that we do not have any theory of how we are going to get agreement on what the global level of emissions should be, although it is possible to get agreement –at least theoretically according to Roemer’s simple model.

Once people have agreed to share, they will have to agree in what their shares should be. According to Roemer, the shares have to be announced in order to coordinate the cooperation. He believes that the sticking point would be that people have to agree with and accept the shares that they propose. However, why would they agree? Again, Roemer defended that we have such basic lack of cooperation until now because the global climate and health contexts are not bad enough yet. Therefore, the population of the countries are not forcing their politicians to take proper actions against climate change. On the other hand, politicians do not want to impose costs on the population –e.g. through taxing carbon emissions– before the population seeks and accepts to do it now. Consequently, the politicians do not have the incentive to negotiate the agreement because they are not feeling enough pressure from the population.

According to Roemer, carbon taxes are the result of democratic activity. A tax on CO₂ consumption and emissions will mean extra costs for the firms. However, who is actually going to pay those extra costs? Usually it is the final consumer who ultimately

pays the taxes, but can the final consumer really afford it? Roemer assured that people will not be poorer under this system, at least on average. He stated that the cost of paying the carbon taxes will be the main incentive that individual firms will have to switch to carbon-free energy, even if this transition implies costs.

The cost of fossil-fuel emissions rose to its highest level in 2018 in more than a decade in Europe, being 23 US\$ a ton. Although it has been an adequate measure to be taken by the EU, the price is still too low. According to Roemer's calculations, firms would pay 135 US\$ for each ton of carbon that they emit. If firms have to pay to emit and want to have benefits, they will have to reduce their emissions. Further, the existence of this carbon tax will give an incentive to alternative energy producers to improve their technologies and to make their energy cheaper. Roemer does not believe that other kind of incentives will be necessary to make the transition.

As stated by Roemer, his model works quite well with respect to the market share. Nevertheless, the problem occurs when there is a monopoly. Normally, firms are always trying to keep their profits up and keep their market share from competitors. However, if there is a monopoly, it is difficult to achieve that firms lower their emissions to reduce their costs, as monopolies do not feel the pressure of rising prices and competition.

This carbon tax may force certain companies and industries out of business, such as coal mining. However, Roemer remarked that this event happens very often as we are transforming constantly, so the companies that are inefficient and unsuccessful die and new companies are born. According to him, the measure of whether a company should exist is whether it can contribute to human welfare. In this context, if a company cannot contribute to human welfare because it is too intensive in the use of carbon and cannot afford to pay the costs that society has set for emitting carbon, then it should not exist.

There are some multinational firms that can create a permit demand in countries but are not linked to the country's economy. Roemer explained that the fact that this carbon price is going to be global means that **firms will have to pay the carbon tax wherever they produce**. The price of firms moving to other countries have to be paid, and it must be controlled by organisations. What a country consumes is not what it produces –instead, it is what a country can afford to buy with its income. For instance, Africa, which is going to be getting 330 billion dollars a year, will be using this amount of money to purchase consumption goods which are not produced in Africa because this country is relatively carbon-inefficient –i.e. it produces relatively high amount of carbon per unit of production.

The Climate Leadership Council is an international policy institute founded in collaboration with business, opinion and environmental leaders to promote a carbon dividends framework as the most cost-effective, equitable and politically-viable climate solution. **The Climate Leadership Council is promoting an initiative that**

supports the idea of taxing carbon emissions in US, called **Carbon Dividends Plan** (<https://www.clcouncil.org/our-plan/>). The four pillars of this plan are:

- **A gradually increasing carbon fee.** A sensible carbon fee should begin at 40 US\$ a ton and increase steadily over time. It will be implemented at the refinery or the first point where fossil fuels enter the economy, meaning the mine, well or port.
- **Carbon dividends for all Americans.** All the incomes from this carbon fee would be returned to the American people on an equal and quarterly basis via dividend checks, direct deposits or contributions to their individual retirement accounts. This amount would grow over time as the carbon fee rate increases, creating a positive feedback loop –the more the climate is protected, the greater the individual dividend payments to all Americans. The Social Security Administration should administer this program, with eligibility for dividends based on a valid social security number.
- **Border carbon adjustments.** Border adjustments for the carbon content of both imports and exports would protect American competitiveness and punish free-riding by other nations, encouraging them to adopt carbon pricing of their own. Exports to countries without comparable carbon pricing systems would receive rebates for carbon fees paid, while imports from such countries would face fees on the carbon content of their products. Incomes from such fees would benefit the American people in the form of larger carbon dividends or could be used for transitional assistance for industries or regions hurt by the carbon fee.
- **Regulatory simplification.** The simplification implies the elimination of regulations that are no longer necessary upon the constitution of a rising carbon fee whose longevity is secured by the popularity of dividends. Many, though not all, of the Obama-era carbon dioxide regulations could be safely phased out. Robust carbon fees would also make possible protecting companies from federal and state harm responsibility for historic emissions.

This approach is similar to Roemer's proposal, but the latter is extended to all countries, incorporates a different principle to distribute revenues, and determines endogenously the price of carbon. According to Roemer's model, the net dividends to Africa, India and Other Asia –i.e. Asia excluding China and India– are 331.2, 121.5 and 79.9 billion dollars a year, respectively, which presumably should be used by the countries to augment the incomes and consumption of people. This may not happen because there are lots of corrupt politicians that are likely to invest its country's dividend into their own bank accounts. Nevertheless, Roemer stated that we must keep fighting and trying to make the model work.

The international unanimity in a cap-and-trade system is not a normative analysis and does not incorporate ethical values like inequality. However, although it takes a

conservative perspective in assuming that countries only care about the welfare of the current and future citizens, it finds that by following this path, a large degree of redistribution takes place and inequality reduces. This is a result of the fact that poorer countries contribute less to climate change and suffer more its consequences, and that redistribution of the global revenue is proportional to climate change damages.

Roemer referred to Marc Fleurbaey (<https://www.re-city.net/en/activitats/8/marc-fleurbaey.html>) and his team, which focused in how to take care of the bottom of the income distribution when distributing the benefits. Fleurbaey's research has paid much more attention to the problem of equalizing and directing the main proportion of the benefits of the carbon revenues to the poor people of the country. Furthermore, Roemer also mentioned Thomas Piketty, referring to him as the one who has wrote the best economic book of the last decade –i.e. the bestseller “Capital in the Twenty-First Century” (2014). Piketty proposes to put a large tax on business class airline tickets because the people who really can afford to pay the tax are the wealthy. Moreover, the carbon emissions per person grow up quite rapidly with income. Therefore, the very wealthy are consuming goods which involve much more carbon emissions in their production than the poor people, thus being fair that the wealthy pay a much larger tax. According to Piketty's estimations, the tax to be paid by business class users in order to solve the problem would be around 200 US\$ a ticket. Thereafter, those taxes would be distributed to poor countries to reduce their carbon emissions.

Conclusions

The COP meetings in Paris in 2015 and the one in Katowice 2018 are necessary efforts to build solidarity among nations and the willingness to cooperate. However, Roemer stated that until now they have failed to solve the problem because they do not have specific sharp proposals about how cooperation should be organized. Countries have to agree on the conception that their rates of growth are going to slow down because it is not feasible to continue growing at the same rate as before. However, Roemer highlighted that a positive growth in welfare is compatible with the limitation of carbon emissions –we do not have to experience neither a negative nor a stationary growth.

In this context, Roemer has proposed two principles that would implement a kind of fairness in solving this huge problem. One is to allocate our remaining carbon budget between the advanced and developing world so that convergence on standard of living will still occur in the same date as if we wouldn't curve GHG emissions. The other one is an international unanimity in a cap and trade system.

These systems do not hamper growth or impoverish in countries with fewer resources, at the same time they also correct inequalities, thanks to a principle of solidarity that allows coping with the biggest problem that our civilization is facing.

Cooperation among nations is imperative to limit carbon emissions. A non-cooperative solution would be severely inefficient. We had suffered from what is called the Tragedy of the commons, that everybody contributes too much to destroy the commons if there is no control over how people use the commons. If regions realise that they are facing a terrible catastrophe, then they will go for an agreement about global supply emissions.

BOX 1. William NORDHAUS' model to allocate carbon emissions

One of the reasons why William Nordhaus obtained his Nobel Prize in Economics in 2018 is because he recognised global warming very early on, so he is the one that has been working on it for 30 years. In fact, Nordhaus published a book and a paper on the efficient use of energy resources and macroeconomic policy many years before the detection of global warming, in 1979 (Nordhaus, 1979a, 1979b). Nordhaus was really a visionary in understanding that it was a very important problem.

Nordhaus also proposed a model to allocate carbon emissions, the Regional Integrated Climate-Economy model (RICE model; Nordhaus and Yang, 1996). Nordhaus' RICE model takes the endowments of countries; emissions are treated as a public bad, over which there are no property rights. A carbon tax is equal to the Pigouvian tax –i.e. a tax on any market activity that generates negative externalities, being set equal to the social cost of the negative externalities–, which, given market optimization by 12 regions in the world, will implement a Pareto-efficient solution. As Nordhaus points out, there is no reason that the solution should be globally fair, except if we have a reason to think the initial endowments of regions are fair, which is unlikely to be the case. The advantage of this method is that it decentralizes the development of a Pareto-efficient solution.

Opposite to Llavador, Roemer and Silvestre's model, Nordhaus' RICE model does not have a theory of cooperation. Although both models are based on a social welfare maximization, they differ in their objective –Nordhaus takes a discounted utilitarianism approach, while Roemer defends a sustainabilitarian way.

Utilitarianism is the normative theory that asserts that the best social policy among a set of alternatives is the one that generates the greatest total welfare, where total welfare is defined as the sum of the utilities for all members of society. Discounted utilitarianism gives less weight to the utility of future generations and therefore treats generations in an unequal manner. RICE model calculates the paths of capital investment and greenhouse gas reductions that maximize a social welfare function, where the social welfare function is the discounted sum of population-weighted utilities of per capita consumption.

William Nordhaus also published a review on Stern's review (Stern *et al.*, 2006). How much and how fast should we react to the threat of global warming? The "Stern Review", based on a cost-benefit analysis, argues that the damages from climate change are large, and that nations should undertake sharp and immediate reductions in greenhouse gas emissions. Nordhaus was very critical with that report largely based on the fact that Stern was not discounting utilities of future generations enough (Nordhaus, 2007).

Nordhaus chooses the rate of discount in his climate change analysis to be 0.015, or 1.5% per annum. This yields a generational discount factor of 0.69 for a 25-year generation. In other words, he discounts the welfare of the next generation by 31%, compared to the welfare of the present generation. Therefore, the discount factor of the generation living a century from now is 0.23. So, their welfare counts only a little more than one-fifth of our welfare in the discounted utilitarian calculus, differing hugely from Roemer's and Stern's discount factor that are 0.99983 and 0.976 for a 25-year generation, respectively. For his part, Nordhaus states:

"The assumption behind the DICE model [Nordhaus' climate change model] is that the time discount rate should be chosen along with the consumption elasticity so that the model generates a path that resembles the actual real rate of interest".

Here, Nordhaus is saying that it would be wrong to apply a much smaller discount rate to the intergenerational problem that consumers apply to their own future utility. However, Roemer wonders why impatience with regard to personal consumption should dictate how much we value saving the planet for those who will live in the future (see chapter 3 in Llavador et al. (2015) for a description of the arguments against discounting the welfare of future generations).

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