0. Introduction I: Basic economic concepts

This introductory lecture can be considered redundant by people who are familiar with environmental economics. Nevertheless it cannot be assumed that all students who participate in this class have the sufficient background. Therefore – to be at the safe side – I wanted to introduce several key concepts that are relevant in this context.

When analysing international problems, economists observe that borders (many of us are so proud of, and many of us are careful about) are often artificial. They ignore watersheds and other natural circumstances. Within their boundaries countries cannot solve many environmental problems effectively.

Economists have special concepts which explain why a single country cannot solve a problem unilaterally. These are

- Public goods; and
- Externalities

Public goods have to comply with two principles: (1) non-rivalry, and (2) non-exclusion. The former implies that the same unit of a good can be used by more than one user at the same time. The latter means that once the good has been provided, nobody can be excluded from using it; at least not easily.

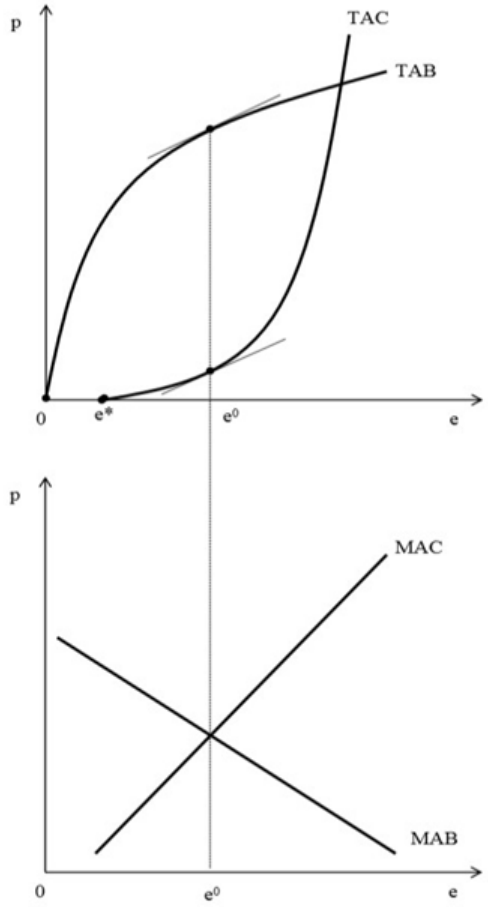
An apple is an example of a good which violates both principles. If a person eats a piece of apple, then the same piece cannot be eaten by anybody else. And if somebody keeps an apple, then nobody can take it. Economists say that apple is a so-called private good. There are numerous examples of public goods though. The first textbook case that was referred to was a lighthouse. If a lighthouse works, then an arbitrary number of vessels can benefit from it (non-rivalry principle). At the same time, none of them can be prohibited from navigating safely, irrespective of the fact whether it did or did not contribute to establishing the lighthouse (non-exclusion principle).

Air defence makes another example of a public good. An air defence system consists of radars, fighter planes, patriot missiles, and so on. If a missile approaches a country, radars will detect it, fighter planes will take off, and an anti-missile will be fired. The same system is needed irrespective of whether it protects a royal palace or a ten-million people city. Thus the non-rivalry principle holds. The non-exclusion principle holds too, since it would be impractical to postpone firing an anti-missile until it is clear who is affected by the attack. Environmental protection provides numerous examples of public goods. Think of air protection. If air is cleaned-up, then the number of beneficiaries can be arbitrarily high. At the same time, nobody can be easily excluded from enjoying the improvement. Both principles hold.

An externality takes place whenever an activity of one agent (a consumer or a firm) affects another one. The externality can be a negative one (an external cost) if it affects somebody else negatively. Otherwise it is called a positive one. A textbook example of a negative externality is lake pollution. If there is a plant which discharges its wastewater, and fishermen

suffer from lower catches, economists say that the plant imposes an external cost on fishermen. Smoking cigarettes is another example of a negative externality. A textbook example of a positive externality is bee-keeping in the neighbourhood of an orchard. Bees pollinate trees and thus improve the crops enjoyed by the orchard owner.

The so-called *Polluter Pays Principle* (PPP) is considered the corner stone of environmental policies. The principle aims at letting the polluter suffer financially from the harm it does by imposing an external cost on somebody else. If the polluter is supposed to abate in order to protect the environment adequately, then the abatement cost is to be borne by it (according to the PPP). Nobody else (neither the victim nor the state budget) is supposed to free the polluter from the obligation to pay. This principle is based on the following graph.



The horizontal axis measures abated emission, while the vertical one – economic variables such as costs and benefits. If emission is not abated at all, then both abatement cost and abatement benefit is 0. TAB, and TAC stand for Total Abatement Benefit, and Total Abatement Cost, respectively. The difference TAB-TAC is the net benefit from abatement. It is maximised if abated emission is equal to e_0. This level of environmental protection can be interpreted as a socially justified one (a social optimum). If the level of abatement is moved to the left from e_0, then the net benefit will shrink because of losing potential gains. If the level of abatement is moved to the right from e_0, then the net benefit will shrink because of excessive expenditures.

The same conclusion is derived when one looks at derivatives rather than total values. MAB and MAC stand for Marginal Abatement Benefit and Marginal Abatement Cost, respectively.

In the language of economics marginal costs and benefits refer to incremental changes caused by increasing or decreasing something by one unit, say, unit of emission. Any high school graduates should recognise easily that what economists call 'marginal values', mathematicians call 'derivatives'. The lower picture demonstrates that the net benefit is maximised when the MAB and MAC are equal to each other. In other words, a socially justified level of environmental protection is achieved when the Marginal Abatement Cost is equal to the Marginal Abatement Benefit. In the example of lake pollution, a socially justified level of protection is when the plant abates as long as its marginal abatement cost is lower that the marginal abatement benefit (from abating pollution) enjoyed by the fishermen. If the marginal cost (of abatement) starts to be higher than the marginal benefit (from fishing), further abatement is no longer justified economically.

Pictures assume that there is an authority (government) which looks at costs and benefits, and forces polluters to abate up to the level justified by benefits enjoyed by the victims. Hence it is assumed that polluters and victims are represented by the same authority. For an individual country its government can be regarded as such an authority.

In international environmental cooperation this commonly recognised enforcement authority is lacking. There is no supranational government to mandate abatement up to the level illustrated by pictures above, and referred to in environmental economics. One country may impose an external cost on another one, but unless they adopt an agreement, there is no enforcement mechanism. Thus – as the examples of international river treaties will demonstrate in the next lectures – the *Polluter Pays Principle* cannot be relied on. On the contrary, *Victim Pays Principle* seems to be more relevant sometimes.

The curse of so-called *free-riding* affects public goods. *Free-riding* means that – given the non-exclusion principle – some beneficiaries do not wish to finance the public good in question. Two motives of such a behaviour can be identified. First, potential beneficiaries pretend to be not interested in the good. They know that once the good has been financed by somebody else, they will use it for free. So why to spend money on financing it? Second, potential beneficiaries do not want to finance a good if they know that those who do not contribute financially, cannot be excluded from its benefits. So shall we finance those who free-ride?

International environmental cooperation does not follow the same rules as environmental protection undertaken by a single country. It has to take into account the fact that countries are sovereign, and they do not necessarily make decisions that are justified by comparing total benefits and total costs. They make decisions to protect the environment if they find it beneficial for themselves. Potential gains for the world (or for their neighbours) are not sufficient to motivate to protect the environment. Both successful and unsuccessful cases of international environmental cooperation illustrate the problem.

Questions and answers to lecture 0

0.1 Why do ecologists say that international borders are artificial?

They are often artificial from the geographical point of view. For instance a part of the border between Canada and United States runs along the 49th parallel, thus crossing the Columbia river which is very important in the context of flood protection. The border between France

and Belgium takes into account important historical considerations, but it is not related to ecosystems involved. Yet the water, wind, and animal migrations do not recognise such borders. The borders are therefore considered obstacles to environmental protection.

0.2 In environmental economics textbooks externalities are often analysed together with public goods. Do you see a relationship between the two concepts?

There are two types of externalities. Economists call them depletable and public, respectively. An example of the former is throwing your garbage into your neighbour's yard; assuming that you have two neighbours – one on the left and one on the right – if you throw it to the left one, the right one is unaffected, and *vice versa*. Imposing the externality on one neighbour "depletes" its potential to affect the other one. An example of the latter is noise. It is "public" in a sense that everybody in your neighbourhood is affected. Its nuisance suffered by the right neighbour is not decreased by the fact that the left one is affected too.

As the name suggests, "public" externalities satisfy principles that were referred to in order to define public goods: non-rivalry and non-exclusion. If there is noise, then everybody is affected, and nobody can be easily excluded from suffering. Consequently, addressing public externalities requires the same approach as addressing public goods. In both cases free-riding can be expected. That is why externalities and public goods require similar economic concepts. A depletable externality is not linked to public good analyses, but it is linked to a public externality in a sense that in both cases somebody affects somebody else directly.

0.3 How can the *Polluter Pays Principle* (PPP) be applied if the polluter disappears before the loss has been observed?

So-called *Love Canal scandal* is perhaps the best illustration of the problem. Love Canal is the name of a small municipality near the Niagara Falls. Children living in apartments built in this municipality in the 1970s required medical treatment more often than others (all children are sick from time to time, but those who lived in the Love Canal area suffered more often, and their symptoms were more acute). Doctors were surprised, and they called for additional environmental monitoring, but air pollution standards were not violated. After a while it was realised that the apartments were built on a recultivated landfill site from the 1920s and 1930s. The landfill operated legally and it was recultivated according to relevant regulations. The concentrations of harmful pollutants did not violate standards, but children's lungs are apparently more sensitive than average, and they were affected before anybody else detected any problems.

Who was the polluter? The most obvious answer is that the company which operated the landfill was. But this company did not exist anymore. Therefore the next idea was to sue households that located their garbage in the landfill. But the households did not exist either. It turned out that local administration who licensed the landfill, oversaw its recultivation, and permitted to build houses was responsible for the problem. Yet administration took decisions that were consistent with the legal framework (and scientific knowledge at that time). Ultimately it was the federal government who assumed the responsibility for the *Love Canal scandal*.

Problems analysed above are reflected in the history of the definition of the *Polluter Pays Principle*. This was defined by the OECD (*Organisation of Economic Cooperation and Development*, some 40 countries – including Poland – that are considered economically

developed) in 1972 in the following way: the polluter is responsible for whatever harm its activity causes – now or in the future. This is called PPP *sensu largo*. Soon however it became clear that there might be problems with catching the polluter once the loss is identified. Thus a narrower concept was defined by the OECD in 1974: the polluter is responsible for meeting environmental regulations. This is called PPP *sensu stricto*. This narrower concept of PPP is independent of whether the polluter does or does not exist at the time when all the consequences of its activities are identified. The PPP *sensu stricto* is also called a "No-Subsidy-Principle", since the polluters are supposed to finance their abatement activities themselves.

In the 1980s the concept of an "environmental bond" was fairly popular. It assumes that a relevant authority imposes a payment corresponding to a likely future loss the polluter's activity may cause. The payment is imposed on an existing polluter in order to avoid the problem of its disappearance in the future. The polluter has an incentive to decrease environmental risk of its products and operations, and to finance scientific research aimed at demonstrating their harmlessness. The idea is interesting, but quantification problems prevented its broader proliferation. Deposit-refund systems are perhaps the only large scale examples of the idea: buying products which can be disposed of incorrectly requires paying an environmental bond (a deposit) to be paid back (refunded) if the product is disposed of properly.

0.4 Please state the mathematical theorem the graphs on page 2 (overhead IEC-0-4) are based on.

Joseph Louis Lagrange was one of the greatest mathematicians, and he proved a number of fundamental results. Therefore there are dozens of "Lagrange theorems". The one the graph on page 2 is based on states that the difference between two functions (here TAB and TAC) is the largest (you see this in the upper picture on page 2) when the straight lines tangent to their graphs are parallel to each other. Tangent lines correspond to derivatives (here MAB=TAB', and MAC=TAC'). You see this in the lower picture: parallel tangent lines (i.e. their slope coefficients are equal to each other) correspond to the equality of the relevant derivatives. Do you remember the Lagrange theorem from your high school (or from your basic calculus class in the university)?

0.5 In the lake pollution example, does economic efficiency require that there are no external costs?

No. The lake pollution should be "economically justified"; this does not mean that the lake has to be pristine. "Economic justification" means that external costs imposed on fishermen are not higher than the abatement cost. If the abatement cost were lower than what the fishermen suffer, the lake pollution would not be "economically justified": fishermen's benefits (avoided losses) could have been increased by more than what the polluter spends on abatement. Please also note that no external cost (i.e. no pollution) is not necessarily "economically justified"; some pollution (i.e. not 100% abatement) may let the polluter save on abatement cost more than the fishermen lose.

0.6 State sovereignty makes international environmental cooperation more difficult than what has been observed at the country level. What instruments do governments have in order to motivate other countries to take decisions that are not justified by their individual benefits?

One way is to invade the other country and force its government to do what it did not want to do voluntarily. More interesting instruments are based on peaceful activities. The most useful concept is a so-called "self-enforcing agreement". This is an agreement such that signatories do not have incentives to withdraw from. For instance, if there is a powerful signatory such that everybody would like to cooperate with, those who contemplate signing have an incentive to do so, and those who have already signed, do not have an incentive to leave. In some agreements, the presence of an important signatory may motivate others to join. An alternative view of a successful agreement is designing an instrument to overcome free-riding. With respect to public goods (many international environmental protection problems are characterised by the non-rivalry and non-exclusion principles) free-riding is an important source of failure. An international agreement may overcome free-riding by demonstrating that others take commitments as well. Thus one motive not to finance the public good often phrased "we do not want to finance anything to be enjoyed by those who do not contribute" is eliminated.

0.7 Does adopting a "toothless" convention (i.e. a convention that does not impose any difficult requirements for their signatories) make sense?

Yes, it does. Some environmentalists are disappointed to see a "toothless" convention; they say: this "toothless" convention is harmful, since it gives an impression that something was achieved, whereas in fact nothing was achieved. Nevertheless a history of international environmental cooperation provides examples of successful developments starting from a "toothless" agreement and developing it into a "biting" one. Experience shows that even a "toothless" convention can be effective in the long run.

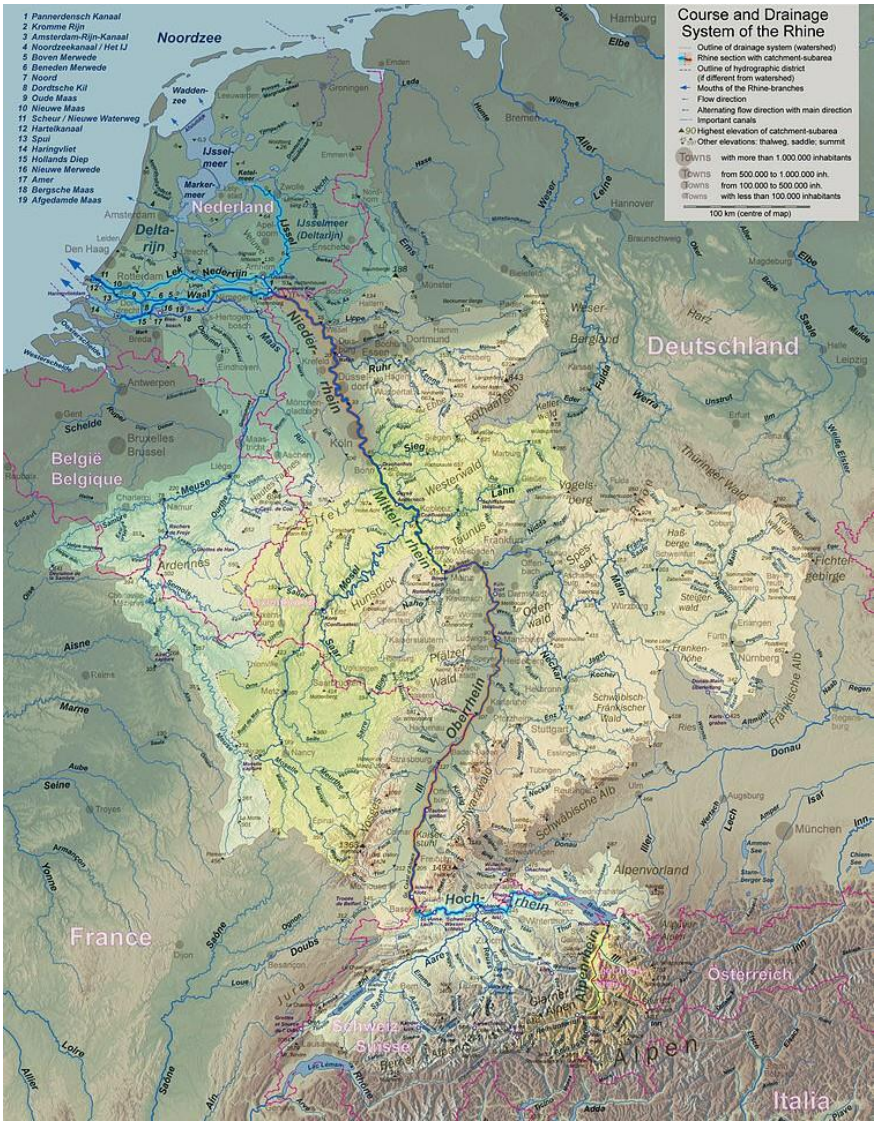
A typical "toothless" convention states that there is a problem and something has to be done (without making clear who is supposed to do what). Apparently countries are not ready to agree on anything more substantial. One requirement the convention introduces is to meet (say, once a year) and discuss. While preparing positions for such periodical meetings, governments have to consult domestic experts, and the problem gets stimuli to be analysed. As a result, after some time, a "biting" protocol to the original "toothless" convention can be added. Subsequent lectures provide examples of how such an evolution looks like.

1. Introduction II: International rivers

Seven transboundary rivers are analysed in order to illustrate how international environmental cooperation evolves, and tries to overcome problems of externalities. Our examples include the Rhine and the Danube in Europe, the Colorado and the Columbia in North America, the La Plata in Latin America, the Nile in Africa, and the Mekong in Asia. We start with the Rhine river.

This is one of the most important European rivers. It starts in the Swiss Alps, flows through Liechtenstein, Austria, Germany, France, and in the Netherlands it reaches the North Sea. In addition, its drainage basin overlaps with Italy, Luxemburg and Belgium. Thus cooperation involves nine European countries.

The Rhine river was mentioned at the Vienna Congress in 1815 (mainly in the context of the navigation freedom), but Bern Convention (1963) was the first international treaty devoted to the river entirely. It was a "toothless" convention. It stated merely that the river should be cleaned up. Somewhat more "biting" provisions were added in two 1976 conventions (chemical pollution and salt pollution). The first convention tried to reduce chemical contamination of the river, while the second one looked at salt discharged from coal mines (mainly in France and Germany). The *Victim Pays Principle* was manifested in the fact that the Netherlands contributed more than 20% to financing convention activities. The process of the river clean-up was broken by the 1986 fire in Basel (Switzerland). A number of chemical plants discharged their toxic wastes and killed all the life that emerged as a result of previous abatement efforts. In 1991 agreements were substituted by the Salt Treaty. It offered more effective decontamination of the river, but the Dutch government was to finance as much as 34% of the abatement cost. Again *Victim Pays Principle*!



The Rhine river

The Colorado river is a story of the American-Mexican cooperation. Relationships between the two countries have been difficult. In 1884 both governments established commissions for

their most important transboundary rivers: Colorado, Tijuana, and Rio Grande. In 1944 an agreement was signed on the quantity of water in the Colorado river reaching Mexico (near the Gulf of California). The terms of the agreement were met by the United States, but Mexicans complained about water quality. Consequently an additional agreement on the quality of water was signed in 1974. A true breakthrough came in 2012 when an agreement was signed on the Lake Mead. A retention reservoir was constructed where the water of the Colorado river can be stored. Mexicans were given the property rights to the water stored there. They own a part of the water in the Lake Mead; they can use it once the water reaches the Mexican border, or they can sell it (to Americans!) if they do not plan to use it. This was a surprising provision – difficult to explain. Why did the Americans give such a favour to their southern neighbour? One explanation was that they wanted to make a breakthrough in their thorny relationships. Another one refers to so-called issue linkage, a concept from game theory, when negotiators offer something beneficial to their partners expecting that when negotiating on another issue the partners will reciprocate. In 2012, a separate treaty on military bases was negotiated as well.

The Colorado River

The Columbia River

The Columbia river originates in Canada, and it flows through the American states of Washington and Oregon. In Canada it flows through sparsely populated Rocky Mountains, and flood losses are concentrated in the USA. Downstream losses can be reduced by building retention reservoirs in Canada. Americans persuaded the Canadians to build retention reservoirs by financing a part of the required investment costs. Once the dams have been built, Canadians invested in hydroelectricity which is sold mainly to the United States. Financial flows between the two countries are so unclear that it is difficult to determine whether the *Victim Pays Principle* applies. To the extent that the Americans contributed to building retention reservoirs in Canada, the principle seems to be followed. At the same time, however, the electricity sold by Canadians to the US seems to be cheaper than expected. It looks as if the Americans took advantage of buying electricity from "their" retention reservoirs. If this is the case, the *Victim Pays Principle* does not hold.

The Danube is another important European river. Its importance stems from the fact, that large sea vessels can go upstream hundreds of kilometres. Thus navigation has been regulated since the 17th century. In 1856 Commission Européenne du Danube (CED) was established. Its sovereignty was granted by Austria-Hungary, Britain, France, Italy, Prussia, and Turkey in 1865. Dissatisfied with excessive sovereignty of CED, Russia withdrew from it in 1881, and tried to control the Danube delta. In 1941-1945 Hitler controlled the entire river.

Since the World War II, the river has been flowing through several independent countries, and the navigation has been regulated by the Belgrade Convention of 1948. Later on, it became

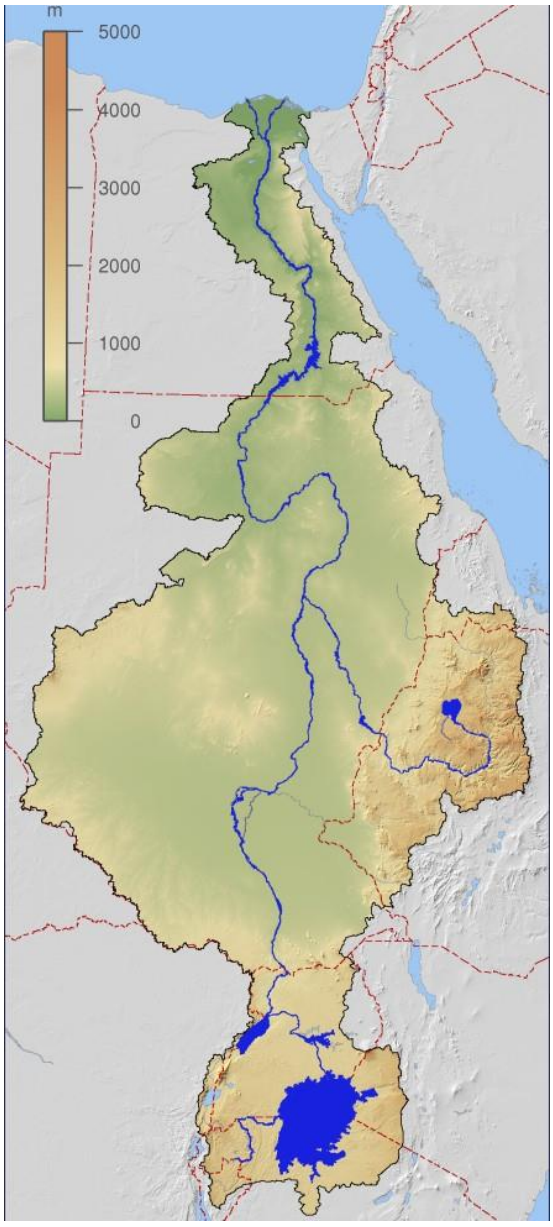
clear that navigation is not the only important problem of the river. In 1994 a new agreement (in Sofia) was signed. It is called Danube River Protection Convention, and it aims at a more comprehensive approach to the river.

The Danube River

The Nile has been one of the longest rivers in the world. Many people think of it as a large flow of water originating in Lake Victoria in equatorial Africa (even in the southern hemisphere), and contributing to the emergence of the Egyptian civilisation. In fact there are three main tributaries originating much further North, from Ethiopia – Blue Nile, Sobat and Atbara – where 85% of the Nile water comes from. Thus Ethiopia is the most important "owner" of the water in Egypt. Yet Egypt was favoured by international treaties of 1891, 1902, 1906, 1925, and 1929. In 1959 it lost most of its water rights when the Aswan High Dam was planned and negotiated with Sudan. Ethiopia was neglected in these agreements. Only recently it started to exert some political power by constructing a large hydroelectric dam on the Blue Nile (with the financial assistance of the World Bank). The governments of Egypt and Sudan negotiate long periods of filling the retention reservoir with water. It is feared that Ethiopia can virtually drain the Egyptian Nile for many years if it fills the reservoir too quickly. Egypt threatens Ethiopia with a war unless its government signs an acceptable agreement. According to Egyptian experts, filling the reservoir should last more than 10 years. It is not clear to me if these claims are supported by hydrologists' calculations. I am afraid that the 10-year requirement is arbitrary in the sense that it does not take into account the trade-offs related to the water stored in the Aswan High Dam reservoir (see my question 1.5). The water can be used to stabilise the flow in the Nile river or to produce electricity when it is most profitable. I am not aware of detailed analyses how to quantify these trade-offs.

The Mekong river is the only example from Asia. Every region has a different name for it (the most common Chinese name is Lancang). It originates in China (Tibetan Plateau), and it flows through five other countries. Thus six countries are involved: China, Burma

(Myanmar), Laos, Thailand, Cambodia and Vietnam. In 1975 the countries signed a declaration on preventing unilateral water appropriations. Four downstream countries – Laos, Thailand, Cambodia and Vietnam – established the Mekong River Commission in 1995. They are afraid of the Chinese agricultural projects. If China uses the river for irrigation purposes in agriculture, as feared by the downstream countries, then less water will be available for them. Those fears are aggravated by the fact that the source of the Mekong's great productivity is its seasonal variation in water level, resulting in rich and extensive wetlands. The annual flood season is especially important in the Lower Mekong Basin (in the downstream countries) where it has shaped the nature and social life. If the flow is stabilised, and the annual floods are eliminated, the biodiversity will be compromised, and millions of people will be deprived of their food base. Therefore both the water quantity and quality are important for the problem of using the upstream part for agricultural irrigation.



The Nile River

La Plata makes the last case analysed in this context. Some people question whether this is a river at all. More than 200 kilometres wide, it looks like a sea gulf. It is a freshwater aquifer nevertheless. Also satellite pictures (see page 13) confirm that this is a river rather than a sea.

The Mekong River

The main tributaries – i.e. the Parana and the Uruguay rivers – make up the second largest watershed in South America (after the Amazon river). The watershed overlaps with Bolivia, Brazil, Paraguay, Uruguay, and Argentina (see the second picture on page 13). In 1969 these countries signed the La Plata River Basin Treaty. There are a number of important questions to be looked at in this context, and the most controversial one is the *Hidrovia* – conceived in the 19th century, and materialised (in terms of financial feasibility) in 1989. The project plans to make the two tributaries – i.e. Parana and Uruguay – navigable, so that large sea vessels can reach some Brazilian cities located hundreds of kilometres from the Atlantic coast. To this end the rivers have to be dredged, and rocks have to be removed. Tourists may be concerned about the fate of the world's most famous waterfall (Iguaçu), and natural scientists are concerned about the fate of wetlands (especially in Pantanal). While the economic efficiency of the project is uncertain, its environmental consequences would be catastrophic for sure.

The La Plata

Critics of the project trust that it will never take off because of financial reasons. Large international financiers like Inter-American Development Bank declared their interest in the investment. The Andean Development Corporation (CAF) spent almost 1 billion dollars for new studies, to "complement" the original ones. Yet *Hidrovia* is still lacking the support it requires.

The Parana and Paraguay river basins

Managing international rivers is a complicated task. Examples analysed in the class illustrate how countries try to regulate externalities involved. In 1992 in Helsinki the UNECE (United Nations Economic Commission for Europe) prepared the Convention on the Protection and Use of Transboundary Watercourses and International Lakes. In particular, the Convention applies to the Danube river and to a controversy between the Slovakian and Hungarian governments over the famous Gabčikovo-Nagymaros case (see picture on page 14; Nagymaros is close to Budapest). In 1977 Czechoslovakia and Hungary signed an agreement

to build a large hydroelectricity plant on the Danube river. Construction works went fairly slowly, and after 1989 Hungary decided to abandon the project at all; it was considered too expensive and too anti-environmental. In 1997 the International Court of Justice ruled that the original 1977 agreement was binding, but the project was a bad one. The Slovakian government insists that Hungary should contribute, while the Hungarian government argues that the project was ill-conceived and it should be abandoned both for economic and environmental reasons. Despite the convention and other legal documents (which bind both countries), and despite numerous analyses, the Gabčikovo-Nagymaros dam complex system has never been completed, and the case has not been resolved yet.

The Danube near Budapest

Questions and answers to lecture 1

1.1. Why do the Dutch agree to the *Victim Pays Principle* by contributing to the Salt Fund financially?

The Dutch are not responsible for the quality of water in the Rhine river, but they are interested in its clean-up. Upstream countries (mainly France and Germany) pollute the river. It was clear that the quality of water will improve over time. Nevertheless the improvement process can be faster if more money is available for abatement purposes. If the Dutch wish to enjoy the improvement faster they can pay for it, and this is what they chose.

1.2 Is the Lake Mead arrangement (giving Mexicans rights to the water stored there) economically justified?

Yes, it is. There are two important economic concepts: efficiency and justice. They are largely independent of each other. The former looks at whether the sum of benefits is higher than the sum of costs, and the latter whether the distributions of benefits and costs are consistent. Economists say that an arrangement is economically justified (efficient), if they find that total benefits net of total costs cannot be made higher. It may turn out, however, that for some economic agents individual benefits net of individual costs are negative or otherwise not satisfactory. If this is the case, the arrangement can be judged unfair (lacking justice) even though it is efficient.

Rights to the water in the Lake Mead are allocated to economic agents (it does not matter whether to Americans or Mexicans). Assuming that their owners are rational, i.e. they do not make transactions leaving them worse off (this is what economists usually assume), they sell the water if the price is higher than the benefit they can enjoy by keeping the right. If one sells the water right he or she must face the cost of not using the water (a loss caused by not using the water) which – by the rationality assumption – is lower than the price of water. Thus the water rights market maximises benefits net of costs.

Whether it is fair or not is another question. Many people would feel happy, if those who were given the rights were poor. An average Mexican is poorer than an average American. From that point of view, the arrangement could be considered fair. In reality, however, it could have been the case that those Mexicans who are given the rights are rich, and those who buy from them the water are poor American farmers. If this is the case, the arrangement would be judged as unfair. Analyses like this illustrate the fact that efficiency is independent from justice. As an efficient one, the arrangement was economically justified (even though it was not necessarily fair).

1.3 Was the Columbia river arrangement (letting Americans contribute to building retention reservoirs in Canada) economically justified?

Yes, it was. Arguments like those explained in 1.2 above demonstrate that both *Polluter Pays Principle* and *Victim Pays Principle* can be consistent with economic efficiency; they just differ in who pays. In a sense, American states were "victims" of the lack of anti-flood measures to be taken in Canada. If Americans wished to lower flood damages, they could finance the measures. And this is what they did. In addition, perhaps they got some extra benefits from cheap electricity imports. This reinforces the original argument about the efficiency of their investment.

1.4 Why did Russia withdraw (in 1881) from the CED?

By establishing CED, countries like Britain and Italy (being rather far from the Danube), started to benefit from free navigation along the river. Following a war with the Ottoman empire in 1878, Russia gained control over a part of the Danube delta. The Russian government felt that CED exercised excessive control over the navigation. Consequently it withdrew from the Commission and started to exercise some control directly.

1.5 How can Egypt control its water balance if Ethiopia fills its retention reservoirs faster than requested?

15% of the Nile water comes not from Ethiopia. Thus even if Ethiopia uses all the water to fill the reservoir, Egypt will not be drained completely. Moreover, the Blue Nile – i.e. where the Ethiopian government builds the reservoir – contributes 59% of the water (the rest originating from other tributaries). This reduces the threat further. It is also important to note that there is a huge periodic variation in the supply of water. Differences in flow measured at the Aswan dam are like 15:1 (8,212 m^3/s *versus* 552 m^3/s). The supply from Ethiopia varies like 50:1 (5,663 m^3/s *versus* 113 m^3/s). The Ethiopian manipulation with the flow of water will certainly affect the Egyptian water balance. In particular, inundation periods – experienced over thousands of years regularly – are likely to be affected. Nevertheless the Aswan artificial reservoir stores some 132 km^3 of water (the total annual precipitation in Poland is around 190 km^3). With the Aswan water, Egypt can control its water balance irrespective of the Ethiopian investments to some extent.

1.6 In 1975 the Mekong river basin countries signed a declaration on preventing unilateral water appropriations. What are they concerned about?

The most obvious outcome of the upstream irrigation systems is the lower quantity of water downstream. In addition, these systems are likely to stabilise the water flow and to constrain inundation periods. As a result, wetland ecosystems are likely to be affected adversely. Less productive wetlands imply lower food availability in downstream ecosystems. Lower Mekong countries are afraid that their agricultural sectors will be less productive if the river is used more intensely upstream.

1.7 Should Argentina be interested in the fate of the *Hidrovia* project?

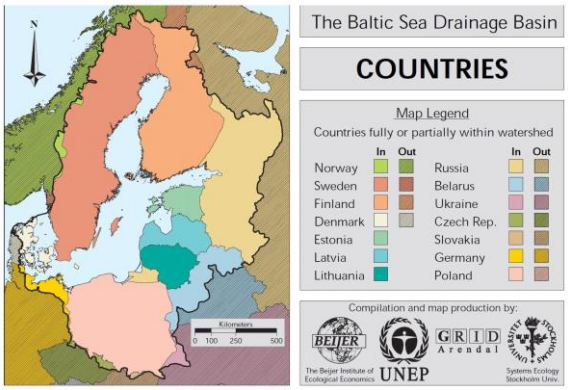
Argentina overlaps with the La Plata watershed, and it is a part of the Paraguay and Parana river systems. The country may not be interested in the fate of Brazilian wetlands (e.g. Pantanal), but a large part of *Hidrovia* is going through its territory. The famous Iguaçu waterfall at the Brazilian border is a unique tourist attraction. The *Hidrovia* project is likely to affect local ecosystems.

2. Eutrophication of the Baltic Sea

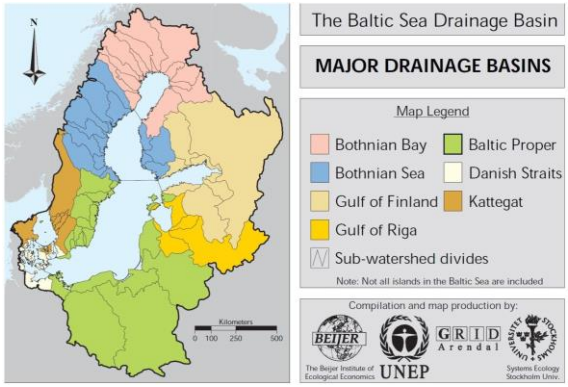
Most of you know what the Baltic Sea looks like, but basic facts have to be quoted for the record. Its total area is 377 thousand km^2, and its drainage basin is several times larger –1642 thousand km^2 (contrary to what is observed in the case of other seas). Its average depth is only 55 metres (much less than elsewhere). The total volume of water is 22,000 km^3, and the average exchange time (the sea is a semi-enclosed one) is 25 years.

It is not clear how many Baltic countries there are (see map below). It looks as if there were 9 of them: Poland, Russia, Lithuania, Latvia, Estonia, Finland, Sweden, Denmark, and Germany. If you look carefully, there are 4 non-coastal countries whose territories overlap with the drainage basin: the Czech Republic, Slovakia, Ukraine, and Belarus. Moreover, there

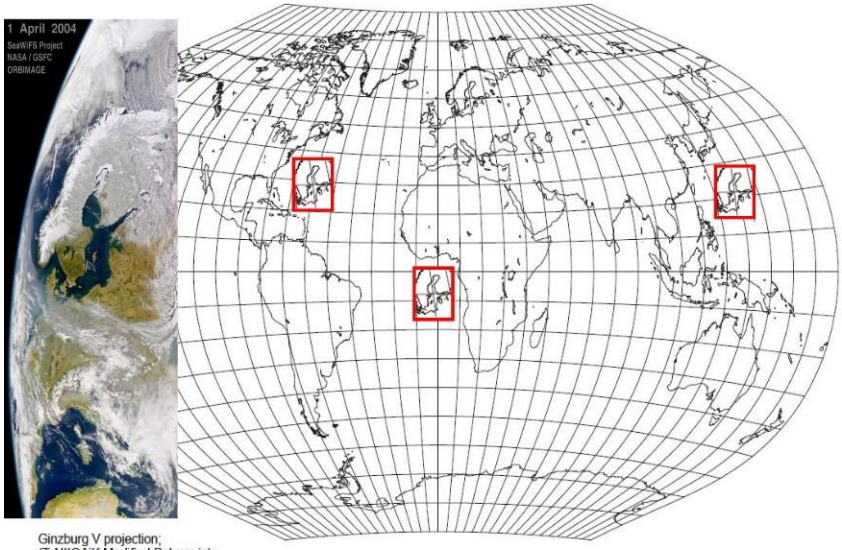
are some doubts about what part of the Danish Straits belongs to the Baltic Sea. If Skagerrak is included, then Norway becomes a coastal country too.



Another map demonstrates what names are used to identify various sub-basins.



The Baltic Sea is precious for several countries, but it is very small when compared to other aquifers (see red rectangles below).

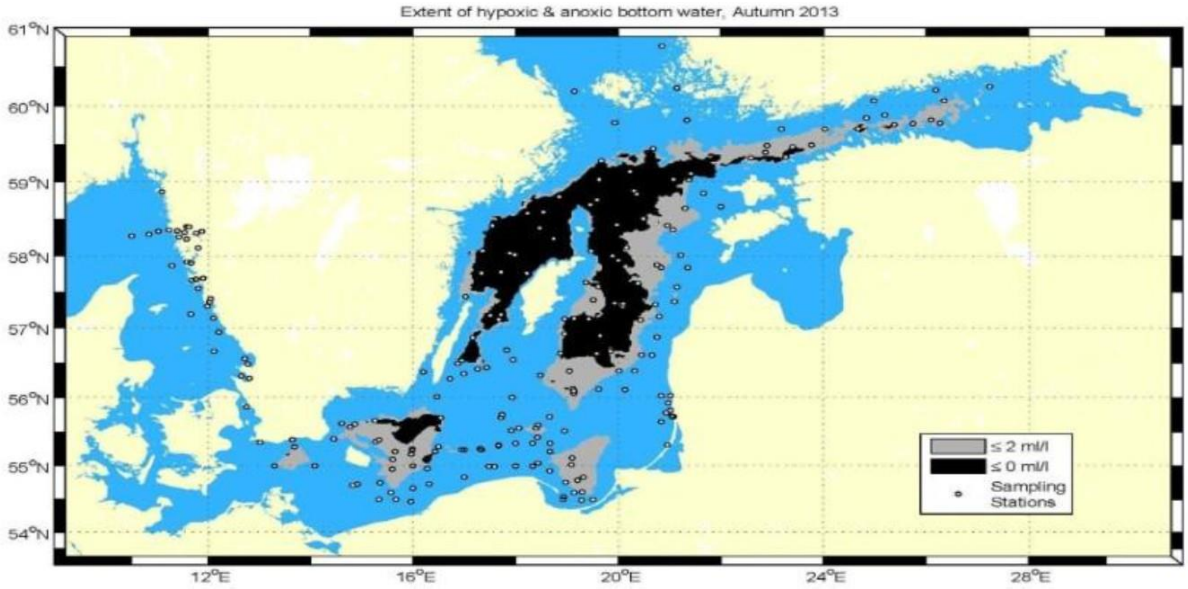


Ginzburg V projection;
(TsNIIGAiK Modified Polyconic);
Neither Conformal or Equal-area;
G. A. Ginzburg; 1950

It is well known that the quality of the Baltic Sea water is inadequate. People swim in the sea, and enjoy coastal recreation, but every now and then disturbing news are brought to public attention. One can read about discharges of toxic pollutants from a plant or a ship. Sometimes fishermen are poisoned by chemical weapons dumped by Prussia by the end of the World War I. Journalists write about a sunk Soviet nuclear submarine, and so on. All these problems are serious, and they do require some actions. Nevertheless, the main environmental problem of the Baltic Sea is eutrophication.

This difficult term of Greek origin denotes excessive inflow of nutrients. There are two major nutrients: nitrogen (N) and phosphorus (P). They are indispensable for life. Farmers add them to the soil in order to increase agricultural crops. Dissolved in the sea, they are crucial for the plant production and therefore also for animals that eat these plants.

A problem starts when the inflow of these nutrients becomes excessive. There are too many plants (in particular, too many algae) compared to what animals can eat. As a result, the uneaten plants die, they smell badly, release toxic substances, and use oxygen dissolved in water in order to decompose. Lower oxygen concentration in water kills fish and other animals, so the problem aggravates. Picture below shows areas with low oxygen concentrations and without oxygen at all (black spots).

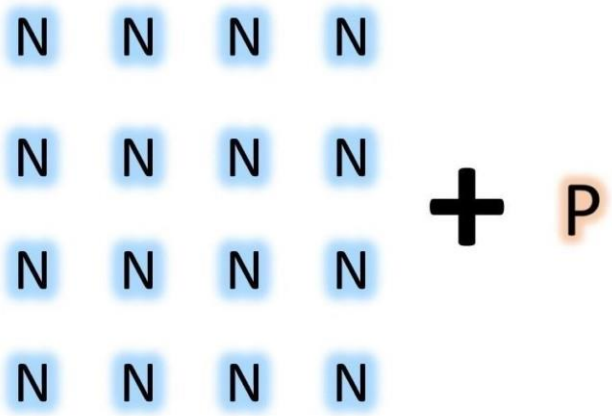


When seen from a satellite, algae blooms look nice (they make the water green rather than blue), but in fact they reveal a serious environmental problem.

The eutrophication of the Baltic Sea is now somewhat less acute than it used to be in the 1980s. Annual discharges of nitrogen went down from 900 thousand tonnes to 700 thousand tonnes, and those of phosphorus – from 40 to 30. It looks as if phosphorus was a much less important nutrient than nitrogen. This is not the case. You may remember from your high-school biology classes so-called Liebig Law. The law says that for a plant to grow a fixed proportion of various molecules is needed.

A satellite picture of the Baltic Sea

Every atom of phosphorus has to be accompanied by 16 atoms of nitrogen in order to be absorbed by Baltic algae. If there are, say, 20 atoms of nitrogen, and only 1 atom of phosphorus, then 4 atoms of nitrogen cannot be absorbed in the plant tissues. Alternatively, if there are 16 atoms of nitrogen, and 3 atoms of phosphorus, the plant cannot use the "redundant" 2 atoms of phosphorus. Because of complex chemical processes, the Baltic Sea contains more phosphorus than what the algae can utilise according to the Liebig Law. Nitrogen is the so-called limiting factor in most places. In other words, if eutrophication is to be lowered, then the inflow of nitrogen should be reduced first. Reducing the inflow of phosphorus will not solve the problem – at least not in the short run.



The Liebig Law in the Baltic Sea eutrophication

Baltic countries realised that the sea is a public good: it can be used by all of them, and nobody can be excluded from enjoying its improved quality. At the same time – because of *free-riding* – it will not be protected adequately, unless all the countries take a joint action.

In 1973 a convention was signed in Gdańsk in order to protect marine resources. International Baltic Sea Fishery Commission was established in order to allocate harvest quota and to prevent overfishing. Soon, however, it became clear that eutrophication – the main problem of the Baltic Sea – is caused by drainage basin activities rather than fishing. Consequently, in 1974, another convention (which puts emphasis on drainage basin activities) was signed in Helsinki. It was amended eighteen years later (in 1992). Formally this is the same convention, but it has so many fresh provisions that some people call it a new one. It took into account geopolitical changes such as decomposition of the Soviet Union, and Germany unification. The most important organ of both conventions is the Helsinki Commission (*Helcom*), located in the capital of Finland, analysing the predicament of the sea, and preparing documents to be adopted by governments who signed the convention(s).

Picture below is often referred to as a success story of the Helsinki convention. It demonstrates the improved quality of the marine environment. Sceptics point out that toxic chemicals found in birds' eggs – a symptom of environmental contamination – declined not because of the Helsinki convention, but rather as a result of bans introduced by other global environmental agreements (such as DDT ban). Nevertheless, there has been a significant decline for many pollutants that contaminate the water. At the same time, a decline of inflow of eutrophication substances was very small.

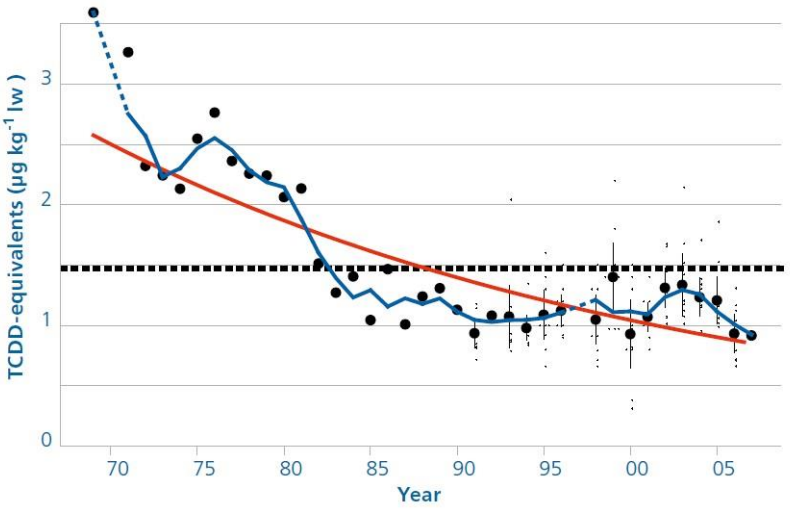
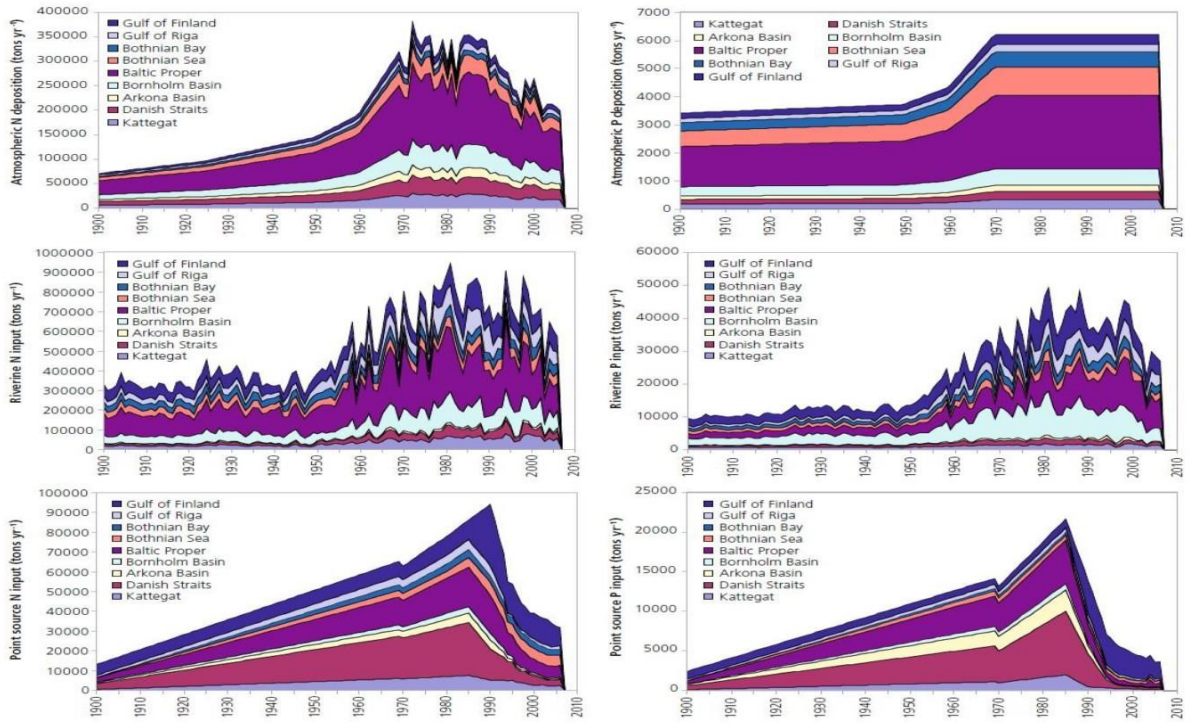


Figure 2.7 Decreasing trends of dioxins (measured as TCDD-equivalents, µg kg^{-1} lipid weight) in common guillemot (*Uria aalge*) eggs from Stora Karlsö in the Western Gotland Basin (HELCOM 2010a).

Pictures below demonstrate that there is some improvement (please note that every graph has a different vertical scale; despite that, in every graph riverine inflows dominate over coastal point sources and atmospheric deposition). The largest numbers were recorded in the 1980s. Point source pollution declined significantly, while riverine inflows (which include agricultural sources, among other things) reveal significant variability linked to annual precipitation.



As revealed by the statistics, 1950s was the last decade of moderate discharges, and indeed, in the middle of the 20th century the Baltic Sea was in a fairly good shape. Inspired by this, a slogan was coined in the 1990s: "Forward to the 1950s!" This requires more than halving the discharges of N and P. For the time being, Helsinki convention failed to deliver such a change.

A question can be asked why it proved difficult to abate nitrogen and phosphorus at such a scale. The table below explains the problem. As long as the ambition level is moderate, say, 20% improvement, the abatement cost is low. However, when it approaches 50%, it hits the level of 4 billion dollars per year. This 1995 assessment was based on the assumption that countries allocate abatement tasks cost-effectively, i.e. choosing projects which realise the abatement as cheaply as possible. To this end, a list of abatement technologies was compiled starting with the cheapest ones, i.e. restoring coastal wetlands (which serve as nitrogen sinks). If a moderate reduction is planned, say, 5%, restoring coastal wetlands can be sufficient which keeps the abatement cost low. If deeper reductions are planned, say, 10%-15%, restoring wetlands is found insufficient, and the next cheapest alternative – like lowering the application of agricultural fertilisers – has to be applied. The most expensive technologies, like tertiary treatment of municipal sewage, are necessary when declaring more ambitious targets of 40%-50%. Statistical records demonstrate that Baltic Sea countries – despite the slogan "Forward to the 1950s!" – are not ready to undertake the abatement to such an extent.

Cost-effective abatement in the Baltic drainage basin

Reduction rate (%)	5	10	15	20	25	30	35	40	45	50
Annual cost (10^9 $/year)	<0.1	0.1	0.1	0.2	0.3	0.5	0.8	1.2	1.9	4.1

Questions and answers to lecture 2

2.1. Is the proportion of the Baltic Sea area and its drainage basin typical for the world?

No. In the case of the Baltic Sea the proportion reads 4.36 (1642 thousand km^2 /377 thousand km^2). In the case of the world it is 0.41 (149 Mkm^2 / 361 Mkm^2). In other words, the Baltic Sea drainage basin is much larger than the sea itself. For other seas, it is the other way around typically. Consequently land based activities have much more important impact on the Baltic Sea than in the case of other places.

2.2 What do geographers mean when they calculate the 25 year exchange rate for the Baltic Sea?

The volume of water in the Baltic Sea is roughly 22,000 km^3. The sea is semi-enclosed. Its water comes from rivers and precipitation. Some of it evaporates. The rest goes to the North Sea through the Danish Straits. It is estimated that – on average – 880 km^3 of water passes through the straits annually. If you divide the two numbers, you will get 25 years. Of course, this calculation is based on an average annual outflow. There are some years that winter storms pump huge amounts of water to the Baltic Sea through the Danish Straits. They are important for salinity and dissolved oxygen concentration, but they do not alter the average exchange ratio.

2.3 Should Norway be considered a Baltic country?

It depends on the definition. Norway is not a party to Gdańsk and Helsinki conventions. However, its territory overlaps with the sea drainage basin (marginally). It is not a coastal country, unless Skagerrak (the Western part of the Danish Straits) is considered a part of the Baltic Sea rather than the North Sea.

2.4 Are nitrogen and phosphorus pollutants?

No. They are not. They are indispensable for life, and that is why they are called nutrients rather than pollutants. The problem starts when they are supplied in excessive quantities. They are responsible for eutrophication (of soil or water).

2.5 Why does nitrogen act as the limiting factor in Baltic eutrophication?

Justus Liebig was a chemist and a biologist. He did not discover what we call the "Liebig Law" (the law was actually discovered by Carl Sprengel earlier), but he popularised the idea that one element may inhibit the growth of an organism, even if other elements are abundant. Thus he observed that elements cannot substitute for each other, but they are complementary (they have to be supplied in fixed proportions). The element which constrains the growth of an organism is called "the limiting factor".

At the beginning of the 21st century, the annual inflow of nutrients to the Baltic Sea was 700,000 tonnes of nitrogen and 30,000 tonnes of phosphorus. Both elements are subject to numerous chemical and biological processes. For instance, some plants can absorb the atmospheric nitrogen and transform it into substances active in the aquatic life. Some

phosphorus can be removed from the aquatic life through sedimentation. According to the Liebig Law, algae growth requires the proportion of 16 atoms of nitrogen per 1 atom of phosphorus. The availability of nutrients in the Baltic Sea makes this proportion somewhat lower than 16:1. Consequently phosphorus is relatively more abundant, and nitrogen is the limiting factor. This has a practical policy implication: if one wants to reduce eutrophication, one needs to abate nitrogen first; phosphorus abatement will not result in reduced eutrophication in the short run. Hence in many economic analyses emphasis is put on nitrogen abatement, but several abatement technologies (e.g. municipal waste water treatment) remove nitrogen and phosphorus at the same time.

2.6 Eutrophication is a problem encountered by many lakes. Why does it hit the Baltic Sea (and not the North Sea or the Black Sea)?

Baltic Sea is like a lake. The exchange of water (with the Atlantic Ocean) is rather slow (25 years), and whatever reaches the sea stays there for a long time. The difference with the North Sea is that the latter is not separated from other aquifers by any straits, and the exchange is immediate. The Black Sea is semi-enclosed and characterised by an even larger ratio of the drainage basin (6:1), but it is much deeper. Its area is somewhat larger than the area of the Baltic Sea (436,400 km^2), but is average depth is 1,253 m resulting in a volume of water 25 times larger (547,000 km^3). Only coastal areas of the Black Sea suffer from eutrophication, and it is not as severe as in the Baltic Sea.

2.7 Atmospheric deposition provides 30%-40% of the nitrogen inflow to the Baltic Sea, and much less (10%-20%) in the case of phosphorus. Why?

Nutrients transported by rivers contribute more than atmospheric deposition. Nevertheless, atmospheric deposition of nitrogen is quite significant. A large part of nitrogen – mainly in the form of nitrogen oxides – comes from car exhaust gases. Wind in Europe blows mainly from the West. Thus Western European cars contribute to the eutrophication of the Baltic Sea. Catalytic converters reduce the nitrogen oxide emission from cars substantially. As a result, atmospheric deposition of nitrogen was largely reduced after the 1970s and the 1980s. Despite that, in some areas – especially in Western sub-basins of the sea – its contribution is still remarkable. In contrast, atmospheric deposition of phosphorus is small (see the picture on page 21, or the right part of the graph in my overhead IEC-2-6). There was no improvement over several decades, so in relative terms (taking into account improvements in coastal discharges and river transport), the role (relative contribution) of atmospheric deposition of phosphorus increased.

2.8 What does cost-effective abatement mean?

It means reaching an objective at a minimum cost. If the objective is to reduce nitrogen inflow by 50%, it means doing this as cheaply as possible. It may imply that one region reduces it by more than 50% and another one – by less. It may imply that some inexpensive options are used, but if they turn out insufficient to reach the objective, more expensive ones have to be added. Baltic Sea abatement options were analysed extensively. Coastal wetland restoration was found to be a very cheap option, capable of abating 1 kg for just 1 euro. If the 50% target

(i.e. abating some 350,000 tonnes) was to be achieved in this way, the cost of the programme would be 350 million euro (a small amount by international standards). Unfortunately the total amount of nitrogen that can be abated this way (i.e. through coastal wetland restoration) is much lower. Consequently, more expensive measures – like lower fertiliser application – need to be used. But they will not suffice to reach the 50% target either. Another more expensive option is to improve the efficiency of municipal sewage treatment plants, and so on. Cost effectiveness is realised when a more expensive measure is used only when all the less expensive ones turn out to be insufficient to achieve the target.

Another tricky issue is who is going to bear the burden of a cost-effective allocation of abatement. It does not have to be the entity providing the measure. For instance, if a wetland restoration site X was identified, then the cost of restoration (as well as the loss resulting from abandoning previous uses of the site) does not have to be financed by the owner of the site. It can be paid by someone else, in particular by somebody who will benefit from reduced eutrophication. Insisting that only the owner of the site is to finance the project can be unfair. Because of the population potential (almost 50% of people who live in the Baltic Sea drainage basin are Poles), many projects identified as cost-effective ones are located in Poland. This does not mean that Polish entities have to finance them. Financial contributions can be proportional to the share in benefits, but this is the topic of the next lecture.

2.9 Why do the Baltic clean-up costs sky-rocket when the ambition level increases from, say, 25% to 50%?

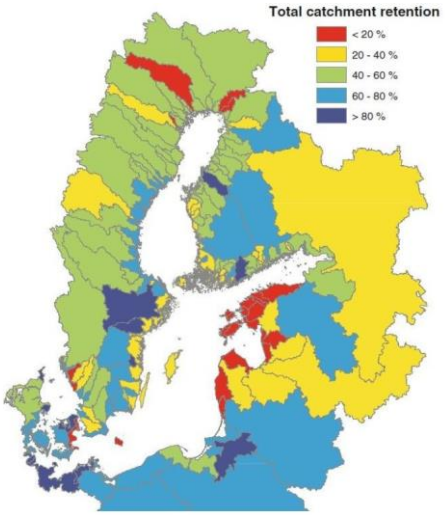
The clean-up costs sky-rocket, because cheap options are insufficient to meet the target, and much more expensive measures have to be applied. Some people say that abatement programmes cannot be cheap. This is not quite correct, since it depends on the ambition level. If the clean-up programme is confined to, say, 10% reduction of nitrogen discharges, cheap options – such as restoring coastal wetlands (see 2.8 above) – are sufficient. Yet if the clean-up programme is more ambitious, say, 40% reduction of nitrogen discharges, cheap options are not sufficient, and more expensive ones (e.g. moving from secondary to tertiary treatment of municipal sewage) have to be applied.

3. Prospects for Baltic cooperation

Our previous lecture identified eutrophication as the most important common environmental problem that the Baltic countries need to solve. It requires a massive abatement effort leading to the 50% reduction of nitrogen discharges. It requires phosphorus abatement as well, but nitrogen – the limiting factor of algae blooms – needs to be addressed more immediately.

As sovereign states, Baltic countries abate to the extent they find it domestically beneficial. At the same time, the "public good" nature of eutrophication requires to abate to the extent it is beneficial for the entire region rather than for an individual country. The first question that needs to be addressed is whether countries indeed can "free ride" on each other activities.

Proponents of a national ("separatist") approach can argue that even a single country can benefit from what its polluters abate. This is partially true. Poland, for instance, will benefit from building a more efficient sewage treatment plant in Gdańsk. Tourists spending their holidays in the neighbourhood will enjoy cleaner beaches. Also permanent inhabitants of the area will benefit from a stronger local economy, and improved environmental amenities. But Swedes will benefit as well. They will gain from reduced eutrophication caused by lower discharges. Is Poland likely to take into account the Swedish benefits too when deciding on the abatement ambition? It is not, unless there exists a mechanism to force the Swedes to do the same and, in particular, to let them participate in what others do for the entire region. A national approach does not allow to undertake abatement to the level that is economically justified for the entire region.



The analysis is even more complex since the same reduction of nitrogen discharged may imply different outcomes for the sea depending on where it was located. For instance, Poland may contemplate whether to invest in a sewage treatment plant in Cracow or in Gdańsk to abate, say 1,000 tonnes of nitrogen. Investing in Gdańsk will imply that the Baltic Sea will avoid receiving 1,000 tonnes of nitrogen. Investing in Cracow has different consequences. Once discharged into the Vistula river, 70% of the nutrient load will be retained in the local riverine ecosystems. The Baltic Sea will avoid receiving 300 tonnes only. At the same time many municipalities located along the Vistula river will enjoy better quality water. Thus, from the purely Polish point of view, investing in Cracow is more beneficial. In contrast, from the Swedish point of view, the investment should take place in Gdańsk.

When you look at the map above you see that retention rates vary widely. In most cases they are high in Poland and low in Sweden. This means that whatever is discharged in Sweden will reach the sea without much "losses", whereas whatever is discharged in Poland will be retained by local ecosystems to a large extent.

Baltic Sea countries put some effort into creating institutions capable of addressing the eutrophication problem. Two conventions were signed: one in Gdańsk in 1973, and one in Helsinki in 1974 (amended in 1992). The conventions try to eliminate mismanagement of the

Baltic Sea resources. They also try to coordinate efforts aimed at reducing the eutrophication of the sea. As explained in the previous lecture, the success of this policy has been moderate.

An important reason for an insufficient progress in abating nitrogen is the lack of a mechanism to overcome the "public good" nature of the problem. A mechanism called for should provide countries with incentives to abate up to the level that is justified by the sum of benefits rather than individual benefits enjoyed by a single country. The mechanism is summarised by a hypothetical fund to let beneficiaries participate in abatement measures undertaken within the drainage basin. In principle all countries pay to the fund, and all of them receive subsidies from it. 'Net transfers' are differences between what they receive and what they pay.

A model corresponding to this problem was constructed by Parkash Chander and Henry Tulkens. The model defines a system of transfers to motivate countries to abate up to an efficient level determined by the maximisation of the sum of benefits net the sum of costs. The derivation of the model requires game theory methods that will not be referred to here. The Chander-Tulkens model (CTM) is summarised by the following equation:

$$T_i = \gamma_i p_i - (\pi_i : \pi_N) \cdot \Sigma_j \gamma_j p_j,$$

where:

T_i – money transfer to country i ('net transfer'),
γ_i – marginal abatement cost in country i,
p_i – pollution abatement in country i,
π_i – benefits in country i from the region-wide abatement,
π_N – the sum of benefits from the region-wide abatement ($\pi_N = \Sigma_j \pi_j$).

Its interpretation is straightforward and quite easy:

- Every country gets its abatement cost financed ($\gamma_i p_i$)
- Every country contributes to the total regional abatement cost ($\Sigma_j \gamma_j p_j$)
- in proportion to its share in total benefits ($\pi_i : \pi_N$)
- A negative amount of T_i means that a country pays rather than receives money
- The sum of transfers is zero ($\Sigma_j T_j = 0$)

While the model is fairly simple, its calibration (i.e. estimation of costs, benefits, and transfers) requires a lot of controversial calculations. The following table on page 27 summarises one version of the model (called CTM(I)).

The first column lists the nine Baltic Sea countries. The next one estimates their shares in the total benefits from the 50% reduction in the eutrophication, and the last one – money transfers required to motivate countries to abate up to what is cost-effective from the entire drainage basin point of view (not necessarily from the point of view of a single country). The assumptions the model is based on can be summarised as follows:

- All numbers are understood as annual flows
- 50% nitrogen abatement is understood as the target for the entire drainage basin (not for a single country)
- π_N was estimated at \$6 billion
- $\Sigma_j \gamma_j p_j$ was estimated at \$4 billion

Hypothetical Baltic transfers (CTM(I))

Country (i)	π_i:π_N [%]	T_i [10^6 \$]
Finland	14.4	-216.9
Sweden	26.7	-395.6
Denmark	16.5	-292.3
Germany	11.2	67.2
Poland	24.1	280.8
Lithuania	1.2	280.0
Latvia	0.8	208.8
Estonia	0.6	177.2
Russia	4.6	-109.2
Total	100.0	0.0

The overall cost estimate (\$4 billion) was explained in the previous lecture. Here let us look at how benefit estimates were arrived at. Economists prefer to deal with numbers derived from real market transactions. Reduced eutrophication is not a market good, so there is no hope to observe its "price". In such situations economists try to find a related market where prices observed can shed some light on the value people attach to the good in question.

Our first attempt (in the 1990s the University of Warsaw was involved in an international project to estimate benefits from reduced eutrophication of the Baltic Sea) was to look at real estate prices near the Baltic Sea coast. We expected that they were related to eutrophication, with less eutrophicated locations revealing higher prices. Biologists explained that eutrophication is something to be observed hundreds kilometres from the shore (see the map on page 18), and therefore it cannot be reflected in real estate prices.

Our next attempt was to look at the tourist traffic from Stockholm to Helsinki and back. There are huge ferries commuting between the two cities every day. The annual number of passengers is roughly 10 million. We expected that if the eutrophication is reduced, the demand for travel will go up thus indicating to what extent people appreciate the improved quality of water. We had to abandon this approach once we realised that most passengers take advantage of cheap alcohol served on board, and they absolutely do not care about whether the sea is clean or dirty.

Having failed to use tourist attractiveness as a proxy for benefits we were interested in, we planned to interview ship owners in order to determine to what extent they can save on maintenance costs if the sea is less eutrophicated. It turned out, however, that these costs do not depend on the water quality.

Our last attempt was to interview fishermen in order to learn how much they would gain by catching fish in a less eutrophicated sea. We realised that, if fact, harvests in a eutrophicated sea can be higher than in a less eutrophicated one, so we had to give up this approach too.

If no market can be easily related to the non-market good in question, economists rely on so-called "declared preference" methods. People are simply asked how much they would be willing to pay (WTP) to get something (e.g. reduced eutrophication of the Baltic Sea). If a simple question was asked "how much are you willing to pay for a less eutrophicated Baltic Sea", then some people would say $2, some would say $200, and most would not give any answer probably. The results of such a survey would be useless.

There has been a tremendous progress over the last sixty years in developing methods to ask WTP (*Willingness To Pay*) questions in a way which reduces the risk of getting random or misleading answers. In particular, economists developed methodologies to ask OE (*Open Ended*) or DC (*Dichotomous Choice*) questions. In the former case the question asked reads "how much are you willing to pay". In the latter: "you are asked to pay *x* dollars; do you agree? – please, say 'yes' or 'no'". A typical survey is prepared in a series of steps, starting with a 'Pilot' questionnaire, and ultimately followed by the 'Main' one. Typical surveys are face-to-face; now they rely on computers. Mail surveys are cheaper, but they are affected by the so-called "self-selection bias" (people who have particularly strong feelings about the topic of the survey are more likely to respond). An additional problem is linked with responses WTP=0. Some people are willing to pay 0 indeed; they are called legitimate "zero bidders". Others, however, state zero willingness to pay not because they mean it, but just because they want to protest against the survey (for whatever reason); they are called "protest bidders". There is a methodology of how to recognise who is a legitimate "zero bidder" (whose answer should be taken into account) and who is a "protest bidder" (whose answer should be omitted).

There are nine Baltic countries, but the project included surveys in three of them only: Poland, Lithuania, and Sweden. An assumption was made that Lithuania was representative for the former Soviet republics (Latvia, Estonia and Russia), and Sweden was representative for Western European countries (Germany, Denmark, and Finland). Another problem was caused by the fact that Lithuania and Sweden applied different methods which typically yield different values: pilot survey yields lower estimates while mail survey – higher ones. Likewise, OE surveys are likely to underestimate WTP, and DC surveys are likely to overestimate WTP. Poland was the only country which applied all the methods concerned. The following table (page 29) summarises "raw" results of surveys, that – after some statistical extrapolations – were used to estimate hypothetical benefits obtained in the nine Baltic countries (the table on page 27). The extrapolations were based on the Polish "Main DC" survey as a 'numeraire', and taking into consideration the fact that for similar countries, WTP is likely to be proportional to their GDP per capita (post-Soviet republics, and Western European countries were considered 'similar' to Lithuania and Sweden, respectively).

It was assumed that the Lithuanian WTP in a hypothetical Main DC survey would have been 28 (because 28=7x56/14), and the Swedish WTP in a hypothetical Main DC survey would have been 251 (because 251=458x56/102).

Mean WTP values in 1995 US$ (including zero bidders and excluding protest bidders)

	Lithuania	Poland			Sweden
	(Pilot, OE)	(Pilot, OE)	(Main, DC)	(Mail, DC)	(Mail, DC)
WTP	7	14	56	102	458

CTM(I) results were reported on page 27, but it is clear that similar exercises can be carried out for alternative calibrations. In particular, it would be interesting to calculate hypothetical transfers in different circumstances, such as:

- Different ambition levels
- Different cost estimates
- Different individual benefit estimates
- Different total benefit estimates

Alternative hypothetical Baltic transfers (CTM(II))

Country (i)	$\pi_i:\pi_N$ [%]	T_i [10^6 €]
Finland	4.2	77
Sweden	15.9	19
Denmark	3.5	92
Germany	47.3	-535
Poland	8.3	351
Lithuania	0.6	114
Latvia	0.3	86
Estonia	0.7	64
Russia	19.2	-268
Total	100.0	0

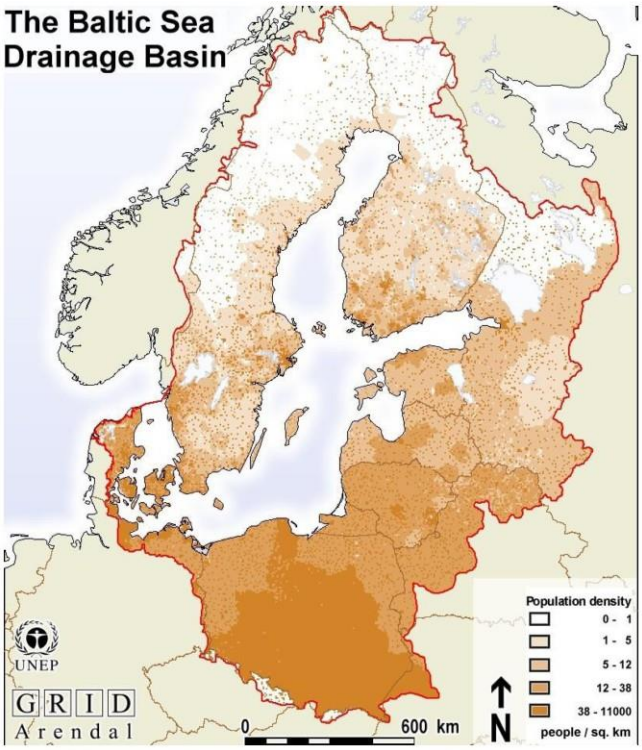
The table above (CTM(II)) reflects annual flows (like in the CTM(I)), and it is based on the following assumptions:

- HELCOM BSAP (*Baltic Sea Action Plan*) instead of the 50% reduction of the total inflow of nitrogen
- π_N estimated at €3.6 billion (based on a different study)
- $\Sigma_j\ \gamma_j p_j$ estimated at €1.5 billion (based on a more recent assessment of abatement costs)

The sums of transfers in both calibrations (1014 million $ and 803 million €) are large – 25% of the region-wide abatement cost in CTM(I) and more than 50% in CTM(II). Sweden turns out to be the single largest beneficiary of the recovery programme in CTM(I). Germany is identified as an even larger one in CTM(II), but the valuation methodology applied there is highly controversial. Given the fact that actual transfers between the Baltic drainage basin countries are at least by one order of magnitude lower than those derived from either CTM, apparently Helsinki Convention signatories are not ready to cost their public good adequately.

Even very modest proposals (corresponding to mere 5% of abatement costs) did not gain any political support.

Another conclusion from these exercises is the asymmetry in distribution of costs and benefits. Sweden is a large beneficiary, while the largest abatement costs are to be born by Poland (which is reflected by the highest transfers directed to Poland in CTM(I) and CTM(II). If you look at the map below, it should not be surprising. Most of the Swedes live close to the coast, and they are likely to appreciate the sea more than others. At the same time, Poles make almost a half of the drainage basin population, so it is quite obvious that a lot of abatement has to be realised in Poland.



An important caveat needs to be mentioned here. If you look at hypothetical transfers calculated in CTM(I), Germany and Russia seem to end up in "wrong" groups: the former is to be subsidised, and the latter is expected to pay. Abatement costs assigned to both countries are probably adequate, but the estimation of benefits is controversial. A part of the problem is the fact Germany and Russia are two large Baltic countries whose territories overlap with the drainage basin only partially. It was assumed in benefit analyses that only people who live in the drainage basin enjoy benefits from reduced eutrophication. The inhabitants of Berlin were thus excluded, even though they may care for the Baltic Sea (Rostock is just a 2-hour travel along a highway). Therefore the German WTP was probably underestimated. On the other hand, the Russian WTP was extrapolated from the Lithuanian survey and it is likely to be overestimated. Lithuanians live close to the sea, and they are proud of being a Baltic country. For an average Russian living in the drainage basin, Baltic Sea eutrophication has probably a lower priority than a number of other issues.

The Baltic Sea is a public good for sure, but estimating benefits resulting from its protection is a challenge.

Questions and answers to lecture 3

3.1. Why are Swedish rivers characterised by retention rates lower than Polish ones?

A typical Swedish river is short and fast flowing. Sweden does not have long rivers that – like the Vistula or the Odra – flow many hundreds of kilometres before discharging into the Baltic Sea. Besides, most Polish rivers are high-degree tributaries (first-degree tributary discharges into a river which discharges into a sea; second-degree tributary discharges into a first-degree tributary, and so on). Thus in Poland it takes more time than in Sweden to reach the sea. Whatever is dissolved in water reaches the sea sooner in Sweden than in Poland. In addition, a slow flowing river provides more opportunities for the nutrients to be utilised by riverine ecosystems. On top of that, retention rates characterising entire catchments in Poland are even higher than for rivers alone, because of groundwater (which flows more slowly).

3.2 In the 1990s the Polish government assigned priority to sewage treatment plants located on high-degree (small) tributaries in Southern Poland. Was this justified?

Yes, it was. If a treatment plant is located by the coast (or close to the river mouth), it protects a small land area. If it is located upstream, then it protects the river and the population living downstream. For instance, Warsaw is protected by a treatment plant in Cracow, but it is not protected by a treatment plant in Gdańsk. From the point of view of the Baltic Sea eutrophication priority should be assigned to sewage treatment plants located in Northern Poland. Sewage treatment plants located on small tributaries in Southern Poland should be given priority if they are financed by the Polish taxpayers.

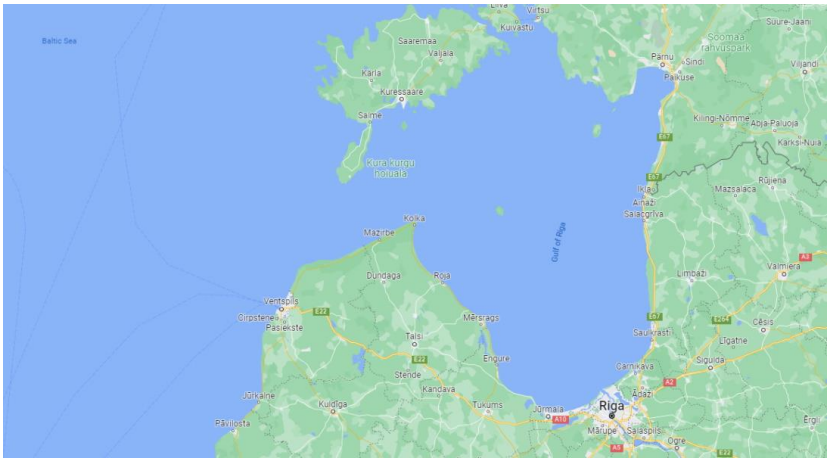
3.3 Do Baltic Sea conventions (Gdańsk and Helsinki) provide incentives to cooperate in the drainage basin?

No, they do not. Both conventions bind the countries of the drainage basin. Gdańsk convention constrains fisheries, and Helsinki convention imposes certain restrictions on land based activities. Nevertheless neither provides incentives to undertake activities *à la* Chander-Tulkens. If countries cooperate with each other, they do this independently (outside either of the conventions).

3.4 If all the Baltic countries abate to the extent justified by their local benefits, is the eutrophication to be reduced adequately?

Not necessarily. The Gulf of Riga provides an example. The Gulf of Riga is semi-enclosed (see picture below). The quality of its water is bad. Latvians can improve it by building a very efficient waste water treatment plant in Riga. As a result the local water quality will improve, and some nitrogen which used to be "absorbed" by the local algae will be released to the Baltic proper. Meeting with its phosphorus-rich water, it will contribute to higher eutrophication there. This does not mean that Latvians should not build an efficient treatment

plant in Riga or elsewhere. It means that a Baltic-wide clean-up plan should be coordinated. What individual countries do is not necessarily sufficient for reducing the eutrophication of the sea.



3.5 What would the CTM transfers (T_i) look like, if local abatement costs were strictly proportional to local benefits?

They would be zero (T_i=0 for every i; what the country receives is equal to what it pays). To see this, let us assume that $\gamma_i p_i = x\pi_i$ (parameter x – interpreted as a fixed proportion of abatement cost – is the same for every country i). Then $T_i = \gamma_i p_i - (\pi_i{:}\pi_N)\cdot\Sigma_j\ \gamma_j p_j = x\pi_i - (\pi_i{:}\pi_N)\cdot\Sigma_j\ x\pi_i = x\pi_i - (\pi_i{:}\pi_N)\cdot x\Sigma_j\ \pi_i = x\pi_i - (\pi_i{:}\pi_N)\cdot x\ \pi_N = x\pi_i - x\pi_i = 0$. The first equality is the definition of T_i. The second one substitutes $x\pi_i$ for $\gamma_i p_i$. The third one moves x before the summation sign, and the next one substitutes $\Sigma_j\ \pi_i$ with π_N.

3.6 Please prove that $\Sigma_j\ T_j$=0 in CTM. What is the economic interpretation of this fact?

$\Sigma_j\ T_j = \Sigma_j(\gamma_i p_i - (\pi_i{:}\pi_N)\cdot\Sigma_j\ \gamma_j p_j) = \Sigma_j\gamma_i p_i - \Sigma_j(\pi_i{:}\pi_N)\cdot\Sigma_j\ \gamma_j p_j = \Sigma_j\gamma_i p_i - ((\Sigma_j\pi_i){:}\pi_N)\ \Sigma_j\ \gamma_j p_j = \Sigma_j\gamma_i p_i - (\pi_N{:}\pi_N)\ \Sigma_j\ \gamma_j p_j = \Sigma_j\gamma_i p_i - \Sigma_j\ \gamma_j p_j = 0$. The first equality uses the definition of T_i. The second one breaks the summation. The third one moves π_N beyond the summation. The fourth one substitutes $\Sigma_j\ \pi_i$ with π_N. The fact that the sum of transfers is zero means that the money does not leak and it does not come from the outside: all payments originate from fund contributions, and all fund contributions are used up for payments.

3.7 How can values associated with non-market goods be derived from values associated with market goods?

One of the first applications of this approach was an attempt of an American national park director to save the park from an investor who wanted to build there a hydropower station (having found the geology of the local canyon favourable). Economic benefits from the electricity production were obvious, but the benefits from keeping the national park were not. The park director was advised to check the license plates of cars in the park's parking lot. Local license plates were not interesting, but license plates from distant places demonstrated that there were people who undertook a costly travel in order to visit the park. Assuming that they were rational, they must have valued the park visit at least as much as what they spent on

the travel. By summing up the travel costs, the park director demonstrated that people valued the park more than the value of electricity production. The park was saved.

Another example of this approach is provided by attempts to put a price on silence. Of course silence is not a market good (it can be neither sold nor bought), so it does not have a market price. Yet, if there are two identical houses except that one is located in a noisy area, and the other one in a quiet area, the former is likely to have a lower price than the latter. The price difference informs about the value people attach to silence.

Methods like these have been used in economics over the last few decades. Estimations based on them are often reliable and convincing, and they are applied in many policy analyses. The challenge is to identify a market good associated with the non-market good in question. In the first example the national park was the non-market good, while travel was identified as a related market one. In the second example silence was the non-market good, while real estate was identified as a related market one. In both cases analyses carried out for a market good shed some light on the economic value of the respective non-market one.

3.8 Calculating WTP based on declared prices makes use of OE or DC questions. Which format seems to be more natural for respondents?

It depends on what you are accustomed to when you buy or sell market goods. In many European groceries prices are not negotiable: you see the price tag attached to a product, and you take a DC type of a decision. The decision is "yes", if you think the price is acceptable, or "no" otherwise. Thus a DC format of WTP questions seems more natural. But in some stores – for instance in the Middle East – there are no price tags. If you ask for a price, the salesperson asks you about what you are willing to pay, or (often by quoting a very high price) invites you to start negotiations. If this is what you are used to, then perhaps an OE format of WTP questions seems more natural.

3.9 Valuation studies carried out in the University of Warsaw in the 1990s suggested that the 50% abatement programme was economically justified. Why?

The economic justification was based on the fact that the total benefits of 6 B$ exceeded the total cost of 4 B$ (assuming that abatement tasks are allocated cost-effectively). This is required to demonstrate the efficiency of the programme. The cost effectiveness of allocation of abatement effort is a strong assumption though. If policy makers fail to create a mechanism to finance it cost-effectively, the total cost can be higher than 6 B$ (not only higher than 4 B$) which undermines the economic justification.

3.10 Was the programme analysed in CTM(II) economically justified?

Yes, it was, since the total benefits were estimated at 3.6 B€, and the total costs – at 1.5 B€. By the way, the difference between inputs to CTM(I) and CTM(II) is caused by the fact that the former was based on the 50% nitrogen abatement target, and the latter – on a BSAP. Besides the latter is cheaper since it takes for granted that many investments (e.g. in sewage

treatment plants) have been carried out in the meantime, and CTM(II) is based on more recent data than CTM(I).

3.11 In CTM(II) Germany enjoys 47% of benefits of the programme, and contributes 67% to its transfer system. Why such an asymmetry?

Transfers are needed if there is an asymmetry between benefit and cost distributions (if distributions are symmetric, then no transfers are needed at all – see also question 3.5 above). In this case the asymmetry is caused mainly by the assumption that entire Germany benefits from the protection, while only a small part (the area in the Baltic Sea drainage basin) is involved in protection activities. The CTM philosophy is to let participate in basin-wide abatement cost proportionally to the share in benefits. Assuming that all Germans benefit from the protection, but they have to abate (for the sake of the Baltic Sea) to a small extent only, they should participate in financing abatement elsewhere in the Baltic Sea drainage basin (not in Germany).

3.12 Population of Sweden is much lower than that of Poland, yet the benefits from reduced eutrophication of the Baltic Sea are estimated to be higher in Sweden than in Poland (in CTM(I) – slightly, and in CTM(II) – almost twice as high). Why?

There are two factors which lead to these high benefit estimates. Sweden is wealthier than Poland. According to the World Bank statistics (taking into account so-called *Purchasing Power Parity*), the Swedish GDP per capita was $ 55,566 in 2021, while the Polish one was $ 35,957. Wealthier citizens value environmental amenities higher usually. But there is a second factor which is probably even more important. Most Poles have never been at the Baltic Sea coast and probably the predicament of the Baltic Sea is not considered a priority by them. In contrast, in Sweden most people live either at the coast, or close to it. Many people have cottages located at the sea coast and they are very sensitive to protecting the Baltic Sea, and to the quality of its water.

3.13 In CTM(I) benefits from reduced eutrophication are enjoyed by those who live in the drainage basin only. In CTM(II) benefits from reduced eutrophication are assumed to be enjoyed by all citizens of a given country. Are these assumptions justified?

Neither of these assumptions is convincing. Both are motivated by practical reasons. In the first case it is easy to take a decision whether somebody should or should not be included in calculations based simply on whether the address belongs or does not belong to the drainage basin. Yet this is a poor predictor of the value a person attaches to the Baltic Sea. In CTM(I) – where it is assumed that only the drainage basin counts – people living in Berlin were excluded from calculations, since the city is located in the North Sea drainage basin. Despite this, perhaps many inhabitants of Berlin would be willing to support Baltic Sea protection programmes (after all, Rostock is only a two-hour drive from their city). On the contrary, CTM(II) was based on benefit calculations where entire populations of the Baltic coastal countries were taken into account. Yet in estimating benefits, distance to the sea plays a role, and it is not clear whether people who live very far from it (e.g. in Munich in Southern Germany) can estimate their WTP for reduced eutrophication of the Baltic Sea accurately.

4. Acid Rain

Acid rain is a term used to cover any sort of precipitation that reveals some acidity. Hence we can also think about acid snow or acid fog. The point is that whatever we have – rain, hail, snow, or fog – it has acidic reaction. Please note that carbon dioxide, which is a natural component of the atmosphere, has acidic reaction too. Therefore any precipitation must have some acidic reaction. Yet – in non-polluted environment – this reaction is slight.

Acidity is often measured in so-called pH units. For those of you who remember something from your high-school chemistry, the measure refers to the logarithm of the number of alkaline ions. Substances that are considered pure alkali have this number 14, and those that are considered pure acids – have zero. Half a way in this scale we have the number 7 which is neutral (neither acid nor alkaline). Pure (distilled) water has pH=7. However, unpolluted precipitation has pH slightly lower (it is not quite neutral; it is a bit acid). The acidity of unpolluted rain is 6.5 which has been caused by the natural concentration of carbon dioxide in the atmosphere.

We say that we have acid rain, if the acidity of precipitation is below 6.5. The acid rain can be caused by contamination of acidifying substances, such as e.g. sulphur dioxide (SO_2) or nitrogen oxides (NO_x, i.e. NO, NO_2, N_2O_5, and others). When oxidized, sulphur dioxide becomes sulphur trioxide, which – in the presence of water – becomes sulphuric acid:

$$SO_3 + H_2O \rightarrow H_2SO_4$$

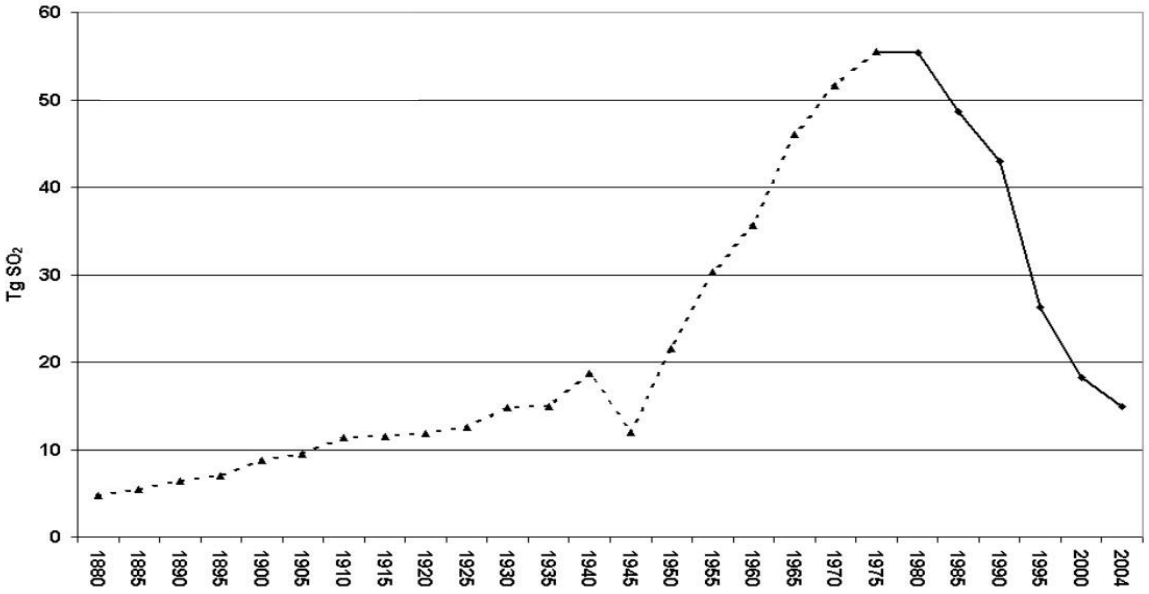
Nobody would like to be sprayed by sulphuric acid, but this is something that – at least as a slight addition – is present in the rain we are exposed to. Acid rain is often linked to excessive sulphur dioxide emission, but it can be caused by NO_x pollution, or anything else which has chemical reaction lower than pH=7.

The rain in Europe used to be very acid. In the 1970s and in the 1980s it was below pH=5. The "record breaking" acidity of the rain was pH=3 or even less somewhere in South-eastern Europe.

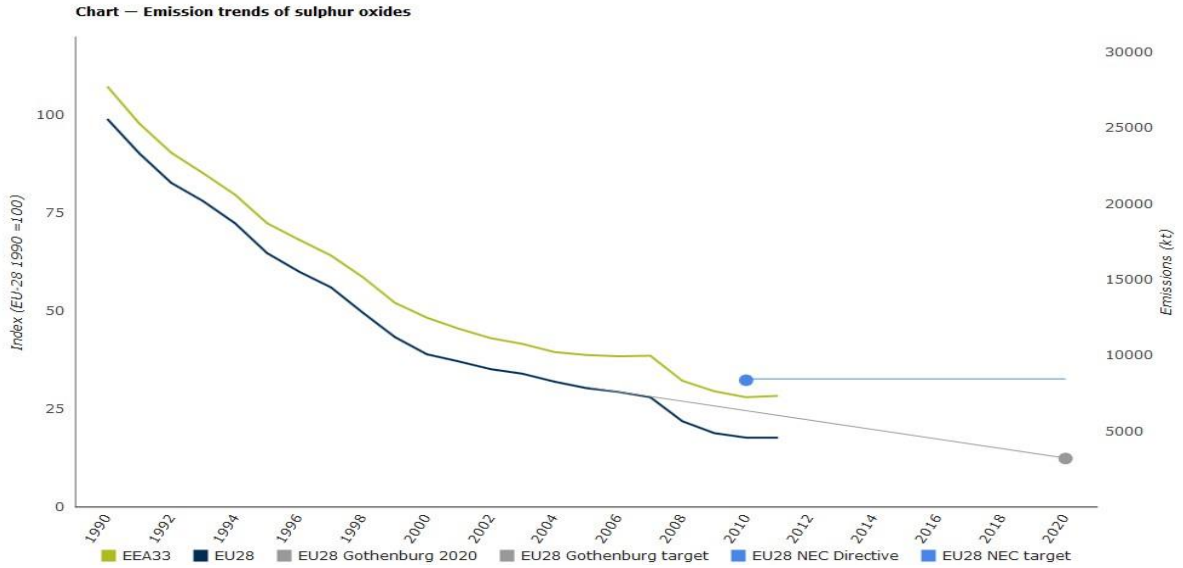
The low pH reaction of rain has detrimental consequences. It affects our health adversely, kills forests and other vegetation, accelerates corrosion, and so on. The *World Health Organisation* (WHO) estimates that long-term exposition to sulphur dioxide concentration higher than 40 $\mu g/m^3$ (μg stands for "micro-gram", i.e. 10^{-6} of 1 g) has severe adverse health effects. In addition it turns out, that trees are even more sensitive than us. The limit for forests is only 20 $\mu g/m^3$. If the concentration of sulphur dioxide in the air is higher than this, forests become sick and eventually die. Large areas of Europe were affected by this process which has even its own name (*Waldsterben*; a German word for "forest dieback").

The European sulphur dioxide emission peaked in the 1980s. It was more or less 60 million tonnes of SO_2. It has declined since then (see pictures below). Those of you who remember

high-school chemistry know that a molecule of sulphur dioxide has the weight exactly twice the weight of sulphur, since the mass number of SO_2 is 32+16*2=64, i.e. exactly twice 32 (which is the mass number for S). In the graph below the emission of sulphur dioxide is measured in tonnes of SO_2. Sometimes it is expressed in tons of S; then its peak would be somewhat less than 30 Mt.



This declining trend is captured in the next picture. The solid lines (green and black) are self-explanatory. The name "Gothenburg" and the acronym "NEC" will be explained later.



In the 1970s and the 1980s acid rain was a very important environmental problem in Europe. It was obvious that no single country can solve it. The table below illustrates European migrations of sulphur dioxide. Once emitted from a stack (especially from a tall stack of a power plant) it may migrate – with the wind – hundreds of kilometres before it falls down as

an acid rain or in the form of dry deposition. The table below illustrates migration patterns characteristic for the 1980s (please note that the numbers are measured in tonnes of sulphur, not sulphur dioxide).

European SO_2 migrations in 1985 (thousand tonne S)

	AL	AT	BE	BG	CS	DK	FI	FR	DD	DE	GR	HU	IS	IE	IT	LU	NL	NO	PL	PT	RO	ES	SE	CH	TR	SU	GB	YU	RE	IND	SUM
AL	6	0	0	4	0	0	0	0	0	0	3	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	8	29
AT	0	23	1	1	32	0	0	3	23	13	0	17	0	0	19	0	0	0	17	0	0	1	0	1	0	2	3	19	0	27	207
BE	0	0	47	0	2	0	0	15	6	17	0	0	0	0	1	0	4	0	1	0	0	0	0	0	0	0	9	0	0	7	113
BG	0	0	0	159	2	0	0	0	2	0	1	3	0	0	1	0	0	0	4	0	3	0	0	0	2	8	0	5	0	17	212
CS	0	6	1	2	429	1	0	4	110	21	0	50	0	0	5	0	1	0	92	0	1	1	0	0	0	3	5	13	0	30	779
DK	0	0	1	0	2	36	0	2	11	9	0	0	0	0	0	0	0	0	3	0	0	0	1	0	0	1	7	0	0	11	88
FI	0	0	0	0	5	1	63	0	13	3	0	0	0	0	0	0	0	0	8	0	0	0	5	0	0	59	4	0	0	69	234
FR	0	2	21	1	23	0	0	313	43	54	0	6	0	1	38	1	5	0	12	1	0	51	0	4	0	1	44	7	0	125	757
DD	0	1	4	0	83	3	0	7	674	57	0	3	0	0	1	0	3	0	30	0	0	1	0	0	0	1	12	2	0	20	905
DE	0	4	20	1	62	4	0	41	148	379	0	8	0	0	14	0	13	0	26	0	0	3	0	3	0	1	43	7	0	62	844
GR	0	0	0	19	1	0	0	0	1	0	47	1	0	0	3	0	0	0	2	0	0	0	0	0	2	3	0	2	0	25	110
HU	0	3	0	4	31	0	0	1	14	3	0	199	0	0	6	0	0	0	22	0	2	0	0	0	0	3	1	34	0	18	345
IS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14	16
IE	0	0	0	0	0	0	0	1	0	1	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	24	57
IT	0	3	0	3	8	0	0	11	7	6	1	6	0	0	401	0	0	0	5	0	0	6	0	3	0	1	3	20	1	69	560
LU	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
NL	0	0	11	0	3	0	0	8	9	36	0	0	0	0	0	0	31	0	2	0	0	0	0	0	0	0	18	0	0	9	131
NO	0	0	1	0	4	4	1	2	11	7	0	1	0	0	0	0	1	10	5	0	0	0	4	0	0	11	18	0	0	102	185
PL	0	2	4	2	151	5	0	6	248	39	0	30	0	0	3	0	2	0	761	0	2	1	2	0	0	18	13	9	0	53	1356
PT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	19	0	0	0	0	0	0	0	24	82
RO	0	1	0	24	25	0	0	1	16	3	0	42	0	0	5	0	0	0	32	0	37	0	0	0	1	26	1	32	0	46	298
ES	0	0	1	0	2	0	0	16	3	3	0	1	0	0	7	0	0	0	1	8	0	500	0	0	0	0	3	1	2	83	636
SE	0	0	2	0	12	13	9	4	38	17	0	2	0	0	0	0	1	3	23	0	0	0	48	0	0	19	15	1	0	115	330
CH	0	0	0	0	5	0	0	7	6	6	0	1	0	0	17	0	0	0	2	0	0	2	0	12	0	0	1	2	0	13	79
TR	0	0	0	13	1	0	0	0	1	0	3	2	0	0	1	0	0	0	2	0	1	0	0	0	50	16	0	2	0	80	177
SU	0	3	3	14	111	8	26	7	154	36	1	57	0	0	7	0	2	0	285	0	11	1	8	0	22288	19	22	0	436	3508
GB	0	0	5	0	4	1	0	13	10	12	0	1	0	4	1	0	3	0	4	0	0	2	0	0	0	0	525	0	0	65	654
YU	2	3	0	50	17	0	0	2	10	4	4	37	0	0	32	0	0	0	16	0	3	1	0	0	1	6	2	257	0	74	527
	AL	AT	BE	BG	CS	DK	FI	FR	DD	DE	GR	HU	IS	IE	IT	LU	NL	NO	PL	PT	RO	ES	SE	CH	TR	SU	GB	YU	RE	IND	SUM

The symbols of countries can be easily recognized: AL stands for Albania, AT for Austria, and so on. CS stands for Czechoslovakia, DD for East Germany, DE for West Germany, SU for the Soviet Union, and YU for Yugoslavia – countries that do not exist anymore.

The table can be read by rows or by columns. If you look in a single column you see emission from a given country which ends up in another country. For instance, if you look for PL (Poland), you will see that the Polish emission ends up in Austria (17), Belgium (1), Bulgaria (4), Czechoslovakia (92), and so on. Of course most of it ends up in Poland (761). Quite a lot ends up in the Soviet Union (285). If you look in a single row you see where the depositions found in a country come from. For instance, if you look for PL then (at the right hand side) there is information that the total deposition in Poland is 1356. Of this number, nothing comes from Albania. From Austria it is 2, from Belgium – 4, and so on. The 761 number was already interpreted when we looked at the appropriate column. Please also note that 53 came from unidentified sources (IND). Nothing came from identified non-European countries (RE).

In the University of Warsaw there were analyses carried out in order to interpret these migration patterns. First of all, we tried to recalculate the table, taking into account the fact that the Polish emission was much higher than reported by the government. This was not 1355 thousand tonnes S (i.e. 2710 thousand tonnes SO_2) – the number if one summed up the PL column – but roughly 4000 thousand tonnes SO_2. Also numbers reported for some other countries were modified according to alternative sources. An additional analysis was to estimate for a given country how the deposition translates into environmental damages, characterized by deposition of sulphur dioxide per hectare, and the concentration of sulphur

dioxide in the ambient air. Also, for every country, we identified its Most Annoying Neighbour (M.A.N.) understood as the country where the highest share of "imported" depositions came from. The table below illustrates selected rows from this analysis.

European SO_2 migrations in 1980s
(fragments)

Country	Emission 1000 t	Deposition 1000 t	Density kg/ha	Concentr. $\mu g/m^3$	Import %	M.A.N.*	Share of M.A.N. %	Un-ident. %
Austria, AT	480	746	89	27	88	IT	14	10
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
East Germany, DD	4220	1836	170	51	36	DE	10	3
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
Italy, IT	3240	2093	69	21	32	FR	5	11
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
Poland, PL	4000	3539	113	34	54	DD	14	5
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
USRR-Europe, SU-E	19940	16106	30	9	35	PL	7	2
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
Total	**67320**	**.**	**.**	**.**	**.**	**.**	**.**	**.**

* M.A.N. – The Most Annoying Neighbour (the country where the highest share of "imported" depositions comes from)

Please note that the table above includes 5 rows only (out of the 28 countries covered on page 37). The "total" filled out in the first column gives an approximate number of the total European emission – roughly 67 million tonnes of SO_2 (e.g. 34 million tonnes of S) rather than a smaller number implied by the official table referred to on page 37. Please also note that the percentage numbers quoted do not add to 100%.

The table shows that Austria is a net "importer", i.e. it emits less than what is deposited in its territory. Other countries (such as East Germany, Italy, Poland and the European part of the Soviet Union) are net "exporters". By the way, most European countries are net "exporters", since wind blows usually form West to East. Consequently, it brings a fairly clean air from the Atlantic Ocean, and sends the polluted air to Asia.

The table shows that the density of deposition in Poland was 113 kg/ha, and it was lower than in East Germany, but higher than in Italy. Concentration in ambient air in $\mu g/m^3$ was calculated using a rule of thumb suggested by our Warsaw Technical University colleagues;

this is a very approximate number. It suggests that the average concentration found in Poland (34) was fairly safe for humans but deadly for trees. What was found in East Germany was dangerous even for humans. These average values refer to aggregate numbers observed at a country level. Of course, concentrations were not distributed uniformly, so there were areas fairly clean and areas with extremely poor air quality.

The most important finding is about the "Most Annoying Neighbour". There are countries – like Austria and Poland – who can complain that the pollution coming from their M.A.N. – Italy and East Germany, respectively – contributes 14%-15% to their depositions. However, as a rule, the pollution from the M.A.N. (like from France to Italy) is negligible – 5% or less. Therefore it is clear that bilateral agreements with such neighbours cannot solve the problem.

Emission migrations in Europe are very intensive, and the acid rain problem cannot be solved unless a multilateral agreement is achieved. The problem can be solved only when all the European countries agree to abate acidifying substances.

Scandinavian countries and Austria were hit by sulphur dioxide migrations more than others. For instance, the deposition in Norway was 185 thousand tonnes of S (the largest "import" – 18 – came from Great Britain), whereas the country emitted only 13 (of which 10 stayed in Norway, and 3 went to Sweden). In other words, domestic emission contributed only 5% to the total in that country. To put it differently: even if Norway abated its emission down to zero, the deposition would decrease from 185 to 175, i.e. by 5% only.

In 1972 – at the so-called Earth Summit (United Nations environmental protection conference in Stockholm) – Sweden tried to draw international attention to the acid rain, but political leaders did not seem to be interested in the topic. Nevertheless Scandinavian countries and Austria continued diplomatic efforts which finally, in 1979, resulted in signing a convention. The convention has a very long name: *United Nations Economic Commission for Europe Long Range Transboundary Air Pollution* (UNECE LRTAP). Sometimes it is called simply the Geneva Convention, since it was signed in that city. It was prepared under the auspices of the *United Nations Economic Commission for Europe* which – for historical reasons – includes United States and Canada (in addition to European countries).

The Geneva Convention was toothless, in a sense that it did not include any abatement commitments or sanctions. It simply said that there was an acid rain problem in Europe, and signatories should do something about it. Even though it was toothless, it included an important provision. Namely, it stated that signatories would meet every year in order to discuss (at a high political level) European acid rain problems. The annual meeting in Geneva in 1984 was particularly important. It resulted in signing the so-called EMEP Protocol, i.e. an agreement on establishing a funding for Environmental Monitoring European Programme (EMEP). Its full official name is even longer: *Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe*.

Some people were sceptical about this project, and considered it a useless bureaucratic endeavour. The scepticism was aggravated by the fact that there were two computing centres established: West (in Oslo) and East (in Moscow). The reason for this redundancy was a

position of the Soviet Union, whose leaders did not want the "West" to dominate the work of EMEP. For some analysts this was a pure waste of money. For others, however, this was a very clever strategy of pressing Eastern leaders to acknowledge that European international migration of sulphur dioxide is undeniable. As a result of migration tables like reproduced on page 37 above, nobody could claim that the problem did not exist, or that it was "invented" at the other side of the iron curtain. Meteorologists who worked in both centres (West and East) produced tables that were consistent. Western experts, who did not want to offend their Eastern colleagues, accepted data even if they were obviously false. Thus you can see that the Polish emission is taken as 2.71 Mt (the official number reported by the government), even though the correct number was around 4.0 Mt.

Scandinavian signatories to the Convention expected that once accustomed to the fact that migration exists, Eastern leaders would not object too strongly to add some teeth to the Convention. They were right, since in the next year – in 1985 – another important protocol to the Convention was signed. This is called "Helsinki Protocol" or "Thirty-Percent Protocol". Later on, after the Oslo Protocol had been signed, the Helsinki Protocol started to be referred to as "The First Sulphur Protocol".

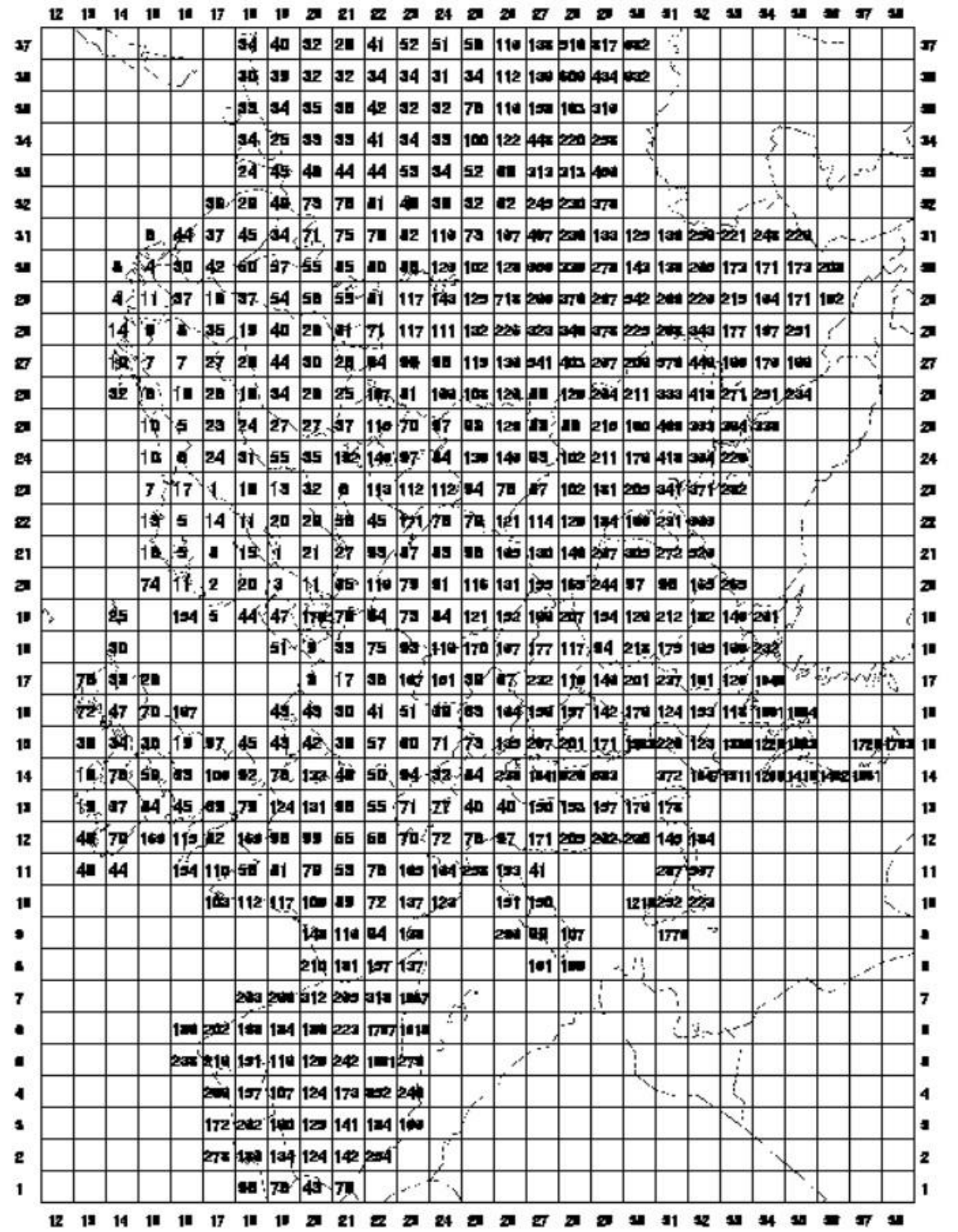
The name owes to the fact that the Protocol stated that all signatories should reduce their sulphur dioxide emission by 30% of what they emitted in 1980 in the next ten years, that is by 1995.

While the acceptance of the original Geneva Convention was universal, the acceptance of its 1985 protocol was far from unanimity. Ten countries refused to sign the Protocol: including the United States, Great Britain, and Poland. The statement of the American delegation was arrogant. It said that US would fight the acid rain when it is justified economically, and using instruments considered appropriate. On the contrary, the British statement was very polite, but negative either. It said that Great Britain attached very high weight to the acid rain, but the baseline of 1980 was quite arbitrary (and unfair for Great Britain). If the baseline were, say, 1975, British economy would have complied with the 30% requirement already. Indeed, in the 1970s huge deposits of natural gas were discovered in the Atlantic shelf near the British coast. The deposits allowed Great Britain to switch from coal to gas. This resulted in a spectacular reduction of SO_2 emission (since the coal contained sulphur, and the gas did not). Yet everything happened before 1980. Consequently the British emission in 1980 was already low, while in 1975 it was high.

Poland refused to sign the Protocol. The argument was its excessive cost for Poland. Indeed, in a centrally planned economy it was hard to conceive that existing power plants are retrofit with expensive desulphurisation equipment or that the energy demand is met by burning cleaner fuels. Other centrally planned economies – like East Germany and the Soviet Union – signed the Protocol in bad faith, since they expected to violate the 30% requirement. They signed, because it seemed that refusing to join "The Thirty Percent Club" would generate bad publicity, and in 1995 – when it is clear that the 30% requirement is not met – some "unexpected circumstances" could be blamed. Quite ironically, the centrally planned system collapsed in 1989, so Eastern Europe did comply with the Protocol: both the signatories (like the Soviet Union) and non-signatories (like Poland).

Critical sulphur deposition

(*5-percentile in centigrams of sulphur per square metre per year*)



The Thirty-Percent Protocol was the first attempt to add teeth to the Geneva Convention, but not the last one. In 1988 a protocol – called Sofia Protocol – was signed in order to increase

some requirements with respect to another acidifying substance, namely nitrogen oxides. In 1991, in Geneva, a protocol was signed to address the question of Volatile Organic Compounds (VOC).

The most path-breaking addition came in 1994 in Oslo, when the Thirty-Percent Protocol was about to expire. Environmental activists emphasized that 30% reduction in pollution load was not sufficient. Additional 20% – so that 50% of the acid rain is abated – was called for. However, the Oslo Protocol introduced two remarkable novelties. First, while it called for the 50% reduction in Europe, it did not require that every country abates 50%; individual requirements could be flexible. In particular, countries with cheaper options available were to be expected to do more. Second, the protocol introduced the concept of critical loads (CL). The map above shows Europe divided into several hundred squares 150 km by 150 km. The number in each square gives the so-called critical load, i.e. the amount of sulphur (measured in 100 g per hectare) which can be considered environmentally safe for at least 95% of the area in that square. It would be impractical to calculate the amount of sulphur which is considered harmless for all the ecosystems (since everywhere there are some ecosystems which do not tolerate sulphur at all). The concept allows that only 5% of them or less (hence the "5^{th} percentile") are damaged when the sulphur deposition is higher than the specified number.

The map is not very clear, but one can see that a typical number in Sweden is low, and a typical number in Poland is high (several times higher than in Sweden). This reflects the fact, that Sweden is much more sensitive to acid rain than Poland is. In other words, Swedish ecosystems can tolerate much less sulphur than Polish ones. For a geologist this is not a surprise. Swedish soils contain much less calcium than the Polish ones. If sulphur is deposited in Poland, then a large part of it can be absorbed by calcium to produce $CaSO_4$ (or something like that) which is tolerated by nature fairly well. In contrast, if sulphur is deposited in Sweden, then it does not find calcium, but reacts with water to produce the deadly sulphuric acid.

The Oslo Protocol (The Second Sulphur Protocol) allocates abatement targets in order to achieve 50% reduction in Europe in a reasonable way. What is meant by "reasonable" is that individual countries have to reduce their sulphur dioxide emission in a way which makes economic sense and – at the same time – 95% of the European territory does not suffer excessively from what is emitted. Regional diversification of CL implies that if a country's emission migrates to an area identified as more sensitive, then its abatement must be higher; if it migrates to an area identified as less sensitive, then its abatement can be lower.

Subsequent meetings of the UNECE LRTAP produced a couple of additional protocols. In 1998, in Aarhus, two protocols were signed: on Heavy Metals, and on Persistent Organic Pollutants (POP). Of course both heavy metals and POPs contaminate not only air, but water and soil as well. However, to the extent they can be transmitted by air (in aerosols or in particulate matter), they are covered by the Convention.

In 1999, in Gothenburg (Sweden), another important protocol was signed. It addressed not only acidification, but also eutrophication, and the tropospheric ozone. You know what is

eutrophication. Nitrogen compounds contribute to acid rain if they are emitted as NO_x. But they are also present in other forms – such as e.g. ammonia, NH_3. Then they contribute to eutrophication. Thus the protocol addressed both problems (acid rain and eutrophication) simultaneously.

The ozone problem will be addressed in the next lecture on the so-called ozone hole; this is also called the "stratospheric ozone problem". The tropospheric ozone deals with ozone found in low altitudes, say, up to several meters. Unlike the stratospheric ozone (which is beneficial), the tropospheric ozone is a contaminant. It affects our health, accelerates corrosion, and harms ecosystems. It is formed in complicated chemical reactions caused by the presence of other substances (which can migrate over long distances) that are not that harmful if they occur separately. The Gothenburg Protocol tried to address a number of problems that seemed to be less pressing before. The Gothenburg Protocol addressed the problem of acidifying emissions not only from the point of view of the acid rain, but – more comprehensively – from the point of view of eutrophication as well (hence the expression "Gothenburg target" in the lower graph on page 36).

Most of the countries that are involved in the European acid rain problem belong to the European Union (EU). Therefore instruments to fight the acid rain are included in EU directives. These directives are binding for the EU countries only, but sometimes Norway and Switzerland declare to comply with them too. The *National Emission Ceiling* directive (2001/81/EC, replaced by 2016/2284/EU; it is abbreviated as NEC, and hence you found this acronym in the graph on page 36) – the NEC directive – establishes alternative upper limits for the emission of various pollutants that were mandated by the Gothenburg Protocol.

As apparent from statistical records, the sulphur dioxide problem in Europe has been largely solved. This does not mean that there is no acid rain anymore. Abatement of nitrogen oxides is more difficult than the abatement of sulphur dioxide. The latter was emitted mainly because of the sulphur content in the fuel. Therefore switching to cleaner fuels helped to solve the problem. Nitrogen oxide pollution poses a different challenge. In the air which is around us there is roughly 80% of nitrogen and 19% of oxygen (the remaining 1% of the atmosphere consists of other gases). Nevertheless the chemical reaction

$$N_2 + 2\,O_2 \rightarrow 2\,NO_2$$

does not take place in the atmosphere if the temperature is "normal". Yet the more temperature increases, the more likely is this reaction to happen. In a power plant or in a car engine the combustion temperature is high which results in nitrogen oxide creation and emission. In power plants we have scrubbers and in cars we have catalytic converters to abate this emission. Despite these, some pollution is inevitable. It becomes nowadays a more important source of the acid rain than sulphur pollution. The chemical reaction

$$3\,NO_2 + H_2O \rightarrow 2\,HNO_3 + NO$$

explains how nitric acid (contributing to the acid rain) can be formed if there is some water vapour around.

Having said all this, it should be concluded that – thanks to international cooperation – the acid rain has been largely eliminated in Europe now. This does not mean that we do not have

the problem elsewhere in the world. There are at least three regions where the acid rain is still a problem. These are: North-east America, Latin America, and South-east Asia.

The North American problem is perhaps the easiest one. It boils down to bilateral relationships between Canada and the US. These countries do not need a convention – a bilateral agreement would be sufficient. Both countries blame each other for creating externalities, but it is not that clear who is the net exporter of pollution in the area. It is difficult to indicate who is the polluter and who is the victim. Many people think that the pollution originates in the US, and it affects Canada. The story is far from simple. Given the fact that very often winds blow from the North to the South, and given the fact that Canadian power plants emit quite a lot, pollution migrates in both directions. The problem in South-east Asia is mainly linked to the development of the Chinese economy. Nevertheless other economies in the region emit large quantities of acidifying substances too. Likewise the Latin American problem – perhaps dominated by the Brazilian emission – calls for a multilateral approach. It seems that the European experience with UNECE LRTAP could be of interest there too.

Questions and answers to lecture 4

4.1. Can snow storms or hail incidents contribute to the "acid rain" problem?

Obviously yes. The "acid rain" is a popular name, but it covers all kinds of precipitation (including snow, hail, fog. etc.).

4.2. Why was a Europe-wide convention considered the only effective instrument to solve the European "acid rain" problem?

I think that the deposition coming from the "Most Annoying Neighbour" (M.A.N.), which is fairly low usually (see M.A.N. columns of the table on page 38 in IEC-4-6 in my overheads), convinced many countries that bilateral agreements cannot solve the problem.

4.3. Why was there a decline in sulphur emissions in Europe between 1940 and 1945?

World War II resulted in lower energy consumption. Of course armies consumed a lot of oil, but power plants (producing electricity and heat out of coal and oil) worked with lower intensity.

4.4. Please analyse the table presented on page 37. The largest numbers are to be found on the diagonal. This can be easily interpreted as the fact that most emissions contribute to local depositions. Do you see any regularities in numbers out of the diagonal?

Proximity of countries results in more intensive migration. On top of that – because of the prevailing Western and Southern winds in Europe – sulphur migrates mostly to the East and North; this can be traced in the migration table (emission "exports" go mainly to countries that are located to the East and to the North of the emitter).

4.5. The table on page 37 was based on official government reports on emissions, and measurements of depositions collected in several dozens of monitoring stations (in Poland there were two such stations). Atmospheric migration patterns were modelled by meteorologists. How can the column of "un-identified emission" be interpreted?

Emission from non-European (but identified) sources is included in the RE ("rest of the world") column. So-called un-identified sources (column IND) may include sources that could have been identified (like additional 1.3 Mt SO_2 from Poland: the government reported only 2.7 Mt SO_2, even though the actual emission was around 4 Mt SO_2). I suspect that a significant part of the 102,000 tS of "un-identified" deposition in Norway (204,000 tSO_2) and 115,000 tS in Sweden (230,000 tSO_2) came from Poland (as well as from other identifiable countries). Scandinavian signatories of the convention preferred it to have such a euphemistic category – IND – rather than identifying real culprits (and provoking them to obstruct the convention).

4.6. In the table on page 37 there are only two countries (Italy and Spain) with non-zero deposition coming from non-European countries. Why?

Italy and Spain are probably the only European countries affected by African emissions significantly. No European depositions originate in Asia (because of prevailing winds), and no European depositions originate in America (because of the geographical distance).

4.7. Why was West Germany identified as the M.A.N. for East Germany?

Because of the proximity and the wind.

4.8. Why are the critical loads (see map on page 38) estimated for South Italy much higher than those for North Italy?

The difference is caused by different soils (low abundance of calcites in the North). Prevalent exposition to fresh (sea) air in South Italy – is probably not relevant.

4.9. Which acidifying emissions from burning fossil fuels are easier to be tackled: sulphur dioxide or nitrogen oxides?

For many reasons, sulphur is easier to be abated. One reason is that you can do it before the combustion: first you clean the fuel (e.g. washing the coal, or refining the oil), and then you burn it. To the extent that nitrogen is present in the ambient air (80%), improving the quality of a fuel cannot solve the problem. Atmospheric nitrogen oxidisation is caused by the high temperature inevitable when any fuel (even a "clean" one) is burnt.

4.10. What can non-European countries learn from the Geneva Convention?

The history of the Geneva Convention and its protocols is instructive. The most important starting point is to let polluters (represented by diplomats) sit at a negotiation table and

analyse migration patterns. Initially a convention can be "toothless", but it can acquire "teeth" gradually – protocol, after the protocol.

5. Ozone layer

The ozone layer was discovered in 1913. Nobody travelled this high, but based on physical observations, scientists predicted that at the height of 15-35 km the atmosphere (almost no air at this altitude) should contain a thin layer consisting of ozone, i.e. of molecules of oxygen – O_3 – built of three atoms each. The ozone has been known for many years. Down at the earth surface it is an unstable molecule which decomposes quickly releasing a "regular" molecule of oxygen O_2, and a single atom of "aggressive" oxygen O. The single atom links with whatever it meets and produces an oxide. Thus "tropospheric" ozone is considered a pollutant, since it damages our body, accelerates corrosion, and affects crops.

However, high in the atmosphere – as the "stratospheric" ozone – it plays a beneficial role of stopping excessive ultraviolet (UV) radiation coming from the sun. Some UV radiation is necessary for us, but excessive UV causes skin cancer and other problems. The ozone layer located in the stratosphere allows to get to the earth surface only a portion of the UV radiation (2%-4% of the total UV radiation coming from the sun), an amount which is just necessary for us to survive and to do well.

In the 1960s space flights confirmed that the ozone layer exists, as predicted. They allowed also to measure it accurately. The density of the ozone layer was decreasing, but this was not discovered until much later. Even though there were regular measurements carried out by satellites, the lowest numbers were routinely deleted by the software as "outliers" – measurements which suggested an error rather than a valid observation. It was only when somebody looked at the raw data (before the software had eliminated "outliers") people realised that these alleged "outliers" showed up regularly in late September over Antarctica. The ozone hole was discovered, and it turned out that the ozone layer was being depleted.

The depletion of the ozone layer has different consequences for different people. In general, it allows more UV radiation to hit the earth surface. Excessive UV radiation causes skin cancer, but the probability of its development depends on who is affected. As a rule, people with blue eyes are more vulnerable, and those with dark eyes – less. Consequently Europe and Australia is affected stronger than Africa. Nevertheless, the ozone layer is a sort of a public good: nobody can be excluded from benefits of its protection, and it works always, no matter how many people are protected. Hence undersupply as a result of free riding can be expected (recall earlier lectures on the Baltic Sea).

Once the ozone hole was discovered, a search was initiated to find a mechanism of the stratospheric ozone destruction. There are two mechanisms responsible: physical (mechanical) and chemical.

The physical (mechanical) process means simply "puncturing" the ozone layer. If a high-altitude plane or a spaceship reaches the ozone layer, it destroys its integrity. Regular flights

never touch it, since they hit the altitude of 12 km only or less. Supersonic flights – cruising at the altitude of 15 km and more – puncture it twice: for the first time when they reach the cruising altitude, and for the second time when they prepare to land. Once this was demonstrated, the US banned Concorde flights from Europe. British Airways and Air France used to offer daily supersonic flights to New York from London and Paris. Indeed their flights contributed to the ozone hole, but it was an order of magnitude lower than the impact of hundreds of military supersonic flights daily. Yet nobody dared to call for eliminating military flights. Likewise, nobody dared to call for slowing down space explorations, even though every launch of a space rocket punctures the ozone layer extensively.

The chemical process of stratospheric ozone destruction proved to be more important. It turned out that freons, or CFCs (*Chlorinated Fluoro-Carbons*), were responsible.

Freons were invented and patented in 1928. In the 1930s DuPont, an American chemical giant, launched their massive production. They were considered a miracle. They behaved like perfect gases (like, for instance, Helium), except that they were much cheaper to produce. Freons found dozens of economic applications. They were used in refrigerators. More recently, they were used to wash microchips which need to be perfectly clean before installing in computers or other electronic devices. They were considered indispensable as propellants used in pressurised containers (cosmetics, paints, etc.) since they do not react with anything. In addition, they were used to produce styrofoam and other insulating materials. Freons were considered absolutely crucial for economic development. As the owner of the patent, DuPont enjoyed a nice profit from their consumption all over the world.

In the 1970s freons were found responsible for the ozone hole. The case was similar to linking carcinogenicity to smoking habits: for many years tobacco companies claimed that scientific evidence was not conclusive. DuPont was rich and powerful enough to claim (and perhaps even to convince some decision makers) that freons were not responsible for the depletion of the ozone layer. The corporation was effective at jeopardising any international attempts to protect the stratospheric ozone. It understood, however, that one day the world would switch to ozone friendly substitutes anyway. Therefore it carried out laboratory research on so-called HCFCs (*Hydro-Chloro-Fluoro Carbons*). Their ozone-depleting potential was lower, but later on they were discovered to be Greenhouse Gases (GHG); this concept will be discussed in more detail in next lectures. At the same time the largest competitor of DuPont, a British chemical giant, ICI (the most important European producer of paints and detergents) worked on an alternative substitute, called HFC (*Hydro-Fluoro Carbons*). They were better, but ICI was at an earlier stage of laboratory research. Therefore the commercial availability of HFCs was a matter of a more distant future.

A struggle between DuPont and ICI made an unexpected turn in 1986. Until then DuPont claimed that freons were safe and indispensable, and fought against any attempts to impose a ban on their production. Signed in 1985, the Vienna Convention for the Protection of the Ozone Layer was a typical toothless agreement. It stated that there was a problem and something should be done. It was very much consistent with DuPont's preaching: "we should care about the stratospheric ozone, but it is premature to ban freons". All of a sudden, the company started to claim that freons destroy the ozone layer, and they need to be banned

immediately. Environmentalists were shocked, but filled with delight that a sinner got converted. They did not realize that in fact, DuPont used an environmental argument in order to win over ICI. The following table summarizes both companies' strategies with respect to HCFCs and HFCs.

Du Pont strategy		
CFC	HCFC	HFC
Keeping a high CFC price as a result of the immediate ban on its production, and supporting it by requiring CFC recovery and destruction	Stimulating irrevocable commitments of as many producers and users as possible, and thus creating *fait accompli*, as well as political support. Extend the period of using HCFCs	Discouraging expectations of early availability of HFC-based technologies
ICI strategy		
CFC	HCFC	HFC
Keeping a low CFC price as a result of postponing the ban on its production, and supporting it by requiring CFC recovery and reuse	Pressing the European Commission to ban HCFCs, making potential investors afraid of such a ban in the future, and thus reducing their number (which will make the ban perspective more credible). Shorten the period of using HCFCs	Vigorous investing in the new technology and hence creating political support for HFCs

Nowadays these very different strategies are referred to in business management courses to explain how environmental protection can be used to promote corporate interests. An additional dimension was added by the fact that DuPont was an important American company, while ICI was an important British company. The former benefited from a close relationship with US administration, and the latter tried to involve the European Commission.

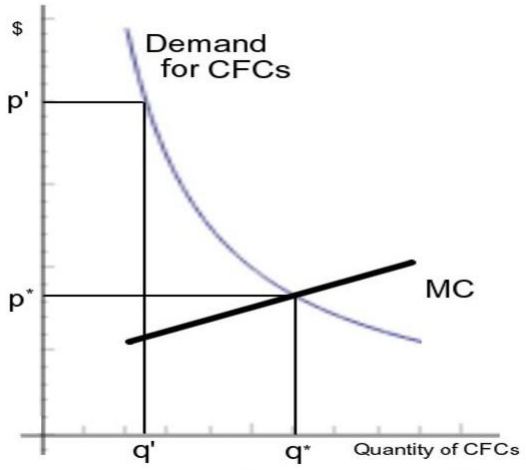
DuPont won. Signed in 1987, the Montreal Protocol (MP) to the Vienna Convention imposes a ban on CFCs, and indicates HCFCs as more ozone-friendly. ICI lost the battle.

It is illuminating to emphasize differences of corporate strategies with respect to CFCs, HCFCs, and HFCs. As a producer of CFCs, DuPont was interested in keeping the price of CFCs as high as possible. A high price of CFCs would also motivate industry to look for an immediately available substitute, i.e. HCFCs. As its only manufacturer, DuPont was ready to produce this substitute. Thus DuPont pressed for a ban on CFC production. But there was a lot of CFCs in the world, for instance, in the pipes of our refrigerators. DuPont's strategy was to recover the chemical by pumping it out from old refrigerators about to be scrapped, and destroying it. As a result, the market supply of CFCs would be low (the supply would come from non-signatories of the MP only, or from developing countries that – perhaps – should be offered some derogations).

On the contrary, the strategy of ICI with respect to CFCs was to postpone the ban, and not to destroy the chemical from scrapped installations; instead, CFCs recovered should be reused somewhere else. By doing this ICI expected to lower the price of CFCs, and thus to lower the pressure for immediate substitution. ICI hoped that after some years they would be ready with

HFCs and – as a result – they would win the market. They tried to lobby the European Commission against HCFCs which – as GHG – are not good substitutes for CFCs.

Apparently, environmentalists who insisted on the immediate ban proved to be convincing, and the European Commission yielded to the United States government who (pressed by DuPont) advocated for the ban. Doing something immediately is often more attractive than waiting for something better but not certain. DuPont turned out to be not only triumphant, but also extremely profitable. By cutting the supply of CFCs rapidly, their price skyrocketed leading to an unbelievable rise in DuPont's profit. The American tax office did what non-socialist governments can do only once every 100 years (socialist governments – e.g. in Poland 1944-1989 – did this over and over again). Namely they imposed a one-time special rate of the Corporate Income Tax, in fact just for one company: DuPont. The tax was called a "wind-fall profit tax". Please look at the graph below (MC stands for the marginal cost of producing CFC) to see why a lower quantity (say, a 60% cut) may lead to a much higher price (especially when the demand is not very elastic).



The argument behind this extra tax was that the lower demand for CFCs (q' instead of q^*) was not a "natural" market process, but it was forced by the government (who signed the MP). Consequently the higher price (p' instead of p^*) was something that the government rather than DuPont should be rewarded for.

The MP was signed very quickly once the Vienna Convention came into force. US was its important signatory (and an aggressive supporter). Here are the most important – and the most novel – provisions of MP:

- Division of the world into two categories (rich and poor countries)
- Shrinking limits of freon consumption
- Extended compliance periods for poor countries
- Per-head-consumption criteria (300 g per annum)
- Trade sanctions
- Transferability of permits

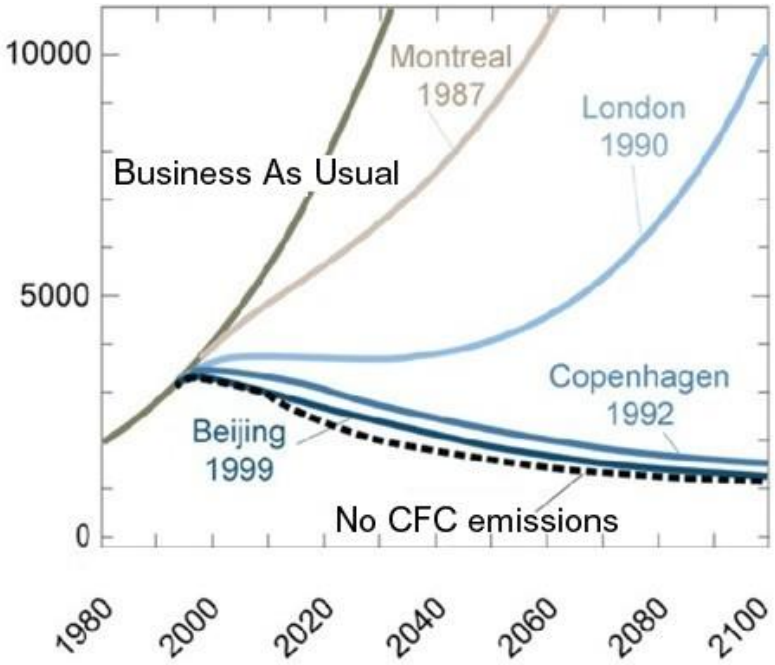
We will analyse all six of them.

The protocol divided the world into two categories: the rich and the poor. As the head of the Polish delegation to a working meeting in 1990, I argued that there were post-communist economies (called "in-transition economies") that could be hardly classified as rich countries. Yet MP did not take this into account, and expected these countries to participate in the agreement as the "rich". It seems to me that only the Russian delegation shared my concern (other Eastern European countries did not participate in the discussion at all). But the Soviet Union was in the civil war at that time, and its delegation did not want to extend the discussion (I got an informal support only; in the plenary meetings they kept low profile). The Indian delegation was so furious that they requested that I withdraw my motion. I realised that the issue was absolutely intolerable for developing countries. My OECD colleagues (from "rich" countries) persuaded me not to raise the issue at plenary meetings. After all, the financial burden for Poland will not be very high, and the Polish economy will receive economic assistance from the West. However, since my request was registered as a formal motion, the Polish government was asked to take formal position on establishing an intermediate category of signatories (neither rich nor poor). At that time Poland applied to be admitted to the OECD (the "rich" country club), so it would be difficult to argue that the country was not that "rich". Nobody wanted to continue the discussion, and the idea died after a couple of months. For better or worse, the MP divided the world into two distinct categories.

The protocol established a ban on CFC production and consumption. The rich countries were to apply it almost immediately, while the poor ones received some derogation periods. Moreover, the rich countries were supposed to pay to a common fund more or less in proportion to their GDP. The poor countries were promised to have their participation in MP financed from the fund. Only so-called incremental costs were to be reimbursed. For instance, if a Brazilian entrepreneur planned to build a plant to manufacture CFC-free refrigerators, then what he (or she) could claim from the fund was not the entire cost of investment, but the incremental one understood as the difference between building a traditional plant (to manufacture refrigerators using CFCs, as before), and building it in a way consistent with MP. These incremental costs turned out to be very small – 60 million USD per year for the entire world in the early 1990s. The Polish fee paid to the fund was around 1 million USD per year; this was not a horrifying amount.

Even the poor countries could not consume freons without any limits. The annual limit for them was 300 g per head. By the way, the Polish consumption was always lower than this (even though Poland was classified as a "rich" country). Shrinking limits for poor countries would lead to some improvement of the predicament, but concentration of CFCs in the atmosphere would keep growing. Amendments adopted in London would stabilise their concentration in the short run, but not in the long run. Subsequent amendments adopted in Copenhagen 1992, and Beijing 1999 established larger reductions in CFC consumption, so that their concentration in the atmosphere – measured in PPB, *Parts Per Billion* (1 molecule per every 1,000,000,000 molecules) – would go down to the level observed in the first half of the 20th century. The graph on page 51 shows several projections of CFC concentration in the atmosphere. The Beijing amendments correspond approximately to what would have happened in the case of no emission.

Even though no such term is used, MP is backed by trade sanctions. Namely the Protocol says that its signatory cannot trade freons with non-signatories. The US was a signatory, and all the developing countries would like to buy freons from the US. This provided very strong incentives to sign it, and a very strong punishment for not signing it. These are clearly trade sanctions. More recent regulations of the *World Trade Organization* (WTO) do not allow environmental treaties to include trade sanctions. MP was adopted much earlier, and nobody objected to such provisions (they did not seem to be tough). The number of ratifications is 197 (all the countries ratified it).



There is one more remarkable feature of MP. Every signatory had a permit to consume certain amount of CFCs (for rich countries the limit was zero sooner than for the poor ones). These permits were transferable (Art. 2.5), but as far as I know, there were no international transfers. The constraints imposed by MP turned out to be much cheaper than anticipated. First of all, a switch to HCFC refrigeration technology proved to be easier than expected; incremental cost proved to be very low. Second, pressurized containers filled with CFCs could be filled with ozone-friendly substances at no extra cost (the substitution turned out to be even cheaper sometimes). Third, in some applications, for instance, in washing micro-chips, soap-based solvents were found to be as effective as freons.

There were few attempts to cheat. Thanks to sophisticated Japanese monitoring equipment it was possible to trace illegal CFC production in China. Illegal production goes on in Africa and Latin America probably too, but the lack of monitoring stations does not let implicate anybody.

As a result of the MP (with amendments), the ozone hole problem was solved. This does not mean that the hole does not exist anymore; it does. Nevertheless there is a trajectory which

leads to the restoration of the ozone layer by the end of the 21st century. In other words, unless something unexpected happens – after almost two hundred years – the ozone layer will resume its mission to protect the earth against excessive UV radiation.

The MP, and the ban of freons resulted in something that can be called "ozone-awareness". Many products contain labels which state "ozone-friendly" or "CFC free" (see picture below). Buyers are informed that there is an ozone-layer, and the product they buy does not destroy it.

The MP is considered the most successful environmental treaty. Indeed it has been quite effective in fixing the stratospheric ozone problem. Yet the issue was an easy one. The abatement turned out to be much cheaper than expected, and rich countries did not protest to finance incremental costs incurred by poor countries. A free-riding problem was solved: a small group of concerned countries won the support of a large group of uninterested countries by a promise to finance the cost of meeting extra requirements. The protocol was probably too quick to promote HCFCs instead of better HFCs, but HCFCs will be eliminated sooner or later anyway (perhaps without DuPont' actions their elimination could have been faster).

For the long run, however, MP set a precedent which – paradoxically – makes other important environmental problems more difficult to address.

The most important contemporary global environmental problem is climate protection. Many people would like to solve it *à la* MP. In other words, let the world be divided into rich and poor, and let the rich pay incremental costs of the poor. If the poor are not interested in participation, the rich will persuade them to join by giving them money. Unfortunately, this

approach does not work. The cost of climate protection is two orders of magnitude higher than in the ozone layer case. Consequently the rich do not want to pay.

Every year over the last two decades there are "discoveries" about how to force the poor to protect the climate: trade sanctions proved effective in the MP, so they can be applied now too. Every now and then academics, journalists or politicians declare that so-called *Border Tax Adjustments* (BTAs) shall be introduced. The idea of BTA is straightforward and quite appealing: if a product comes from a country which did not introduce climate protection measures as we did, then it should be taxed before entering our territory. However, this is precisely a trade sanction – something which contradicts WTO rules. After few days, when the idea turns out to be impossible to implement, its proponents give up for some time; it will be "re-discovered" next year.

Climate protection problems are linked to the MP in yet another way. DuPont's strategy was to promote HCFCs at the expense of HFCs. HSFCs proved to be GHGs which makes the climate protection more difficult now. It can be said that the ozone hole problem was solved at the expense of climate (to some extent).

To summarize the lecture on the ozone layer, it must be said that the MP has been very successful. It stopped CFC emission, and offered a solution to recover the ozone layer by the end of this century. It introduced several precedents which are recommended to be replicated in other international environmental agreements. These are: (1) division of the world into two categories ("rich" and "poor"); (2) international permit trading; (3) the rich pay "incremental costs" of the poor; and (4) trade sanctions. Only (2) can be easily replicated in other treaties; (1), (3), and (4) are difficult if possible at all.

The division of the world into the "rich" and the "poor" is a good idea, but its implementations are problematic. For instance, in the Climate Convention – for historical reasons – South Korea is considered poor, while Bulgaria is considered rich. Much more rational criteria need to be developed in order to implement this classification adequately. In the MP the rich agreed to pay incremental costs incurred by the poor, because these costs were very low. In the case of Climate Convention (and in many other international agreements) these costs can be very high, and a simple reimbursement mechanism is just unrealistic. Trade sanctions are illegal according to WTO regulations. Nevertheless, even if WTO principles could be violated, the idea of BTA is difficult to operationalize. BTAs boil down to a rule that a customs authority imposes a tariff on a product manufactured in a country that did not comply with regulations which exist in the importing country. But modern manufacturing processes are very complex, components may cross borders many times, and therefore it is very difficult to determine what was produced in any specific country.

Questions and answers to lecture 5

5.1 Why was not the ozone hole discovered in the 1960s already (when satellites started to take measurements of the atmosphere)?

Because of a software failure. Computer programs that produce statistical reports routinely delete so-called outliers, i.e. minimum and maximum observations. These numbers deviate from average observations so much, that there is a suspicion that they are simply erroneous. Observations recorded over Antarctica every September were interpreted (by the software) as "outliers" and excluded from further analyses and printouts. It was just that somebody looked at raw data – before the software deletes any observations – and realized that these alleged "outliers" showed up in certain places regularly. In other words, they were not outliers, but they included important information. This incident demonstrates the necessity of looking at raw data, before anybody and any computer program "orders", "refines", "modifies" or otherwise treats them.

5.2 Why is the ozone layer considered a public good?

It satisfies both principles: non-rivalry and non-exclusion. The former is satisfied, because if there is a layer that filters excessive UV radiation, then it works for anybody who is exposed to this radiation – no matter how many people are affected. The latter is satisfied, because it would be impossible to have anybody exposed to unfiltered radiation, if it was filtered by the ozone layer.

5.3 Is the presence of ozone in the environment always beneficial?

No. There are two distinct problems: tropospheric ozone, and stratospheric ozone. The former refers to the presence of ozone where we live. As an aggressive oxidant, it is considered a toxic substance. The latter refers to the ozone which exists at the altitude where nobody lives, and therefore the ozone can do no harm. On the contrary, it reduces the flow of UV radiation which is bad for us. In other words, stratospheric ozone is beneficial, while the tropospheric one is not.

5.4 Suppose that you are a spokesperson for DuPont. What arguments would you refer to (before 1986) in order to downplay damages caused by CFCs, and to fight against a ban on CFCs?

The scientific evidence is not conclusive. Studies that demonstrate alleged damages caused by freons are based on shaky assumptions, and there are serious scientists who question them. At the same time, freons are indispensable for our welfare. Could you envisage our life without refrigerators? Could you envisage our daily hygiene without shaving foams, deodorant sprays etc.? Could you envisage stopping the use of styrofoam and other insulating materials? By the way, the alleged indispensability of using freons was preached by some critics of the Montreal Protocol even in the 1990s.

5.5 Suppose that you are a spokesperson for ICI. What environmental arguments would you refer to if your company wanted to pursue an idea of CFC reuse rather than destruction?

The modern world is sometimes called "the throw-away society". We throw away everything that we do not like. Instead, we should recycle everything. Freons pumped out from old refrigerators make an excellent example of a product which can enjoy "life after life". Instead

of destroying it, we can reuse it. It would be a waste of energy to have freons destroyed, and to have manufactured a new chemical to substitute them.

5.6 How was it possible for the US government to justify a confiscation of extra revenues enjoyed as a result of a cut of production (a tax imposed on DuPont's "wind-fall" profit)?

The argument of the government was straightforward and convincing. It was not the market that reduced the quantity of freons sold, but federal government intervention (signing and ratifying the MP). Consequently, the new (higher) freon price resulted from the government action. If the profit of a firm results from such a non-market development, it is called a "wind-fall" profit (a profit which does not result from any business activity – it comes as if it were brought by the wind). Consequently the extra revenue should go to the government rather than to the firm.

5.7 Do you think a division of the world into two categories: the "rich" and the "poor" is fair? If yes, could you suggest a criterion better than the classification done by the United Nations referring to the 1970s?

I think the distinction between the "poor" and the "rich" is a relevant one. However, it should be justified by a better criterion than who was considered "developed" in the 1970s (according to these criteria South Korea is poor, and Bulgaria is rich). Perhaps a current GDP per capita should be referred to?

5.8 What "teeth" were added by the MP to the Vienna Convention?

The Vienna Convention did not envisage any requirements to reduce the ozone depleting substances (it did not "bite"). The Montreal Protocol introduced limits for everybody (it started to "bite").

5.9 Signed in 1987, MP underwent several amendments. When – for the first time – did signatories reach an agreement leading to a permanent reduction in the atmospheric concentration of CFCs?

Amendments introduced in London (1990) allowed for reducing the concentration of CFCs in the short run only (until 2030-2040; after 2040 CFC concentration would grow again). Deeper cuts, implied by amendments introduced in Copenhagen (1992), allowed for reducing it permanently.

5.10 Why were not the "incremental costs" of abandoning CFC consumption very high?

It turned out that switching to a new technology of refrigeration did require some extra costs which were rather low. In the case of propellants in sprays, it turned out that CFCs could be substituted with something else at no cost (sometimes the substitution allowed even to save on costs). In the case of washing microchips, it turned out that other solvents (including common soap) could do the job. All in all, substitution to the CFC-free technology was found to be cheaper than expected.

5.11 What makes the success of the MP difficult to replicate in other international environmental agreements?

Other environmental agreements imply much higher abatement costs. Countries hesitate to overcome effects of free-riding if they have to pay for free-riders. They did not hesitate to proceed with MP, because the global abatement cost was relatively small. Thus the "rich" did not object to paying incremental costs incurred by the "poor".

5.12 Suppose that you are a customs officer in a country that established BTA. What information would you request in order to decide what tariff to apply for a given imported good?

The idea of BTA (*Border Tax Adjustment*) is to tax imported products according to the rate that would be applied to a domestically manufactured product. A customs officer has to establish an appropriate tariff to be imposed on an imported product. He (or she) has to determine where the product comes from. If it comes from a country which has identical regulations as we do, then BTA is zero. Let us assume that we live in a country that taxes a given product at the rate of, say, 30%. Its imported substitute comes from a country where the same product is taxed at the rate of, say, 12%. Then BTA is to add an extra 18%. However, let us assume now that 40% of the value of the product comes from a country where the tax rate was 10%, and 60% from where the rate was 20%. Hence the average tax can be considered 16%. In order to "increase" this rate to 30%, the BTA should add an extra 14%. In order to determine an appropriate BTA, you should know what part of the value comes from what country, and what were the tax rates applied in these countries. Of course, a customs officer cannot be expected to have this knowledge. He (or she) must have a table with tax rates applied in respective countries to groups of products of interest. But the problem is more complex. Contemporary manufacturing processes imply massive intra-sectoral trading (products or their parts cross borders several times before being sold to the final customer). Determining what part of the value comes from where requires extensive knowledge of accounting. But even if you have such a knowledge, some trades take place within the same firm (a subsidiary located in country X trades with another subsidiary of the same firm located in country Y). The prices indicated in official accounting can be arbitrary (this is called "transfer pricing", and it represents an unsolved problem). Hence reports on what part of the value originates from where (whether in country X or Y) are difficult to verify. An exporter can manipulate with "transfer pricing" to demonstrate that a major part of the value comes from a country where the tax rate is high, and thus BTA should be small. Is it practical to expect that a customs officer has appropriate information (in particular: whether "transfer prices" were fair or manipulated) in order to calculate BTA?

6. Climate as a public good

Climate is one of the best examples of public goods. Let me recall two principles that define a public good (Baltic Sea was analysed by us as an example of such a good). The non-rivalry principle states that if a unit of such a good is used by somebody, then the same unit can be

used by somebody else without interfering with the first user. In other words, the number of users does not count. The non-exclusion principle states that once the good was supplied then nobody can be easily excluded from using it.

Let us look at consequences of these two principles. The more users of the good, the better, since there are more beneficiaries. At the same time, the supply of the good should be financed by somebody. Nobody wants to volunteer for two alternative reasons (sometimes both reasons are combined). I do not want to finance the supply of a good, if I know, that the good can be used not only by me, but also by somebody else who did not finance it. Alternatively, I do not want to finance the supply, because I expect that it will be financed by somebody else, and I will be able to benefit from it for free (the non-exclusion principle guarantees that I cannot be excluded). This type of behaviour (a typical outcome of public goods' characteristics) is called in economics *free riding*. It results in undersupply of the good, that is in the supply lower than economically (and thus socially) justified.

In international context the problem can be formalized in the following way. If the difference between total benefits provided by the good and the cost of its supply is to be maximized, the following Samuelson (cooperative) criterion should be satisfied:

$$MC_i = \Sigma_i\, MB_i,$$

where:

- MC_i – the marginal cost of delivering the good incurred in country *i*,
- MB_i – the marginal benefit from delivering the good for country *i*, and
- summation extends over all the countries (which use the good).

To see why the Samuelson criterion maximises the sum of net benefits (TB-TC, i.e. total benefits minus total costs) let us find the partial derivative of this expression with respect to q_i, that is the level of activity undertaken by country *i* (B and C stand for benefit and cost, respectively, and T stands for "total"):

$$\partial(TB\text{-}TC)/\partial q_i = \partial(\sum_i B_i - \sum_i C_i)/\partial q_i = \partial\sum_i B_i/\partial q_i - \partial\sum_i C_i/\partial q_i = \sum_i \partial B_i/\partial q_i - \partial C_i/\partial q_i = \Sigma_i\, MB_i - MC_i$$

(while benefits in other countries may depend on what the country *i* does, their costs do not: $\partial C_j/\partial q_i = 0$ for $j \neq i$). This partial derivative is equal to 0, when $MC_i = \Sigma_i\, MB_i$ indeed.

Yet when countries take decisions to what extent the supply of the good should be financed, they usually comply with the following Nash (non-cooperative) criterion:

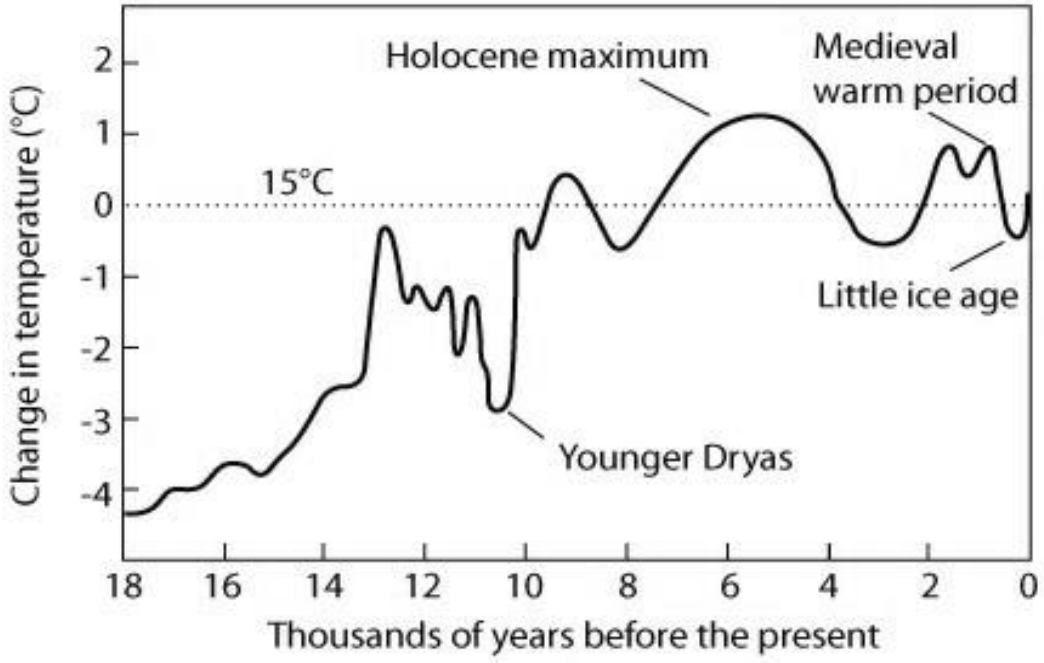
$$MC_i = MB_i.$$

In other words, instead of financing the good up to the point which is justified by benefits enjoyed by all the users, they finance it only up to the point which is justified by benefits enjoyed by themselves (i.e. disregarding other users).

Climate protection complies with the two principles defining a public good. Because of the non-rivalry principle, benefits can be enjoyed by an arbitrary number of users (countries, firms, or consumers). At the same time – as a result of the non-exclusion principle – nobody wants to undertake its protection up to the economically justified level. Many users expect that protection will be carried out by somebody else, and those who did not do anything will not be excluded from the group of beneficiaries.

One thing has to be clarified. Climate protection is understood here as "mitigation" of climate change. But climate change may force to take certain rescue actions, like planting trees in order to enhance shadowed areas, improving irrigation systems in agriculture to counteract droughts, instructing the elderly to stay home if is too hot outside, and so on. These actions – called "adaptation" measures – can be taken at an individual country level effectively. The public good aspect of climate protection refers to "mitigation", not to "adaptation".

Before we proceed with further economic analyses of climate protection (mitigation measures), a look at history would be illuminating. The following graph shows changes in the global temperature over the last 18,000 years. The temperature changed significantly. Yet it is not the amplitude of the most recent change, but rather its unprecedented pace which is a matter of concerns. The next picture (on page 59) shows the visible growing trend of the temperature since the late 19th century. There are some ups and downs, but overall the temperature increases.

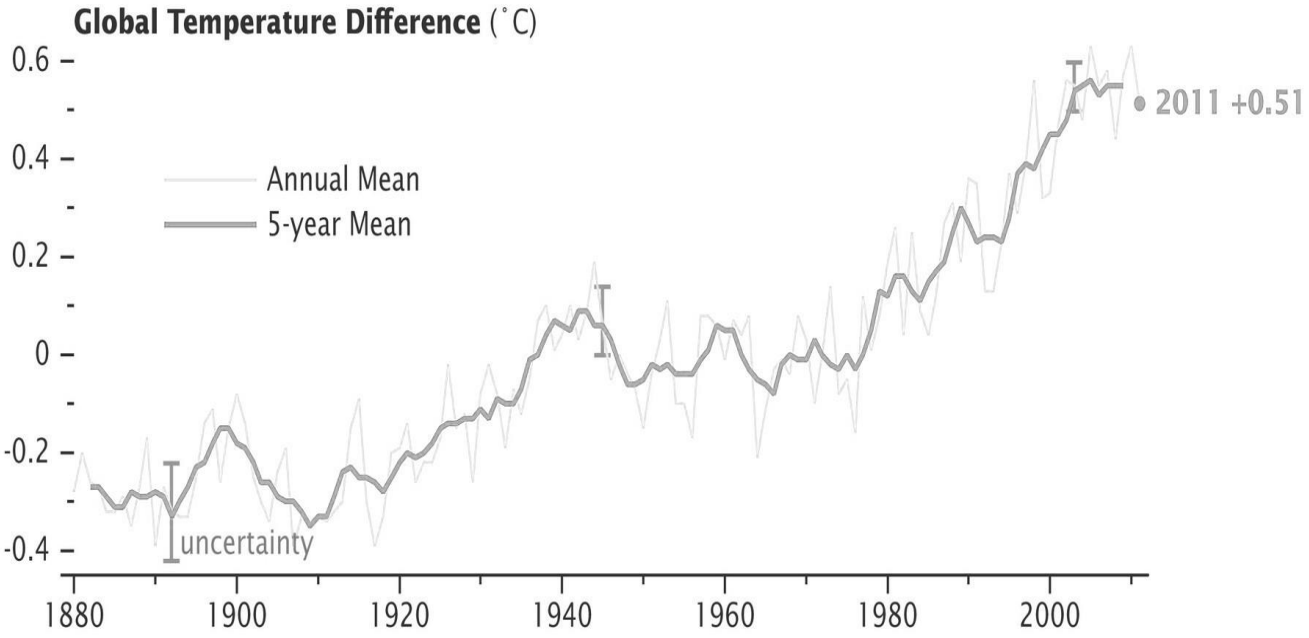


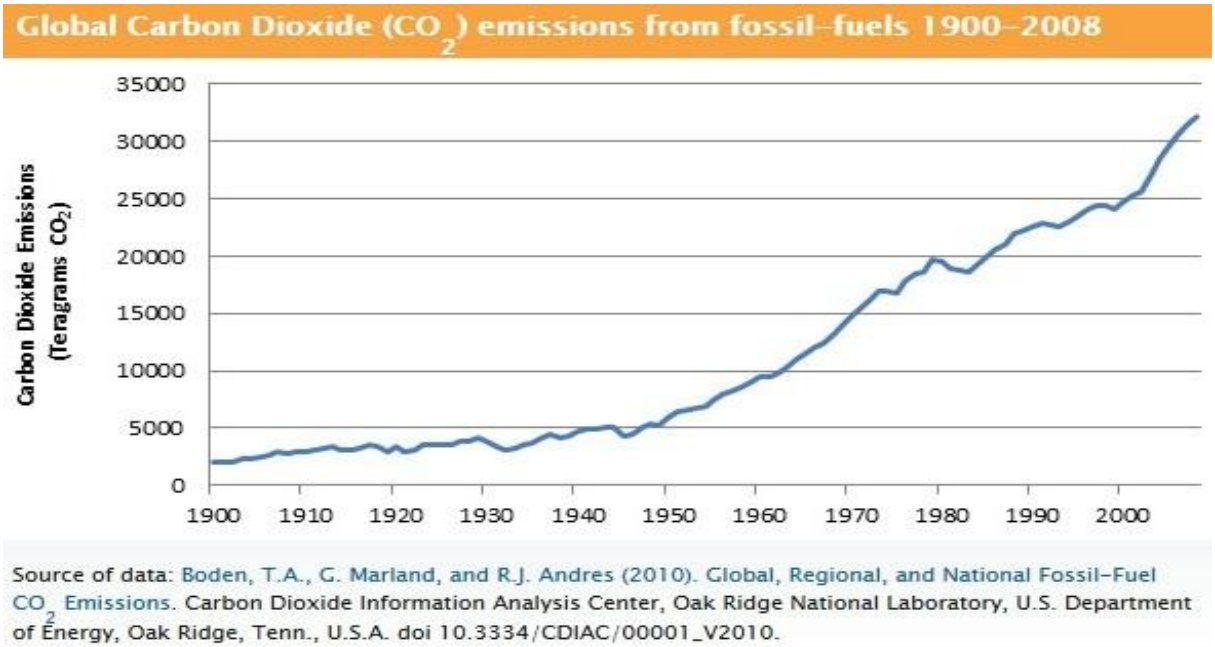
Carbon dioxide emission has been identified as the main driver of this trend. Its emission from fossil fuel combustion (the main source of the gas) is graphed on page 59 (lower picture). Carbon dioxide is considered a "trace gas" in the atmosphere. Its content is very small. The concentration is measured in PPM (*Parts Per Million*, 1 molecule per 1,000,000 molecules). Once emitted, carbon dioxide stays in the atmosphere many years. Its concentration – estimated at 280 PPM in the 19th century – exceeded 400 PPM in 2014.

In 2004 China surpassed the United States as the world largest carbon dioxide emitter. Please note (see the lower picture on page 60) that US, EU, and Japan emit less than they used to in the past. The growth comes from the rest of the world.

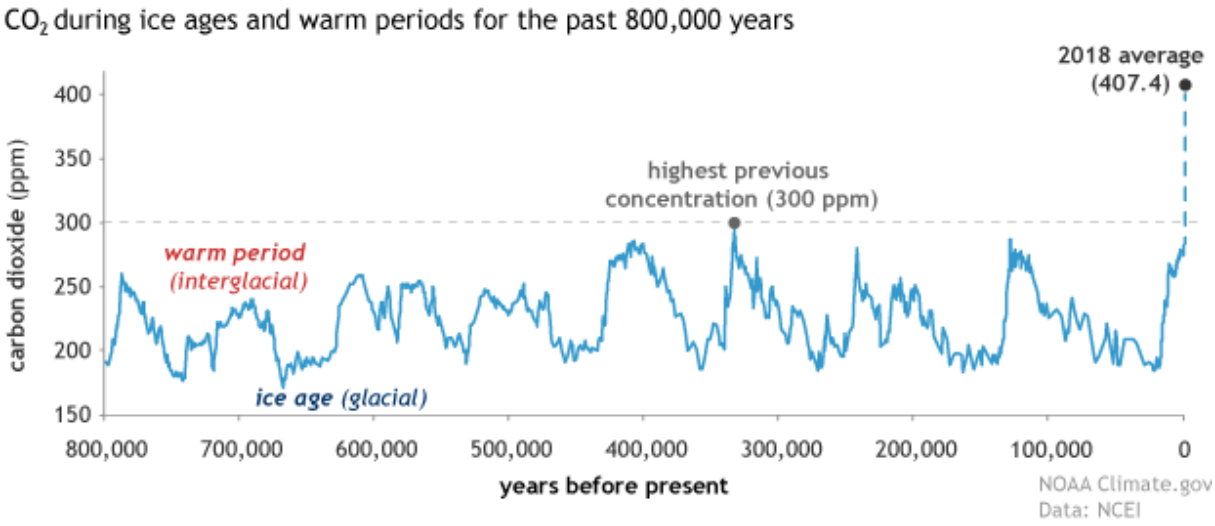
In addition to carbon dioxide, there are several other trace gases – e.g. methane, HCFCs, and others – that are considered "greenhouse gases" (GHG). The name is due to the fact that for many years their "warming" potential has been utilized in greenhouses. If you grow plants in

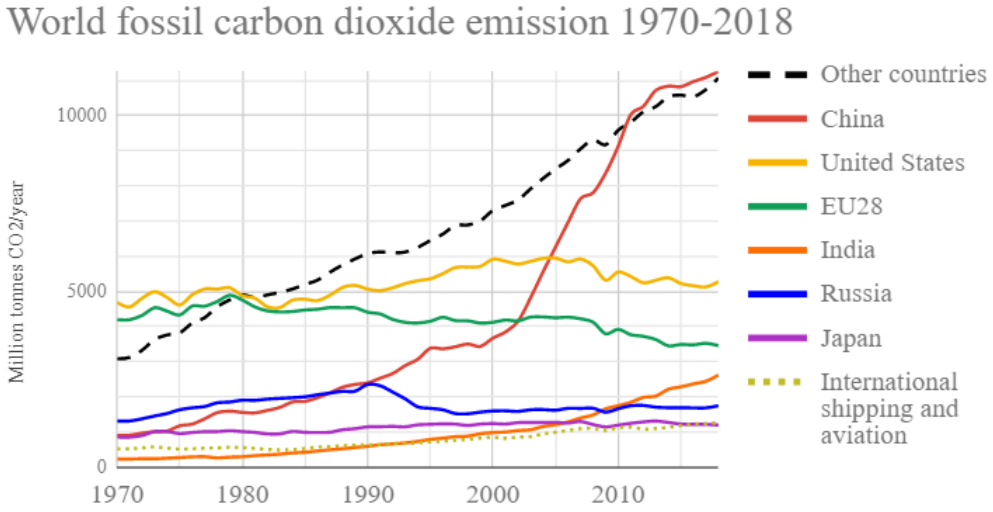
a small area, you may protect them with a transparent cover, so that photosynthesis takes place during the day. During the night, when plants breathe, they emit carbon dioxide which makes the air inside the greenhouse somewhat different from what can be found outside. Incoming solar energy is hidden in ultraviolet (UV) radiation to some extent. The outgoing energy makes larger use of infrared (IR) radiation. Carbon dioxide – like other gases identified as GHG – is more transparent for UV than for IR. As a result, more solar energy is let in than it is let out. Consequently the temperature must go up.





According to climatologists, this "greenhouse effect" is responsible for the temperature rise. This is not just a coincidence that global carbon dioxide emission resembles the trajectory of average global temperature rise. Please note however, that graphs shown above cannot be compared directly, because they refer to different time scales.

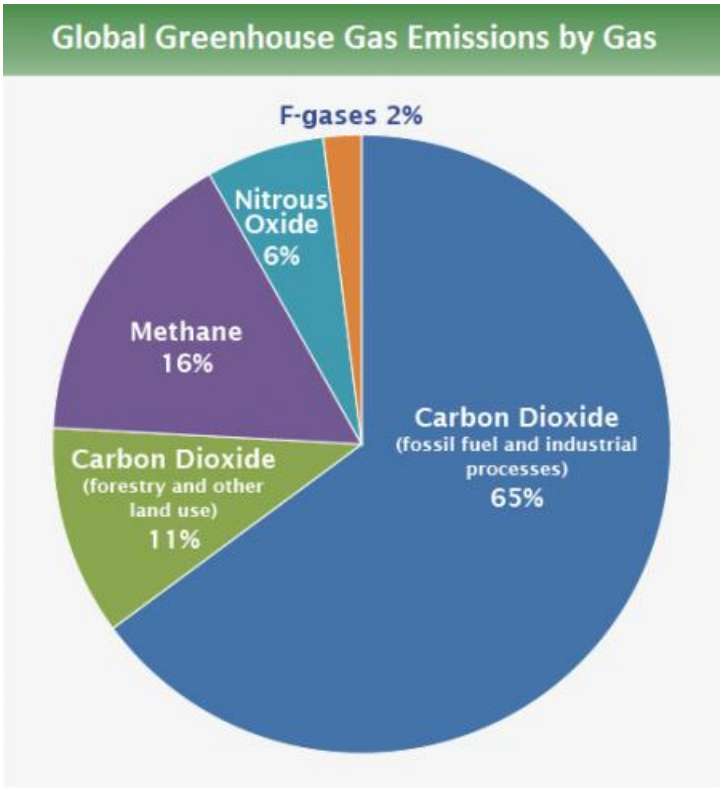


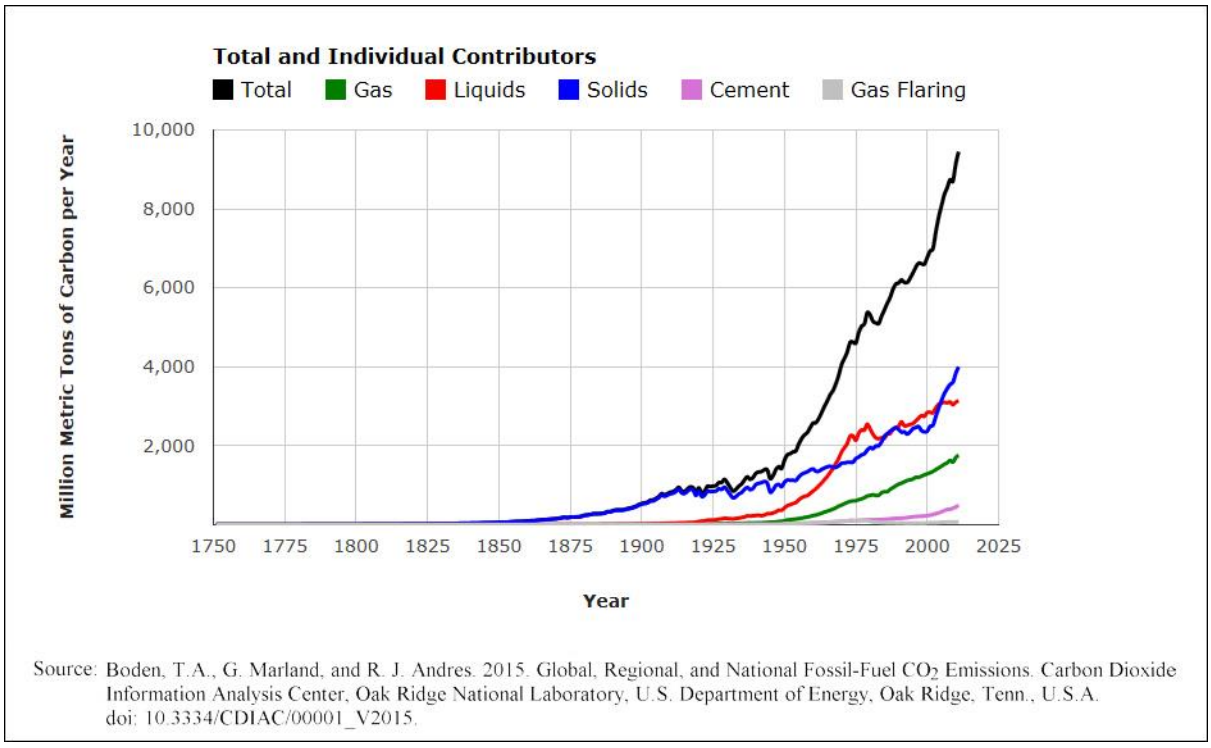


Carbon dioxide is the most important GHG, but it is not the only one. The other GHG include Methane, Nitrous Oxide (N_20; so-called "laughing gas"), and F-gases (including freons and their substitutes). The aggregation of GHG is typically done not on a simple weight basis (adding tonnes), but taking into account their Global Warming Potential (GWP). The latter is somehow arbitrary. Physical characteristics based on "transparency" for UV and IR is obviously a non-arbitrary feature. However, in addition to "transparency", GWP depends on the residence time in atmosphere. Once emitted, GHGs can reside in the atmosphere many years, and their decomposition may depend on a number of circumstances that are not entirely clear. The 16% contribution of methane reflects the fact that its GWP is many times larger than in the case of carbon dioxide; even though in terms of weight, methane emission corresponds to a tiny fraction of carbon dioxide. Methane is emitted mostly from agriculture. In Europe it comes from cows mostly. Elsewhere, for instance in Asia, it comes mostly from rice cultivation. Carbon dioxide contributes 76% to the total GHG emission. This includes forest fires, and other emissions caused by land use changes. Methane is the second most important GHG.

Until mid-20th century, burning coal was the main source of carbon dioxide emission. In the 1960s coal was overtaken by oil. The third most important source of carbon dioxide emission

is natural gas. Emissions originate also from some manufacturing processes – mainly in cement industry – but this is their minor source (like "gas flaring" – a safety feature practised by refineries).



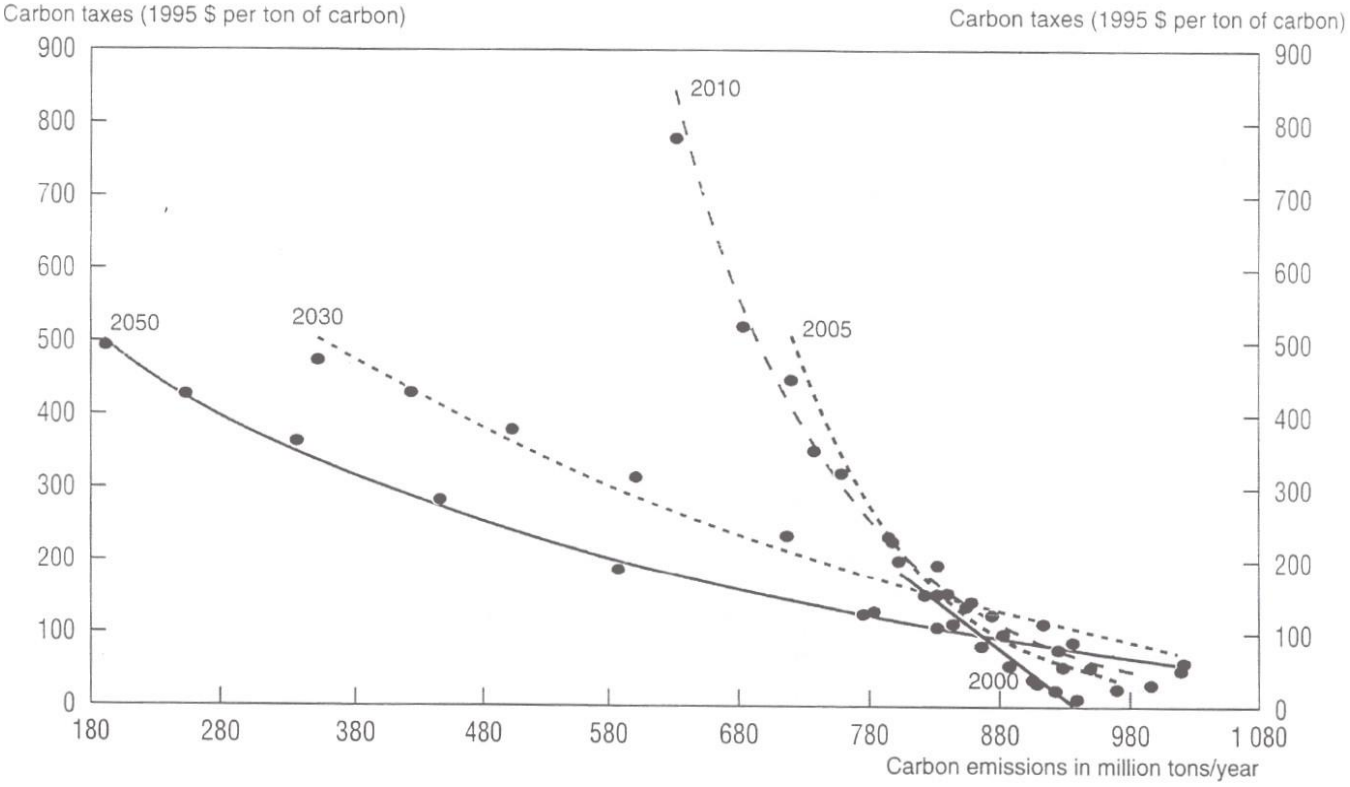


Please note that carbon dioxide emission is typically measured in tonnes of carbon dioxide. Based on the mass number, one can observe that a molecule of carbon dioxide is 44/12 times

heavier than a carbon molecule (mass number of carbon is 12, and the mass number of carbon dioxide is 12+2*16=44). The emission can be also measured in tonnes of carbon; the carbon dioxide emission has to be divided into 44/12 (or multiplied by 0.27) in order to arrive at tonnes of carbon. Thus in the graph above, the total of approximately 9.5 billion tonnes of carbon (around the 2015) corresponds to 35 billion tonnes of carbon dioxide. Now it is more than 40 billion tonnes.

To the extent that climate change implies the temperature rise, some people may not be very concerned about it. Especially if you live in Siberia or Northern Canada, temperature growth of several degrees Celsius does not have to be considered detrimental. Nevertheless the average temperature observed in Africa is rather high even now; its growth will ruin agriculture, disturb biodiversity, and may affect human health adversely. On top of that there is the sea level rise. Many people associate it with glacier melting, but in fact it is triggered mainly by the volume growth of water caused by the increased temperature of ocean. In addition, the higher frequency of extreme weather events, such as heat waves, floods, torrential rains, droughts, and tornadoes is predicted. It is estimated that economic losses caused by the climate change are much higher than mitigation costs. But – given the public good nature of climate protection – this fact does not imply that countries will undertake this protection up to a justified level.

Carbon abatement cost in EU-15

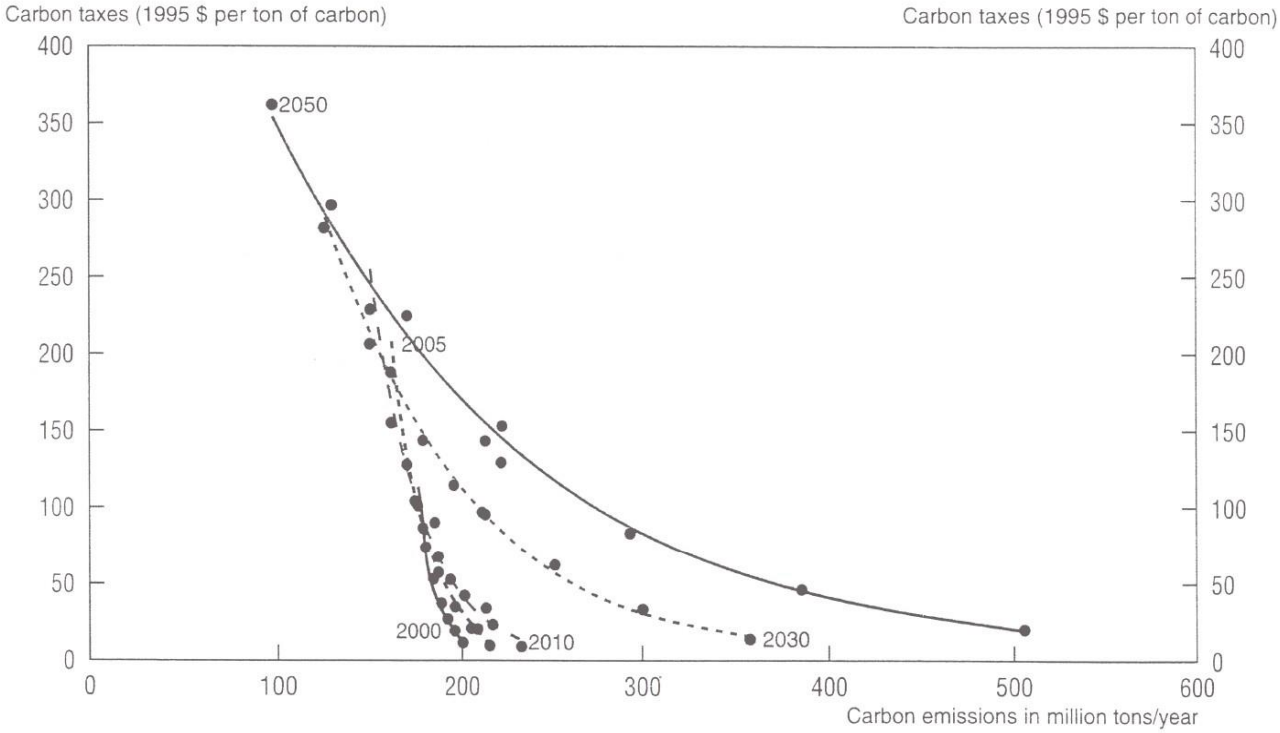


The two graphs (on page 62 and 63) illustrate the situation in Europe. EU-15 stands for the member states of the European Union before 2004 (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom). Eastern Europe is understood as Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic, and Slovenia.

Graphs illustrate abatement cost curves. Please note that vertical axes reflect abatement cost of one tonne of carbon (i.e. abatement cost of 3,667 kg of carbon dioxide). It description says "carbon taxes"; this is a short-cut. If you establish a carbon tax of, say, 100 $/tonne, then a rational emitter will reduce the emission if the cost of the reduction is below 100 $/tonne, and it will not reduce it if the cost is over 100 $/tonne (it would be cheaper than to emit and to pay the tax). Therefore contemplating a tax of *x*$/tonne is equivalent to asking the question how many tonnes of carbon can be abated if the cost of abatement is up to *x*$/tonne.

The horizontal axis measures the emission. If there is no carbon tax in EU-15, that is if there is no abatement forced in this way, the emission is around 1 billion tonnes of C (i.e. around 3.667 billion tonnes of CO_2). If a tax is introduced, emitters are going to abate. But there are several abatement cost curves, each associated with a year: 2000, 2005, 2010, 2030, and 2050. As a rule the earlier the year, the steeper the curve. They correspond to technologies available in a given year. It is expected that reducing emission to, say, 600 million tonnes of C implies the abatement cost of 800 $/tonne in 2010, but only 200 $/tonne in 2050. It means that abatement in the future will be cheaper than it is now. According to the graph, abatement cost implied by a very deep reduction – down to 200 million tonnes – implies the cost of 500 $/tonne in 2050. Given technologies available, the same reduction would be impossible at all earlier.

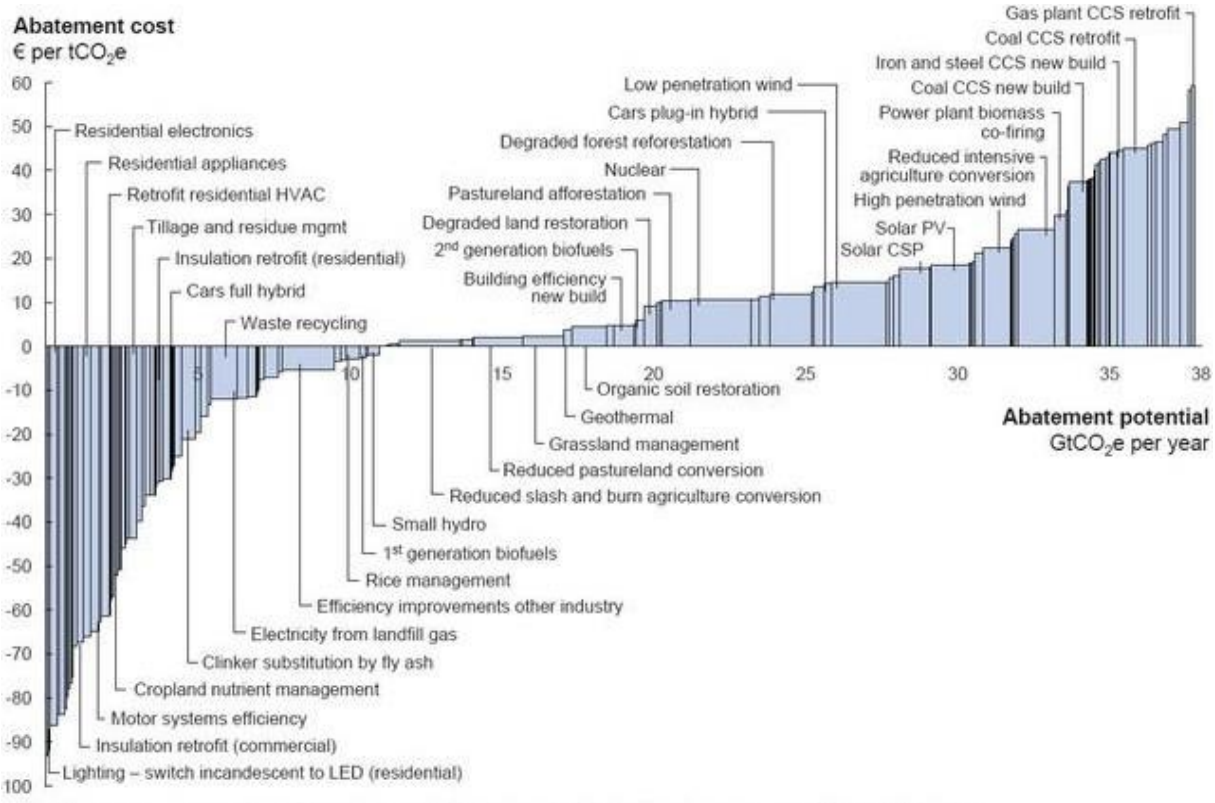
Carbon abatement cost in Eastern Europe



A similar graph was compiled for Eastern Europe. The axes measure the same. Please observe two things: firstly, the emission in Eastern Europe is lower than in EU-15; secondly, abatement costs are lower too. For instance, without any carbon taxes, the emission is envisaged at the level of 350 million tonnes in 2030. In order to reduce the emission by 50% (in 2030), a tax of 200 $/tonne should be imposed.

The two graphs combined demonstrate that abatement costs in the West are much higher than in the East. If the total cost of abatement is to be minimized, Eastern Europe should reduce more emissions than Western Europe. Is this fair? For many people this would be an unfair conclusion. It would be fair, if the West participated in abatement in the East. Can this be arranged? The answer is yes, and it can be accomplished by emission trading (in the graphs on pages 62 and 63 there are no subsidies taken into account). The European emission trading will be discussed in the lecture on the Kyoto Protocol. In this lecture I would like to analyse fairness in the global context. But before this analysis, let us look at the famous "McKinsey steps".

McKinsey is a large multinational consulting firm, who calculated carbon dioxide abatement cost for a number of technologies, such as "tillage and residue management", "pastureland afforestation", "power plant biomass co-firing", and "CCS" (*Carbon Capture and Storage*). The height of a step is the cost of removing a GHG (not necessarily carbon dioxide), measured in €/t CO_2e. CO_2e – carbon-dioxide equivalent – is the unit applied in GHG analyses, as explained on page 60. The width of a step corresponds to the mass of CO_2e abated through a given technology. The graph suggests that if we wanted to get rid of the entire emission of GHG estimated at 38 billion tonnes of CO_2 equivalents, the most expensive options would require to apply measures with the abatement cost of 60 €/t CO_2e. More remarkable is that – according to McKinsey – 11 billion tonnes can be abated at no cost; even at a profit.



Let us take, for instance, "pastureland afforestation" This means taking pastureland (which in many cases serves to produce beef) and planting trees instead. Young growing trees will sequestrate carbon from the atmosphere thus providing "negative" emission of CO_2. The width of the step corresponds to 1 billion tonnes, and its height to 10 €/t. Consequently the

graph suggests that by converting some pastureland to forests the world can decrease the annual emission of carbon dioxide by 1 billion tonnes at the cost of 10 €/t.

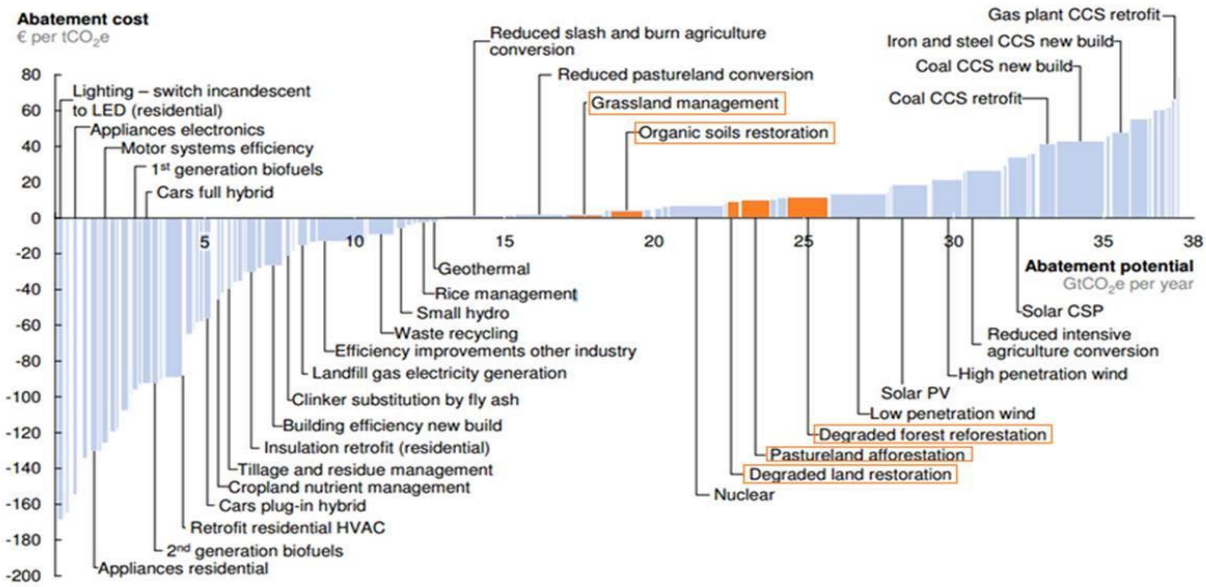
Another step is called "coal CCS retrofit". Its width is somewhat lower, and it height is higher – almost 40 €/t. CCS is an example of an absurd technology. As noted earlier, burning 1 tonne of carbon leads to emitting 3.667 tonnes of carbon dioxide. As a gas, it has a volume which is gigantic. Nevertheless, if pressurized or if cooled down to a very low temperature, it can be liquefied and transported e.g. by rail. When the European Parliament voted for the so-called CCS-ready Directive (2009/31/EC) in 2009, one deputy praised its beauty by saying that if there was a train transporting coal from a coal mine to a power plant, then it used to go back to the mine empty. With the Directive, it will transport carbon dioxide back to the mine to inject it to the underground space emptied by the coal extraction. Nobody objected, even though this was a pure nonsense. First, in order to transport liquefied carbon dioxide, you need four times the number of trains used to transport the coal. Second, the geological structure of emptied coal mines does not allow to have the liquefied carbon dioxide to be stored there. Despite this, CCS still is contemplated by some "experts" who call for spending budgetary money to finance more research on this absurd technology. A couple of years ago the Norwegian government stopped wasting the taxpayer money for this purpose, and environmental NGOs admitted that this technology should not be considered as a mitigation measure. By the way, if "coal CCS retrofit" was ever to be applied, its cost would have been much higher than 40 €/t suggested by McKinsey.

McKinsey steps need to be looked at with caution. Problems with identifying mitigation measures and their cost is one matter of concern. Another concern is the widths of individual steps. By analysing a technology, the consultant assumes that nothing will change in the economy. Thus it ignores the so-called rebound effect. The latter was introduced to economic analysis by Stanley Jevons, an English author who looked at the coal question in the middle of the 19th century. At that time many people lamented that the improved efficiency of a steam engine would decrease the demand for coal. He observed that – on the contrary – it would increase the attractiveness of a steam engine to such an extent, that the demand for coal would grow significantly. And he was right. Rebound effect shows up over and over again. For instance – in the 21st century – improved fuel efficiency of cars results in the increased attractiveness of car travel so that transport emissions grow. This is sometimes called "green paradox", because one would expect that if every car emits less, then the total emission should be lower as well. The rebound effect demonstrates that this does not have to happen.

As a result of criticism, McKinsey is much more cautious now, and publishes "steps" with annotations. Please note the statement on page 66: "It is not a forecast of what role different abatement measures and technologies will play". This is an indirect acknowledgement of the fact that a reliable forecast calls for what economists refer to as "general equilibrium" models (models that look at complex indirect consequences of changing prices; something McKinsey steps are not based on).

But the most puzzling part of McKinsey steps is their left-side part, i.e. the part which suggests that some abatement (up to 11-12 billion tonnes of CO_2e on page 64, and more on page 66) can be accomplished by commercially viable measures. Firms and consumers who do not take advantage of these measures are simply not rational and they lose money. Of course this may occur sometimes, but economists are cautious whenever they face an explanation: "people are stupid". If there is identified a not applied opportunity whose cost is negative theoretically, i.e. which should have been applied spontaneously, then there are

probably some hidden costs. For instance, in the graph printed there is a step called "Waste recycling" that – according to McKinsey – can abate 1 billion tonnes of carbon dioxide and – at the same time – benefit users with 10 € per each tonne removed. An excellent business! Why do not people do it? One explanation is that they do not do it, because they are stupid. Economists should not resolve questions by stating that people are stupid. Perhaps they are, but – more likely – there are some additional obstacles to applying this apparently profitable measure.



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €80 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: Global GHG Abatement Cost Curve v2.1

In the case of "waste recycling" the profit comes from avoiding the cost of managing the waste in a traditional way. At the same time, recycling requires certain infrastructure which is not free, and its cost should be taken into account. McKinsey's critics suspect that this has been underestimated.

Another example of what McKinsey steps may mislead about is "Retrofit residential HVAC". The acronym stands for Heat, Ventilation, Air Conditioning. In other words, the technology is about improving the existing buildings with better thermal insulation and heating/cooling systems. The steps assume that the benefit of this measure is about 90 € per tonne of carbon dioxide emitted (see page 66; the savings estimated on page 64 are lower). Indeed, this is what you could gain if you retrofitted your house. The problem is that many people (including our class participants) do not live in their own houses; they rent apartments. Let us assume that the owner of an apartment – which was rented at the price 1000 € per month – did apply the technology. In order to recoup the cost he (or she) has to increase the rent to, say, 1050 € per month. The tenant will be better off, if prospective electricity savings are, say, 100 € per month. Yet the problem is that when we rent an apartment we look at rental prices first. Maintenance cost is relevant too, but – as empirical observations demonstrate – a rent higher by 50 € is not counterbalanced by 100 € in expected savings on electricity bills. Perhaps obligatory energy audits accompanying all rental transactions could help, but for the time being "Retrofit residential HVAC" is not utilised to the extent envisaged by the steps.

The bottom line of these analyses is that climate protection requires global GHG abatement, and this is costly. Another conclusion is that countries have different costs of this abatement. If the cost of the global effort is to be minimized, then more should be done where it is cheaper, and less – where it is more expensive. But due to the public good aspect, how can countries be motivated to do more than what is motivated by their own benefits? In other words, how to motivate them to move from the Nash criterion to the Samuelson criterion? And, finally, how to make the arrangement fair (something we encountered in the European East-West context on pages 62-63). As promised, we will look now at how such a fair solution could be constructed.

Let i=1, 2, 3, …, k denote a country (we can think of k as 197 – the number of UN countries). And let x_i be the emission of carbon dioxide from the ith country. The present global sum of carbon dioxide emissions is: $x_1+...+x_k$ = 48 billion tonnes (roughly). At the same time, the number of people in the world is approximately 8 billion (we take these numbers to allow for easy arithmetic calculations). This implies an allowance of 6 tonnes per person per year. If we multiply 6 by the number of people we will get the total CO_2 emission. This suggests the following allocation principle for countries: $x_i=6L_i$, where L_i is the population of the ith country. What would be consequences of such an allocation of emission permits?

- European Union and the United States would be left with allocations much below their current emissions,
- China – somewhat more than the level of current emissions,
- Other developing countries – much above.

Tradability of permits would then imply a flow of wealth in a direction that is consistent with popular equity convictions. In order to keep their emissions at the historical level, EU and USA would have to buy extra permits from developing countries (which emit much less per capita).

In order to decrease the global emission (which is necessary from the point of view of climate protection), in the future, the allocation principle $x_i=6L_i$ can be gradually decreased, to, say, $x_i=5L_i$, $x_i=4L_i$, and so on. This is the simplest possible allocation principle which takes into account fairness. Poor countries could be given even more generous allocations, because they do not have technologies available elsewhere. Yet, wealthy countries are not ready to accept it. They suggest that distributing carbon dioxide permits should be in proportion to GDP (or some other index of well-being). This would leave the EU and the US with a much higher allocation than under the previous scheme, and – consequently – with the necessity of much lower payments to developing countries.

Prospects for solving the climate change problem are not optimistic at all.

Questions and answers to lecture 6

6.1 Why is the carbon dioxide called a GHG?

The name "Greenhouse Gas" (GHG) comes from the fact, that for many centuries, gardeners increased the temperature over flower beds covered by transparent roofs just by increasing the concentration of carbon dioxide (i.e. without heating). They managed to do this, since they captured the carbon dioxide released by plants when they breathe (in the absence of roofs and

walls the carbon dioxide escapes from the garden and mixes in the atmosphere). All gases that can increase the temperature are called "Greenhouse Gases". Carbon dioxide (like methane – emitted in agricultural production, among other things) is one of them.

6.2 What makes the climate protection an economic public good problem?

In the case of climate protection the two principles defining public goods hold. The non-rivalry says that no matter how many beneficiaries we have, the same "service" can be enjoyed by everybody. Therefore no matter whether we have one country or many countries, benefits can be enjoyed by all of them simultaneously. The non-exclusion says that irrespective of the fact whether a country did or did not contribute to the protection, it cannot be excluded from whatever happens with the global climate.

6.3 What does the free-riding mechanism imply for mitigation?

Free riding implies the lack of sufficient incentives for mitigation up to the socially desirable level. If a country contemplates whether to do something to protect the global climate, it is discouraged from doing enough for two reasons: (1) the country may not wish to have others (in particular those who did not do anything) benefit from its action (the non-rivalry principle says that others will benefit too); and/or (2) the country may expect that somebody else will mitigate, and then benefits can be enjoyed by everybody else for free (the non-exclusion principle says that nobody can be excluded).

6.4 Does the free-riding problem affect adaptation?

No. Adaptation is to be carried out by individual countries for themselves. Once again, let us remind that there are two distinct categories of activities in the area of climate change: (1) to abate carbon dioxide and other GHGs; and (2) to adapt to whatever changes the climate undergoes. (1) is called "mitigation", and (2) is called "adaptation". Both are important, and – to some extent – they are undertaken by countries. While every country benefits from its adaptation measures individually, mitigation measures are plagued by the free-riding, as explained in 6.3 above.

6.5 Over the last million years or so the atmospheric concentration of carbon dioxide changed widely. Why are people so concerned about its recent rise?

Even though the concentration fluctuated indeed, the recent change is unprecedented for two reasons. (1) The concentration is much higher than before (more than 400 PPM; earlier it used to be always below 300 PPM); and (2) it proceeds at a much higher pace than any time in the past.

6.6. Great Britain was the largest CO_2 emitter in the 19th century. China did not emit much at that time. When you look at the graphs on pages 59-61, what do you think of taking cumulative emission (emission cumulated over the last 100-200 years) as a measure of a country's impact on global climate?

GHGs stay in the atmosphere for many years. That is why climate change depends not only on the present emission, but on the past emission as well. If you look at the graphs referred to in the question, you see that the 19th century emission was very small compared to what we have now. Consequently emission summed over the last 100-200 years is dominated by what

countries emit now. Hence Great Britain's contribution is smaller than that of China. Approximate estimates for the cumulative emissions (there are no precise records) indicate that North America, Europe, and China each are responsible for 16%-17% of the total. In other words, these three regions jointly have made roughly 50% of the total.

6.7 Graphs on pages 62-63 (or IEC-6-13 and IEC-6-14 in my overheads) suggest that if no abatement is undertaken (there is no carbon tax) the emission of carbon dioxide tends to grow (in EU-15 from below 1 billion tonnes to more than 1 billion tonnes, and in Eastern Europe from 200 million tonnes to 500 million tonnes). Why?

Over the next couple of decades, in Western Europe emission is projected to increase sligthly, and in Eastern Europe – dramatically. The reason is not only the ineffectiveness of policy measures (especially in the absence of carbon taxes), but economic development in Europe. Western European economies are much better developed than Eastern European ones. Most of their industrialization was carried out earlier. Now they develop more by investing in services, and other less polluting sectors. The result is that emission in Western Europe is much higher than in Eastern Europe. But Eastern Europe wants to "catch-up", and replicate the Western European economic structure. Therefore it wants to invest in industry (and other highly polluting sectors) like Western Europe did earlier. Consequently carbon dioxide emission from Eastern Europe is likely to grow much faster than in Western Europe now. Carbon taxes may change the trends, but my question asked what is likely to happen in their absence.

6.8 McKinsey steps illustrated on pages 64 and 66 (or in IEC-6-15 and IEC-6-16 in my overheads) look somewhat inconsistent. For instance "building efficiency new build" is considered either costly (5 €/tonne of CO_2 abated), or (later) profitable (-25 €/tonne of CO_2 abated). Why?

I do not know, but I suspect is that this is because of the technological progress. My question is about the specific "step" called "building efficiency new build". I suspect that a transition from being costly to being profitable is caused by technological progress in construction and the availability of insulation materials. What was difficult, say, five years ago, is much easier now. For instance, in Poland there is a legal requirement that windows must be characterized by so-called U=1.3 W/m^2K, or less. This means that every square meter of a window cannot lose more than 1.3 W of heat if the difference between inside and outside temperature is 1^oK (or Celsius). Windows which complied with this standard were expensive a couple of years ago. Now, they are cheaper. At the same time the price of energy increased. As a result, the savings on energy are higher now than they used to be, which – perhaps – makes energy conservation more attractive.

6.9 Do you think that CO_2 allowances for countries should be based on a per capita basis, or perhaps on the basis of some welfare considerations? For instance, societies enjoying a higher level of welfare should be given more permits.

I think they should be based on a per capita foundation which seems to me fair: every country has the permit proportional to its population. As a rule, if a country has a higher GDP per capita then it is wealthier and it should be expected to contribute financially more. And so it does under the hypothetical regime based on per capita allocation (not based on GDP per capita). To see this, please consider two countries: a poor one with 15 million people, and a rich one with 15 million people. They get the same limit of CO_2 emission: say, 90 million tonnes (in my lecture I suggest a 6 tonnes per capita allocation). However, their GDPs per

capita are different; the poor one has 2,000 USD, and the rich one – 20,000 USD. The former emits, say, 50 million tonnes, and the latter – say, 130 million tonnes. Therefore the former has unused permits for 40 million tonnes (90-50=40), and the latter needs an extra permit in order to emit additional 40 million tonnes (130-90=40). We can expect that the former will sell the unused permits to the latter. The latter will have to pay to the former. The money will flow in the right direction (from the rich to the poor). Yet proponents of the alternative philosophy "societies enjoying a higher level of welfare should be given more permits" advocate for a solution which lets these wealthier countries contribute less rather than more. It can be envisaged that – if this philosophy is applied – the poor country gets permits for 50 million tonnes only ("they do not need more, because they do not emit more"), and the rich gets permits for 130 million tonnes ("they deserve this, because they provide their citizens with higher welfare"). There will be no transfers of permits, and – consequently – no money flows. Hence I am for the per capita basis, and against bases taking into consideration GDP per capita or some other measures of well-being.

7. Berlin Mandate

Despite the title, this is a continuation of the climate change lecture. It will be clarified in a moment, why such a strange title.

In my previous lecture, I argued that the problem was a difficult one. Its solution requires that countries take a joint action in order to overcome the free-riding problem. An economically justified level of climate protection will not be achieved, if countries do what they are motivated to do by their own benefits only; they need to take a concerted action. Some people believed that such a concerted action happened in 1992.

A so-called Earth Summit took place in Rio de Janeiro in 1992. Kings, queens, princes, presidents and other VIPs participated in a huge meeting convened by the United Nations, devoted to environment and development. The concept of "sustainable development" became popular there, but this will be the topic of a separate class. Today we will look at the climate protection problem – something that was discussed in Rio too.

The *United Nations Framework Convention on Climate Change* (UNFCCC) is often called the "Rio Convention", even though it was not signed there. It was signed in New York a couple of weeks earlier. Yet it was discussed in Rio de Janeiro extensively. Soon it was ratified by all the signatories. Now the number of ratifications is 197 (it cannot be higher). The convention came into force in 1994 already. In 1993 it scored 166 ratifications – more than enough to become effective (50 ratifications were required).

It was a typical toothless convention. It stated that the world should take a concerted action in order to protect the global climate, but it did not specify what a given country is supposed to do. There was, however, one short clause that turned out to be extremely important in the future. This is the concept of *Common But Differentiated Responsibility* (CBDR). It reads:

> *The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with*

> *their **common but differentiated responsibilities** and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.* [art. 3 par. 1]

The phrase "common but differentiated responsibilities" was referred to in art. 4 par. 1 as well.

In my opinion, CBDR makes sense. Obviously both Nigeria and Great Britain have a common responsibility to protect the global climate. But – of course – in both cases it is different because of the colonial past, and in particular because of what Great Britain did in the 19th century. Also – for obvious reasons – the last sentence about the developed countries leading the battle makes sense. The problem started in Berlin in 1995, at the first conference of the parties to the Convention. A specific interpretation of CBDR was adopted then. Namely, the signatories agreed to the principle – and this makes a key part of the Berlin Mandate (BM) – which reads "Not [to] introduce any new commitments for Parties not included in Annex I". The agreement referred to the Montreal Protocol and to its division of the world into "rich" and "poor". The "rich" (including e.g. Bulgaria) were listed in Annex I, and everybody else (including e.g. South Korea) was considered "poor". The Berlin Mandate introduced a rigid dichotomy which did not let solve the problem for more than two decades.

Before looking at the role of Berlin Mandate, let us list all the annual meetings of *Conference of Parties* (called COP):

- COP-1 Berlin (1995)
- COP-2 Geneva (1996)
- COP-3 Kyoto (1997)
- COP-4 Buenos Aires (1998)
- COP-5 Bonn (1999)
- COP-6 Hague (2000) / Bonn (2001)
- COP-7 Marrakesh (2001)
- COP-8 New Delhi (2002)
- COP-9 Milan (2003)
- COP-10 Buenos Aires (2004)
- COP-11 / MOP-1 Montreal (2005)
- COP-12 / MOP-2 Nairobi (2006)
- COP-13 / MOP-3 Bali (2007)
- COP-14 / MOP-4 Poznan (2008)
- COP-15 / MOP-5 Copenhagen (2009)
- COP-16 / MOP-6 Cancun (2010)
- COP-17 / MOP-7 Durban (2011)
- COP-18 / MOP-8 Doha (2012)
- COP-19 / MOP-9 Warsaw (2013)
- COP-20 / MOP-10 Lima (2014)
- COP-21 / MOP-11 Paris (2015)
- COP-22 / MOP-12 Marrakesh (2016)

- COP-23 / MOP-13 Bonn (2017)
- COP-24 / MOP-14 Katowice (2018)
- COP-25 / MOP-15 Madrid (2019)
- - / - (2020)
- COP-26 / MOP-16 Glasgow (2021)
- COP-27 / MOP-17 Sharm El-Sheikh (2022)
- COP-28 / MOP-18 Dubai (2023)
- COP-29 /MOP-19 Baku (2024)

Starting 2005, they are combined with MOPs (*Meetings of Parties*). For instance in 2005 this is COP-11 / MOP-1, in 2006 it is COP-12 / MOP-2, and so on. The reason for this is that in 2004 the Kyoto Protocol (KP) came into force. Starting 2005, its signatories are supposed to meet annually too. Hence it became customary that KP meetings are organized jointly with UNFCCC meetings ("back-to-back").

In 2000 the COP-6 meeting in the Hague could not be concluded on time. Its conclusion took place in Bonn, several months later. There were three meetings organized in Poland: COP-14 / MOP-4 in Poznan in 2008, COP-19 / MOP-9 in Warsaw in 2013, and COP-24 / MOP-14 in Katowice in 2018. The COP-25 / MOP-15 was planned in Santiago de Chile, but just before its start, the Chilean government announced that – because of street violence – it could not guarantee safety for the delegates, and asked Spain to host the meeting. The 2019 meeting took place in Madrid (because of the COVID pandemics, there was no meeting in 2020).

The 1997 COP-3 in Kyoto is perhaps the best known event, but I underlined the 2015 COP-21 / MOP-11 in Paris. The latter is remarkable, since it was the first successful attempt to overcome BM. Not everybody appreciates this, but Paris Agreement has been the first UNFCCC document which departs from the unfortunate interpretation of CBDR adopted in Berlin in 1995.

More publicised than the Paris Agreement, the Kyoto Protocol has been an implementation of BM. Signed in 1997 (at COP-3), it came into force in 2004, once the threshold of 55 ratifications "covering" at least 55% of emission from Annex I was reached. It is not incidental that the ratification condition refers to the emission from Annex I; non-Annex I countries did not have to report their emission formally.

History of KP ratifications is fascinating. The number of 55 ratifications was easy to be reached. As agreed in BM (no commitments for non-Annex I parties), the protocol did not establish any binding commitments for non-Annex I countries. Therefore all such countries were happy to sign and ratify it; there are more than 150 non-Annex I countries, and their emission keeps growing. On the contrary, Annex I (42 countries and the European Union) do not increase their emission, and they contribute much less than 50% of the total now. Once the US Senate rejected the philosophy of the KP in a unanimous vote, it became clear that there would be no American ratification (even though the American delegation signed the KP). The American vote against the Kyoto Protocol was 'bi-partisan' (in American politics

this term means that Democrats agree with Republicans; Al Gore voted against too, but later on he forgot about this fact).

Therefore it also became clear that in order to reach the 55% of Annex I emission, the Russian ratification was necessary. Russia understood that without its ratification the KP would be dead. It also understood that the European Commission was desperately trying to save the protocol. Thus it did not ratify the Protocol until the European Commission satisfied all its political requests (2004).

Berlin Mandate has to be considered a great failure. For more than two decades it sanctioned a massive growth of CO_2 emission. According to calculations of EBRD (*European Bank of Reconstruction and Development*), the global emission grew at the pace of 0.6% per annum before 1992. After 1992 its growth rate was 1.2%. But a real jump – up to 2.6% – took place after 1997, once the BM was implemented by the KP. According to estimates by the IPCC (*Intergovernmental Panel on Climate Change*), the rate of growth of GHG emission was 1.3% in 1970-2000, and 2.2% in 2000-2010.

Many people feel a sort of helplessness. What can Annex I countries do if the non-Annex I countries continue to emit large quantities of carbon dioxide? Unless one struggles to overcome the BM, strange ideas breed. One such outrageous idea is so-called geoengineering (polluting the atmosphere in order to limit the inflow of solar energy). It is difficult to understand that such a notion could have been conceived, but apparently some people think that this is the only viable solution to the problem of untamed carbon dioxide emissions in non-Annex I countries. A similar attitude can be traced in the promotion of "negative" emissions to be provided by CCS (*Carbon Capture and Storage*, an absurd technology explained in the previous lecture).

But history of making climate protection an important part of government policies does not confine to the failure of BM, and inventing irrational ideas how to proceed if the growth of emission is considered inevitable. In 1988 the *Intergovernmental Panel on Climate Change* (IPCC) was established as a joint venture of national governments (195 governments take part in its activities). It was instrumental in drafting the UNFCCC. Its undertakings are consistent with the Berlin Mandate, and especially with CBDR. The undertakings are financed by Annex I countries in a somewhat unclear way. Nobody knows what is the budget of IPCC, since Annex I countries finance their government delegates individually. Government delegates coming from non-Annex I countries are financed either by the IPCC Secretariat, or by governments of some Annex I countries. There are no universal rules.

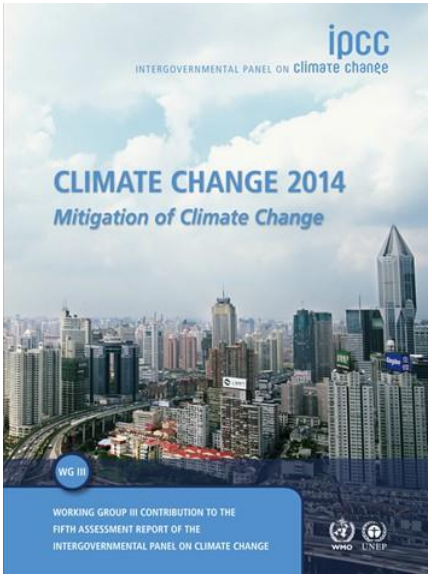
Despite this lack of clarity, IPCC has sponsored useful activities. In particular it has published so-called *Assessment Reports*. Their preparation has been carried out in three large scientific working groups:

- Working Group I – *Physical Science Basis*
- Working Group II – *Impacts, Adaptation and Vulnerability*
- Working Group III – *Mitigation of Climate Change*

The areas of interest of these groups are implied by their names. The groups consist of competent professionals. Even though their members are officially appointed by respective governments, experts provide independent, state-of-the art scientific assessments of climate change issues. Several such assessments were published until now.

- 1990 1AR
- 1992 Supplementary Reports
- 1995 2AR
- 2001 3AR
- 2007 4AR (Peace Nobel Prize)
- 2013-2014 5AR
- 2021-2022 6AR

The acronyms refer to the number of a report. For instance 1AR means the *First Assessment Report*, and so on. The authors of the fourth report (4AR) – hundreds of people – received jointly the Peace Nobel Prize (the prize went to IPCC, but it was understood as a recognition of the report quality). The reports result from a massive intellectual endeavour (financed by the Annex I countries). The 5AR (which I contributed to as a Working Group III member) had more than 800 authors. Like previous reports, it provided a good synthesis of scientific literature of the subject. The IPCC Secretariat had certain influence on its conclusions, but it was the independent experts (authors of the report) who reviewed the scientific literature in order to inform the world on the predicament.



The reports are very extensive. 5AR is several thousand page long, and it consists of dozens of chapters. Of course, nobody can read the full text. Consequently each chapter is accompanied by an abstract (two-page long or so). These are called Technical Summaries, and they are quite informative. But even such shorter texts are incomprehensible for government members. Hence summaries of these summaries are prepared too. They are called "Summaries for Policy Makers" (SPM). The problem with SPM is that they are subject to a unanimous voting of government delegates. They are adopted sentence-by-sentence; every

sentence can be questioned by any delegate. Thus, if a sentence contains anything that is not convenient for one government, it cannot be approved in a unanimous vote. As a result, SPMs contain only sentences that are absolutely useless. While the original reports contain information that is potentially policy-relevant, SPMs are largely free from such contents. Unfortunately, it is SPMs rather than the original body of the reports which is referred to by journalists, and – in the end – a large part of the professional effort included in the reports has no political influence.

Here is an example of a meaningless statement from an SPM of the Working Group III report: "[local mitigation] plans and strategies are in their early stages of development and implementation in many countries, making it difficult to assess their aggregate impact on future global emissions". The sentence avoids explaining how local mitigation – because of the public good aspect of climate change – does not have to cause global emission to decline (especially under the BM regime).

My pessimistic opinion on policy implications of IPCC reports has to be supplemented with a more optimistic assessment of their scientific impact. First of all, they provide excellent reviews of the relevant scientific literature. Moreover, they introduced quite a rigour in addressing uncertainty. We all use words such as "likely" or "probably", but everybody may understand something else.

Acknowledging the fact that academics differ, the reports emphasize the distinction between "evidence" and "agreement". The former refers to facts, and the latter to their interpretation. The former is classified as "limited", "medium", and "robust". The first category covers facts with narrow empirical support. This has nothing to do with the latter, i.e. agreement. Irrespective of abundance or scarcity of empirical evidence, there may be differences in opinions on what the facts mean. The latter is classified as "low", "medium", and "high". Let us take the example of methane emission. The evidence is robust, because of measurements carried out. However, scientists disagree to what extent the presence of methane has been caused by specific processes. In particular, it is not clear to what extent the methane comes in the form of leaks during fossil fuel extraction and transport. It is estimated that leaks may contribute up to 30% of the total emissions, but the confidence is considered low. Likewise observations of melting glaciers do not allow for easy interpretations. There are a number of "competing scientific explanations for the causes of change" (as the report says), and consequently – again – the confidence is considered low.

Likelihood of the outcome [%]	Expression to be used
99-100	*virtually certain*
95-100	*extremely likely*
90-100	*very likely*
66-100	*likely*
33-66	*about as likely as not*
0-33	*unlikely*
0-10	*very unlikely*
0-5	*extremely unlikely*
0-1	*exceptionally unlikely*

Perhaps even more important is how the reports use words "likely" and "probably". The table on page 75 serves as a sort of a dictionary to be applied in IPCC publications. The word "likely" is appropriate whenever the probability of what it refers to exceeds 2/3. If it exceeds 90%, the word "very" should be added; if it exceeds 95%, the word "extremely" should be added instead. If the probability exceeds 99%, authors should use the expression "virtually certain".

The 5AR states that "[i]t is extremely likely that human activities caused more than half of the observed increase in global average surface temperature from 1951 to 2010. This assessment is supported by robust evidence from multiple studies using different methods." Please note how careful wording is applied. The report does not state that human activities caused the observed temperature rise. First of all, it says "it is extremely likely" (i.e. the probability is higher than 95%). It also says that methods used explain more than a half of the measured evidence. Thus there is some room for non-anthropogenic (natural) processes as well, but the scientists do not agree on how to interpret what the evidence shows.

IPCC activities have been influenced by the BM. As mentioned earlier, in 2015 the first successful attempt to overcome the curse of BM took place. At COP-21/MOP-11 the path-breaking Paris Agreement was achieved. For the first time it was acknowledged that all signatories to UNFCCC are expected to limit their GHG emission. The commitments are voluntary, and – as critics emphasize – they are insufficient to protect the climate. Nevertheless a mechanism was established to make the (voluntary) commitments more ambitious over time.

The Paris Agreement introduced so-called *Nationally Determined Contributions* (NDC). These are lists of what a given signatory to UNFCCC plans to do in order to limit its GHG emission. They are voluntary, but once declared, they may become binding. There are no sanctions for violations, but there are prospects for benefitting from complying with such voluntary (yet binding) declarations. Many NDCs are hardly meaningful. For instance, the Chinese government declared to decrease GHG emission per unit of GDP (if GDP growth is planned, this does not imply declining emission). The Mexican government declared to stop deforestation by 2030 (in other words, until 2030 the deforestation will continue). Such NDCs are disappointing. Nevertheless many Annex I signatories accepted them without condemnations, because – for the first time – non-Annex I countries acknowledged that they were going to limit the emission.

The sum of NDCs is far from what would be needed in order to protect the climate. Nevertheless, the Paris Agreement makes a breakthrough in attempts to overcome the curse of the BM. For the first time non-Annex I countries adopted some commitments. They are voluntary and not sufficient to protect the climate, but they are better than nothing. The previous philosophy of waiting until the Annex I countries will solve the problem was ineffective.

The Paris Agreement indicates that it is necessary that the global temperature rise should be limited to 2^{o}C, and it would be better to limit it to 1.5^{o}C. Adopted NDCs are not sufficient

even for the less ambitious target. From this point of view, the agreement can be criticised as a disappointing one. Indeed, it is. Yet it is remarkable, because for the first time it was envisaged clearly that what Annex I countries do is almost irrelevant for climate protection.

An incentive mechanism is linked to Article 6.2 of the Paris Agreement. The article states:

> *Parties shall, where engaging on a voluntary basis in cooperative approaches that involve the use of internationally transferred mitigation outcomes towards nationally determined contributions, promote sustainable development and ensure environmental integrity and transparency, including in governance, and shall apply robust accounting to ensure, inter alia, the avoidance of double counting, consistent with guidance adopted by the Conference of the Parties serving as the meeting of the Parties to this Agreement.*

"Nationally Determined Contributions" (NDCs) were defined earlier. A concept of "Internationally Transferred Mitigation Outcome" (ITMO) needs to be explained. Under the Paris Agreement it is possible that a non-Annex I country sells its emission reduction to an Annex I country, who can then subtract this reduction from its binding commitment. It is anticipated that the price of such a transaction is attractive enough to cover the abatement cost and provide its seller with a surplus. In order to prevent double counting (that is selling the same ITMO twice, or selling a fraudulent "reduction" from an arbitrarily high baseline; note that non-Annex I countries do not have official baselines), the article refers to some "robust accounting". The wording was not precise enough, so its refinement was to be worked out during subsequent COPs/MOPs. Unfortunately, an agreement has not been reached until now. At a meeting in Madrid in 2019 there was an exotic coalition of Australia and Brazil to introduce loopholes to the article 6.2 in order to allow for some double counting. As signatories could not reach agreement, an amendment is still lacking. Optimists say that "no deal is better than bad deal".

Questions and answers to lecture 7

7.1 Does CBDR make sense?

I think that it does. It would be ridiculous to expect that Nigeria and Great Britain have the same responsibility for climate protection. Nigeria was a British colony, and could not develop economically as Great Britain did in the 19th century. The British CO_2 emission was high and that of Nigeria – low. The present predicament is caused by reckless emissions of (now) developed countries. The current emission (from Nigeria, among other things) contributes to the predicament, but the catastrophe was initiated earlier. Therefore it is justified that developed countries (Great Britain, among other things) take the lead in the battle against the catastrophe.

7.2 What specific interpretation of CBDR was adopted in Berlin in 1995?

As adopted in 1992, CBDR makes sense. Unfortunately, its 1995 interpretation turned out to be bad and far reaching. It states that non-Annex I countries will not take any binding

commitments (neither now, nor in the future). In other words, it allows the non-Annex I countries to emit carbon dioxide without any limits.

7.3 Freeing non-Annex I countries from binding commitments proved to let the global emission grow drastically (at an accelerating pace). Why did Annex I countries agree to such an ineffective principle?

It was not clear in 1995 that non-Annex I countries' emission would grow so fast. Annex I countries hoped that their emission would not grow. This (irrational) hope was motivated by three types of motivation.

- The first type of motivation was based on ethical grounds. We (the developed countries) sinned in the 19th century. Therefore we have to do more than others. We are guilty, and thus we have to repent.
- The second type of motivation referred to "providing a good example". If we (the developed countries) demonstrate how to behave, others will follow us. Providing a good example is an excellent method of raising children, but it fails in international diplomacy. Non-Annex I country diplomats do not behave like children; they are rational, and if they see that they do not have to abate, they take the opportunity to produce at a lower cost. Of course, in the future they will have to bear consequences, but the time horizon they have is a very short one (perhaps a couple of years – not even a decade).
- The third type of motivation was a more sophisticated one. Economic history provides examples of a technological change leading to drastic cost decreases. As a result, producers are motivated to switch to alternative methods because they are forced by economic incentives rather than someone's political pressure. It was hoped that carbon intensive technologies (such as coal combustion in traditional power plants) soon would become more expensive than technologies based on renewables (wind-mills, photovoltaics, etc.). This hope proved to be premature, and carbon intensive technologies have been still cheaper than alternative ones. High-carbon technologies managed to retain their competitiveness between 1995 and the present.

As it is apparent now, none of these three motives proved rational, and CBDR was interpreted in a way preventing the UNFCCC from being effective.

7.4 Why did the BM refer to the Montreal Protocol?

MP was a success story, and some people hoped to replicate its success in the climate area. In particular, the division of the world into the "rich" and the "poor" proved successful in a sense that the "rich" did not protest against financing incremental costs to be borne by the "poor" under the MP. Yet there is a tremendous difference between the ozone layer and climate change. The former is very cheap while the latter is very expensive. The reference to MP was not justified.

7.5 Kyoto Protocol is the best known amendment to the UNFCCC. Thanks to KP the Convention acquired "teeth". Were these teeth really biting?

Not really. The "teeth" bit only the Annex I countries, and left the non-Annex I countries with no commitments.

7.6 Which country (and why) did enjoy the strongest position in negotiations about the ratification of the KP?

To become legally binding, the KP required to have at least 55 ratifications and to cover at least 55% of the Annex I emission (under the UNFCCC non-Annex I countries do not even have an obligation to report their emissions; thus their emissions cannot be referred to in any legal document). The number of ratifications was not a problem. In large quantities, ratifications (now 192) were provided by non-Annex I countries which have no binding commitments. As far as Annex I is concerned, the 55% threshold assumed that most large emitters – like USA, Russia, Japan, Germany, France, and Canada – would ratify the Protocol. However, in a unanimous vote the Senate of the United States decided not to ratify any agreement of the KP type (the US government signed the KP in bad faith just for diplomatic purposes). Thus it became clear that without Russia (another large emitter) the Protocol would not reach the 55% threshold. It has been analysed in game theory that a player whose decision is pivotal has a tremendous power (especially if there are other players who are very much interested in the outcome). Russia realized that the European Commission was very much interested in having the KP survive. Hence it hesitated to ratify the Protocol until the end of 2004. It ratified the Protocol once all its political objectives (not connected to climate change) had been achieved.

7.7. Why was not the KP successful at stopping the growth of GHG emission?

Because it leaves most emitters without any commitments.

7.8 Is "geoengineering" a promising tool to combat the climate change?

No. It is an absurd idea of polluting the atmosphere (any single country can do it by emitting a large quantity of particulate matter or aerosols at a high altitude) in order to limit the solar radiation reaching the Earth surface. Even though it is mentioned by some people here and there, it was officially renounced by major environmental NGOs. If practiced by somebody, it would revert the trend of cleaning-up the atmosphere that has taken place in the 20th century.

7.9 In what sense has IPCC work been influenced by the BM?

In its proceedings, the IPCC makes a sharp distinction between experts coming from Annex I countries, and from the rest of the world. The former should be paid by their respective governments. The latter are paid either by the IPCC Secretariat, or by some sponsors. For instance the Swiss government pays expenditures of experts coming from some non-Annex I countries.

7.10 IPCC enjoys the position of the most competent body to analyse climate protection. Is this opinion justified?

I think that it is justified. The IPCC recruits its experts from all over the world. To appoint so-called Lead Authors of the 5AR, it received about 2,000 names, out of which more than a half were rejected. Those who were finally selected, enjoyed the status of official government appointees. Nevertheless they wrote what they considered consistent with the scientific literature rather than with their respective government statements. The report drafting procedures are extremely complicated and they are subject to a large number of comments from other scientists and practitioners (more than 100,000 comments were recorded in the course of 5AR preparations). These procedures may result in compromising scientific accuracy sometimes, but if the scientists justify their statements convincingly (especially by referring to peer-reviewed academic literature), potential political oversight can be minimized.

7.11 What innovative approach to communicating uncertainty is practiced in IPCC reports?

IPCC reports are very careful in referring to uncertainty. The subject matter of climate change is extremely complicated, and hardly any statements can be claimed as theorems. Thus every statement should be phrased cautiously. IPCC experts are aware of this, and they are obliged to use very rigorous language. For instance, they can use the wording "virtually certain", if the probability of something can be estimated higher than 99%. Even more importantly, they need to distinguish between what can be read in the scientific literature, and how scientists interpret what they found. The former is called "evidence", and the latter – "agreement". Hence even if the evidence is "robust", the agreement as to what it implies can be "low". IPCC reports emphasize that readers should be aware of the fact that scientists make a distinction between evidence (which is a matter of empirical investigation) and interpretation (which is subject to broader knowledge and – perhaps – intuition).

7.12 Why is the Paris Agreement a breakthrough in tackling the global climate protection?

It is a breakthrough, because for the first time (after the BM) it was agreed that everybody (not only the Annex I countries) should do something. Before the Paris Agreement non-Annex I countries claimed that they were not supposed to take any commitments. The commitments – in the form of NDCs – they take now are voluntary, but this is better than nothing.

7.13 What incentives non-Annex I countries may have to adopt meaningful NDCs?

At the moment many NDCs are not quite sincere. Nevertheless it is hoped that gradually they will become more meaningful, i.e. they will indicate some baselines (which can be called *Business As Usual*, BAU). An Annex I country X may find that it is cheaper to reduce emission in a non-Annex I country Y below its BAU level than to reduce it in X domestically. If this happens, then the country X can negotiate with Y a permit transaction (a sales from Y to X) whose price is lower than abatement cost in X, and higher than the abatement cost in Y, so that both countries consider it profitable. But public opinion in country X is presumably sensitive about whether the abatement project to be carried out in Y implies a real emission decrease or simply a transfer from one sector to another (perhaps even an increase in the

global emission). The transaction is not likely to be accepted, if the NDC it refers to is ambiguous (i.e. unless it contains meaningful targets).

7.14 Why may some countries (e.g. Australia and Brazil) be interested in the double counting of ITMOs?

Brazil is a non-Annex I country where inexpensive abatement options can be found. Its government is considered preoccupied with other (non-climate) goals, and thus it does not care much about reducing global emissions. It would probably not object if an ITMO was counted twice (letting a Brazilian firm sell the same project twice). Australian government actions can be interpreted as a typical free-riding behaviour. Australian government may assume that its emission does not make a crucial impact on the climate (the climate will be spoiled anyway). At the same time, by letting its firms buy permits cheaply from suspected sources, it will help the domestic economy to develop easier (cheaper).

8. Kyoto Protocol (KP)

The shortest characterization of the Kyoto Protocol to the UNFCCC agreed to in 1997 boils down to the following five statements:

- Materializes BM
- Limits CO_2 emission from Annex I only
- Baseline of 1990
- To abate 5.2% on average (in Annex I countries only)
- Compliance period 2008-2012

The COP-3 took place in this concrete building (see page 81) which has an auditorium that can host 6,000 people. For my colleagues who are familiar with SF movies, it resembled a "Star Wars" scenery. The KP is considered one of the most important environmental agreements, even though it failed to stop carbon dioxide emission growth for more than two decades.

Let us explain the five points listed above.

KP materializes the Berlin Mandate. Please recall that BM introduced the principle "Not [to] introduce any new commitments for Parties not included in Annex I". In other words, it established certain (not very ambitious) constraints on carbon emission released form Annex I countries (i.e. where the emission does not grow), and allowed non-Annex I countries to increase their emissions without any limits. Apparently non-Annex I countries – notably China, India, and Brazil – used this opportunity to increase their emission drastically. They achieved this by increasing production that in the Annex I became more expensive. This is exactly what BM implies (despite hopes of some analysts who expected that non-Annex I emission would not grow so fast). It should be stressed that KP limits the emission from Annex I countries only.

The reduction of their emission (the required level of abatement) was somewhat different for various countries. On average it was 5.2% in Annex I countries. Some of them – like Iceland – were allowed to increase their emission (the reduction target was +10%; this meant that the emission could be 110% of the baseline). Some countries – including Russia – were allowed to keep the emission unchanged (the reduction was 0%; this meant that the emission could be 100% of the baseline). Some countries – including Poland – were required to reduce their emission by -6%. Most European countries were required to reduce their emission by -8%.

The reason for this differentiation was that countries faced very different abatement opportunities and costs. Iceland almost does not use fossil fuels for heating purposes (they use geothermal energy). Carbon dioxide is emitted mainly by cars. Allowing Iceland to increase the emission means that their citizens were expected to increase the car traffic somewhat. They had no opportunities to abate in the energy sector, because the energy sector was basically carbon-free already. Freezing emission in Russia was considered the only way to have this emitter agree to the Protocol.

The Protocol indicated 1990 as the "default" baseline for emission reduction, but it allowed some countries to choose another base year. Poland took opportunity of this and chose 1988 instead. The reason behind this decision was that Polish emission decreased significantly from 1988 to 1990 as a result of economic collapse of the centrally planning system (affecting many Eastern European economies). Therefore taking the 1990 as a starting point would be unjustified. Taking the 1988 gave Poland a much easier reference for subsequent abatement.

The compliance period was indicated as 2008-2012. Kyoto targets were understood as 1/5 of the total emission in 2008-2012 (five years). If emissions were to change linearly, 1/5 of the total 2008-2012 emission would correspond to 2010. This is what international community had in mind, but it allowed for some flexibility and decided that the 2010 target is achieved if the average annual emission in 2008-2012 is what it was expected for 2010.

This is not the only flexibility mechanism built into the protocol. Perhaps the best known is the one related to emission trading. This is provided by three articles:

- Article 6 allows emissions trading between firms in Annex I countries
- Article 12 allows *Clean Development Mechanism* (CDM), i.e. claiming an emission reduction credit by an Annex I country created through abatement in a non-Annex I country
- Article 17 allows *Joint Implementation* (JI), i.e. claiming an emission reduction credit by an Annex-I country created through abatement in another Annex I country

Article 6 is the simplest one. It simply allows one Annex I country to transfer some of its abatement to another Annex I country. Quite paradoxically, article 12 opened a way for increasing the global emission (subsidized by Annex I countries). The following example will explain this paradox.

Let us assume that an Indian entrepreneur announces a decision to invest in a refinery which is expected to emit 15 million tonnes of CO_2 per annum. Environmentalists protest against this. They demonstrate that India will increase its emission by 15 million tonnes and hence it will aggravate the global problems. The entrepreneur says that climate protection is very important, but – given the technology – the emission cannot be made lower. The environmentalists say that there is a new technology which lets the emission be just 12 million tonnes. The entrepreneur analyses the technology and estimates that its cost would be 2 million € higher than what he (or she) planned. The environmentalists say that the difference ("incremental cost") will be paid by an Annex I country which can claim the "abatement" of 3 million tonnes of CO_2. Even if they pay, say 4 € per tonne of carbon dioxide "abated" in this way, this will be cheaper than doing the abatement domestically (the domestic abatement cost is probably higher than 30 € per tonne). Both sides are happy with such a transaction. The Annex I country pays 12 million € for the "abatement" of 3 million tonnes (instead of paying more than 90 million € if domestic abatement was to be carried out). The non-Annex I country entrepreneur is happy to proceed with the investment if the incremental cost – or even more – is to be paid by somebody else. The bottom line is that the global emission goes up (by 12 Mt), and Annex I countries subsidize this.

By the way, most of CDM projects were carried out in China. Therefore the acronym CDM is sometimes read as "China Development Mechanism". The fact that CDM is open for fraud was obvious in the 1990s already. Nonetheless, environmental NGOs advocated for it perhaps in good faith. Many politicians both from Annex I and non-Annex I countries (perhaps some of them in bad faith) advocated too, and thus Article 12 was included in KP. The article 6.2 of the Paris Agreement tries to eliminate this pathological mechanism, but – as I indicated in the previous lecture – some of its signatories defend the old fraudulent arrangements.

Article 17 of the Kyoto Protocol authorises emission trading among Annex I countries. The difference between articles 6 and 17 is that the former covers trades between firms, and the latter – between countries.

Emission trading is not the only additional flexibility mechanism included in the KP. Other flexibility mechanisms include:

- Slight weakening of the dichotomous division of the world into "rich" and "poor" (inherited from the Montreal Protocol) by allowing flexible baselines
- Some economies in transition were allowed to choose alternative baselines and less than 8% reduction (typical for most European countries)
- Poland took advantage of this provision by choosing 1988 (as the baseline) and committing to 6% reduction

In principle the KP inherits the dichotomous division of the world into "rich" and "poor" from the MP. Yet it was somewhat weakened by allowing flexible baselines for economies in transition (formally they are in Annex I, but they are not that rich). Several countries – including Poland – took advantage of this flexibility, and chose 1988 (instead of 1990), i.e. the last year before the unprecedented economic collapse in 1988/1989.

For an economist, the most interesting implication of the KP is emission trading. The European Commission did not want to approve this mechanism. It considered it an unwise "American" invention that does not fit the European tradition and extensive legislative systems. For many years Poland suffered from this prejudice when it tried to introduce emission trading to its environmental regulations. Polish politicians were discouraged by their Western European colleagues from "experimenting" with this "American" instrument. The argument was not very accurate. If fact, emission trading was an American instrument, since it was applied there for the first time. Yet it was not a new instrument in the 1990s (it was conceived in the 1960s and implemented in the 1970s for the first time). The European Commission was against articles 3 and 17 of the KP. Finally it agreed to have them included, because otherwise COP-3 was about to conclude without any agreement. However, once emission trading became a part of the KP, the European Commission changed its attitude towards this instrument completely.

In 2003 – anticipating the Russian ratification of the KP – the European Commission established so-called ETS (*Emission Trading System*; there are other explanations of the acronym – e.g. *Emissions Trading Scheme*, and so on). In its preamble, the 2003/87/EC Directive states (please note that it does not refer to the KP which was not legally binding at that time):

> *This Directive aims to contribute to fulfilling the commitments of the European Community and its Member States more effectively, through an efficient European market in greenhouse gas emission allowances, with the least possible diminution of economic development and employment.*

The preamble was understood by some member countries – including Poland – that KP signatories which are to comply with the Protocol anyway do not have to participate in ETS. The Commission insisted that – despite the wording of the preamble – ETS was to be binding for all. The good news is that emissions trading was allowed in Europe finally.

There is also bad news. ETS can be understood as a measure aimed at increasing the political power of the European Commission. European treaties do not allow the Commission to impose taxes. ETS auction is considered a surrogate mechanism instead of taxes. If carbon dioxide permits were distributed for free, then of course there would be no revenues from their distribution. But the Directive envisages a growing part of their supply distributed in auctions. The auction revenues go to whoever organized the auction. For the time being, the

auctions are organized by national governments, not by the Commission. Yet the Commission controls (at least partially) revenues collected by the governments. In particular, it mandates that auction revenues finance certain types of projects Thus, in a sense, ETS substitutes for tax revenues.

There are more than 10,000 installations in the European Union (around 1,000 in Poland) obliged to participate in the ETS. Initially permits were "grandfathered", i.e. allocated for free, more or less according to historical emission (hence the name "grandfathering"). If a firm did not use its entire permit (if for whatever reason the emission was lower than that covered by the permit), the unused part of the permit could be saved for future use. This is called "banking". Or the unused part could be sold to somebody else. Gradually, these "grandfathered" permits were shrinking, and in order to justify the emission, firms had to use their own previously "banked" permits, to buy them from somebody else, or to buy them in an auction organized by the government. Every year the governments ran auctions with the volume of permits to be sold gradually decreasing. This was expected to elevate the average price of permits, but it did not.

Before 2020 permit prices were disappointingly low. In 2005 they started from a fairly high level of 25 €/tonne of CO_2, soon they declined almost to zero, and continued at a very low level for several years. Environmentalists complained that low permit prices keep traditional power plants alive, and do not let carbon-free energy (e.g. wind-mills and photovoltaics) become competitive. They demanded that the European Commission confiscates a part of permits to be auctioned and thus allows their price to increase. In fact the Commission did confiscate a part of permits that were expected by emitters (so-called "backloading" – something I am going to explain in a moment), and caused their price to increase up to the level of more than 25 €/tonne of CO_2. As a result of the recent crisis these prices went down, but they went up again and reached the level of 100 €/tonne of CO_2 in 2022 (later on they went down somewhat).

Low permit prices for most of the time (typically less than 10 € / tonne CO_2) motivated the European Commission – especially after 2012 – to manipulate in ETS e.g. by

- Manipulating permit allocations
- "Backloading" (i.e. postponing or confiscating permits)
- Creating "reserves", etc.

With climate-related policy objectives – such as a transition from fossil fuels to renewable energy sources – in mind, the European Commission expected ETS to provide incentives to promote decarbonisation of the economy. Low permit prices did not provide such incentives since traditional power plants did not have to spend much on buying permits. Hence the Commission took various decisions to make power plants pay. One of the earliest ones was to manipulate with permit allocation at the plant level. This plan did not succeed, because traditional power plants managed to exert political pressure in order to give them fairly generous permits. At the same time, the credibility of ETS was undermined seriously, since emitters realized that the price of permits depends on political plans of bureaucrats rather than market forces.

"Backloading" is one of the most popular terms referred to in the context of ETS. It means "freezing" unused permits kept by governments for a future use. Every firm participating in

the ETS has an account where permits are recorded. Because of commercial confidentiality, it does not matter whether the permits were "banked" by firms, bought from somebody else, or acquired in an auction (organized by the national government, or elsewhere in Europe). It would be illegal to confiscate permits held by individual firms. However, it is legally possible to confiscate permits planned to be sold in government auctions in the future. This is what the European Commission did in 2014. It reduced the planned supply of permits to be auctioned by 900 million tonnes of CO_2:

- 400 million allowances in 2014
- 300 million in 2015
- 200 million in 2016.

The decision what to do with them was to be taken in 2019-2020. Officially they were postponed for future use, but they could be confiscated as well. They are stored in the so-called *Market Stability Reserve*. This reserve was created in order to reduce price volatility (i.e. increase the supply of permits if their market price goes up quickly, and decrease it if the price goes down). The "backloaded" sum is likely to be confiscated rather than given back to the governments.

Emission trading is not a new instrument now. It has been implemented in the world since the 1970s. It is covered in environmental economics textbooks as a "classic" policy tool. The textbooks praise its advantages, but – at the same time – warn against typical mistakes made by policy makers. One such mistake is manipulating allocations when transactions take place. Buyers and sellers are not sure whether what they buy and sell is "real" or not. As a result, the market cannot function very well. Unfortunately, the European Commission made this mistake several times.

This is not the only misuse of the instrument. Environmental economics textbooks explain that emission trading should not accompany subsidies aimed at reducing the emission. Let us explain this by looking at what happens in the renewable energy market. To see the problem, let us assume that the demand for energy is fixed, and a traditional power plant does not have enough permits to produce electricity as before. Therefore it produces less. The difference is supplied from a wind-mill which does not need to buy a CO_2 permit. This renewable electricity production would emerge spontaneously. However, there is an additional subsidy to the wind-mill. The budgetary money is spent on something that would have happened anyway. In the end, people are surprised and complain that despite the subsidy, there is no additional improvement in the process of reducing carbon dioxide emission. Unfortunately, this is what happens in Europe too.

All these hectic decisions around ETS are motivated by the desire of the European Commission do decrease the emission of carbon dioxide. They can be successful when it comes to the local emission. Yet they fail to decrease the global emission. A typical reaction to this failure is the following statement: "Despite what we do, the global emission continues to grow". But a more adequate statement is: "Because of what we do, the global emission continues to grow". This is a paradox caused by the inadequacy of unilateral action explained by the concept of carbon leakage (CL).

Let there be two regions: abating, and non-abating (like Annex I and the rest of the world). The formal definition of carbon leakage looks awful:

$$CL(\Delta R) = (f_N(GDP_N,P_N,GDP_A(R_0+\Delta R))-f_N(GDP_N,P_N,GDP_A(R_0))) / \Delta R$$

where

- A, N – respectively, abating and non-abating regions
- R_0 is the baseline (standard) reduction target adopted in A
- ΔR is an additional reduction target contemplated in A
- P_N identifies an abatement policy adopted in N
- f_N is an emission function for N
- GDP_A is a function of a reduction target adopted in A; thus – in the definition above – we have either $GDP_A(R_0)$, or $GDP_A(R_0+\Delta R)$.

It cannot be simplified. But if you want to grasp its intuitive meaning, it merely says that $CL(\Delta R)$ is the rate of the global emission growth if the abating region contemplates to reduce the emission by ΔR additionally. If it is zero, then our abatement is neutral (i.e. the global emission will go down just by what we did). If it is negative, then it means that the non-abating region will decrease the emission as well. But if it is positive, then the non-abating region will increase its emission. If it is 100%, then it means that the non-abating region will increase its emission exactly by what the abating region decreased. In other words, the global effect of abatement in A is totally annulled by what N is going to do. If $CL(\Delta R)>100\%$ then the more A does, the higher the global emission is. This is paradoxical.

Economists analyse three mechanisms of this "green paradox":

- Changes in prices of fossil fuels. An additional abatement effort in A results in lower demand for fossil fuels, which thus leads to their lower price. This, in turn, provides incentives for additional use of fossil fuels in N.
- Changes in prices of final goods. An additional abatement effort in A results in higher prices of carbon-intensive goods there. Their production moves to N, which leads to higher emissions of carbon dioxide in N.
- Changes in production factor prices. An additional abatement effort in A reduces the remuneration of capital there. The capital moves to N, which leads to higher emissions of carbon dioxide in N.

Let us look at each of these three mechanisms.

The first one refers to changing prices of fossil fuels. Let us assume that one country, say, Poland, stops using coal (in order to reduce carbon dioxide emission). The demand for coal goes down. As a result, its price goes down either. Countries where no anti-coal policies are in place take advantage of this lower price, and they find coal more attractive than before. Consequently, their emission of carbon dioxide goes up.

The second mechanism refers to changing prices of final goods. Let us assume that one country, say, Italy realized that the production of T-shirts is too expensive (because of climate protection policies among other things) and shut down a plant. The production can be moved to a non-Annex I country, say, Pakistan where no similar abatement requirements are present. As a result, the carbon dioxide emission moves from Italy to Pakistan. If the Pakistani and Italian production processes are equally efficient, then the total emission is the same as

before. If the technology applied in Pakistan is inferior to that applied in Italy, then the total emission is likely to go up.

The third mechanism refers to investment. Let us assume that a French investor is to take a decision where to invest. He (or she) can invest at home (or in another Annex I country), or somewhere else (in a non-Annex I country), say, in Bolivia. In the first case, profitability of the investment will be affected by abatement regulations. In the second case, this profitability will not be compromised by such regulations. It is obvious that he (or she) will choose to invest in a non-Annex I country.

The idea of CL can be objected on the grounds of the following simplistic example. There was a plant in Spain that was shut down as a result of environmental regulations. Identical plant was established in Mexico. Its emission transferred from Spain to Mexico. This would be a perfect example of CL (from an Annex I country to a non-Annex I country), except that – according to statistical evidence – it does not happen (or it happens extremely rarely); hence CL does not exist. Yet the three mechanisms outlined above explain that CL does not confine to this hypothetical counterexample.

CL is real. It does happen, and it explains a large part of the carbon dioxide emission growth after 1992. Its implications can be summarized as follows:

- Ineffectiveness of "climate protection" policies when a global limit on carbon dioxide emission does not exist (there exist limits – called "caps" – for some countries only)
- Abatement commitments of Annex I countries result in higher emissions in non-Annex I countries (if the latter do not have binding commitments)

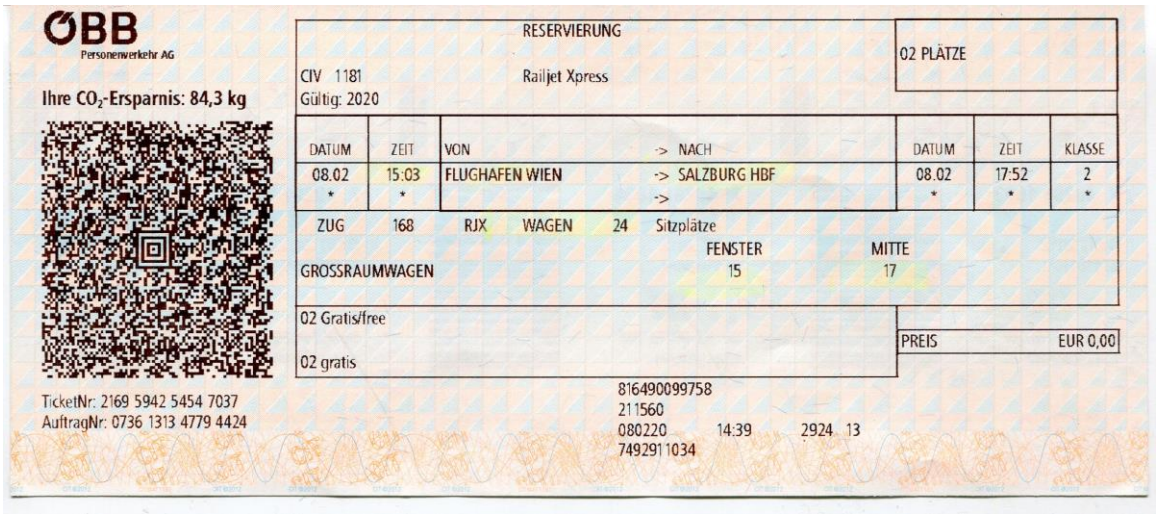
In other words, by ignoring CL, the KP – and, more generally, the BM – is largely responsible for the climate protection failure.

Annex I country governments are aware of the failure, and they try to introduce some anti-leakage measures. The best known idea is perhaps *Border Tax Adjustments* (BTA), discussed in lecture 5 on the ozone layer (see also question 5.12). The idea makes theoretical sense, but it is impossible to be implemented. It seems to be simple and appealing: if a product comes from a country which did not introduce climate protection measures as we did, then it should be taxed before entering our territory. In practice – as I explained earlier – it would be difficult to operationalize, and it is against WTO regulations. Moreover, there are some estimations demonstrating that trade restrictions introduced through BTA may actually decrease welfare (they will protect a domestic industry, but – despite this – citizens will be worse off).

In the absence of BTA, Annex I countries introduced a special category of sectors to be shielded against CL. These are: *Energy Intensive Trade Exposed* (EITE) sectors. EITE encompasses industries that can be hurt by the CL. Power plants do not necessarily belong to this category, if they are not exposed to trade (it would be very difficult to import electricity from, say, Mongolia to Japan). If a firm is in the EITE then it can claim certain subsidies or some privileged status in ETS.

From the point of view of climate protection, the KP has to be judged a failure. Nevertheless, it raised the awareness of climate problems and contributed to the popularity of "Carbon

Footprints" (CF). If you type such an expression into Google, you will get around 30 million entries. There are CF calculators that allow to estimate how many units of carbon dioxide you produce if you eat something or do something. Many firms advertise by declaring that their merchandise produces less carbon dioxide than something else. For instance, on my train ticket from Vienna to Salzburg there is the following statement: "Ihre CO_2-Ersparnis: 84.3 kg" (your CO_2-saving is 84.3 kg). This is not quite true. It is based mainly on "McKinsey steps" argument (an idea discussed in lecture 6). If you take a train, you use certain amount of energy and – as a result – you imply certain emission of carbon dioxide. But if you chose a car or a plane, you would cause an even higher emission. Thus by taking the train you save somewhat. Yet people who calculate this "saving" do not know which mode of transportation I was going to substitute with the train. If this was a bicycle, then my trip from Vienna to Salzburg would not cause the same carbon dioxide emission like a car or a plane. And even if a car would be the alternative to compare with, then my implied emission per person would be different if I travelled without any passengers, or with three other people.


ÖBB
Personenverkehr AG

Ihre CO_2-Ersparnis: 84,3 kg

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Please be careful when you hear that by doing something or eating something you increase or decrease carbon dioxide emission by certain amount. This is not necessarily true. Because of the "green paradox", sometimes it is not even certain whether you decrease or increase at all.

Questions and answers to lecture 8

8.1 In what sense does the KP implement the BM?

The KP establishes constraints on emission from the Annex I only. This is exactly what BM envisaged: *Not [to] introduce any new commitments for Parties not included in Annex I*. Non-Annex I countries were not expected to take any commitments under the Kyoto Protocol, and this is consistent with BM.

8.2 Why was Iceland (a definitely "rich" Annex I country) given a permission to increase rather than decrease carbon dioxide emissions?

It would be unfair to expect that Iceland abates the same percentage of carbon dioxide emission as, say, Denmark. The Danish economy emits carbon dioxide from burning fossil fuels in order to heat, among other things. In 1997 the emission from the Danish power sector was 47%, and that from the transport sector – 27%. In Iceland the power sector contributed

0% to emission (6.4 thousand tonnes of the total of 3 million tonnes). It was obvious that Iceland did not have abatement options similar to those available to Denmark. Moreover, car traffic – an important source of GHG emission – was expected to grow from around 3.7 million passenger-kilometres in 1997 by 50% by 2010. The abatement target for Iceland was to take this into account. Besides, the emission of Iceland has a very small share in the total emission from the Annex I.

8.3 Why did Poland change the default base year of 1990 to an earlier year of 1988?

The central planning system in Poland collapsed totally after the 1988. GDP and the electricity production declined drastically. As a result, the carbon dioxide emission in 1990 was 375 million tonnes, i.e. much less than what was emitted in 1988 (469 million tonnes). If related to 1988, the Kyoto target was 441 million tonnes (94% of 469). If the baseline of 1990 was adopted, the target would have been 352 million tonnes (94% of 375) – much more difficult to achieve.

8.4 If carbon dioxide emission increases or decreases exponentially at a constant non-zero rate (say, at the rate of +1%, or -1% per annum) is the 2010 emission higher or lower than the average for 2008-2012?

The average for 2008-2012 is equal to what was emitted in 2010 in the case of a linear trend only. If the trend is non-linear, but exponential like in the question above, then the 2010 emission is higher than the average for 2008-2012 in the case of a negative rate, and lower – in the case of a positive rate.

8.5 Does the Kyoto Protocol allow emission trading?

Yes. It allows for emission trading between Annex I countries (art. 6 and 17), and between Annex I countries and non-Annex I countries (art. 12).

8.6 Why did some economists object to Article 12 of the KP which establishes so-called *Clean Development Mechanism* (CDM)?

They objected, because (unlike Annex I countries) non-Annex I countries do not have any emission reduction targets. Hence if a firm from a non-Annex I country claims that emission was reduced somewhere, then it is impossible to refer to any baseline in order to calculate how many tonnes were actually abated in total (not through a given project – as in the example of a hypothetical Indian refinery).

8.7 Why are there some Annex I countries who defend the CDM by fighting against clarifications to be included in article 6.2 of the Paris Agreement?

Fraudulent calculations of "abatement" are detrimental from the point of view of global climate protection. However, climate protection is a public good. Therefore individual countries can be interested in keeping fraudulent transactions as profitable for a single economy (even though they are detrimental for climate protection).

8.8 The preamble to the ETS directive alludes to the Kyoto Protocol, but it does not refer to it explicitly. Why?

At the time of adopting the Directive, the KP was not in force (Russia had not ratified the Protocol yet). Thus it was not legally binding. Consequently the Directive could not refer to it. The preamble to the ETS directive says vaguely about *fulfilling the commitments of the European Community*. The commitments it referred to were included in the Kyoto Protocol.

8.9 Why do many firms prefer "grandfathering" rather than auctions of permits? Which firms are likely to prefer auctions rather than "grandfathering"?

A firm which emitted carbon dioxide in the past, would like to have the right to emit it in the future. In the case of "grandfathering", it will get some permits for free. In the case of an auction, it would be forced to pay for the permits. Newly established firms, or firms that plan to start production causing carbon dioxide emission, would be deprived of permits under the "grandfathering" scheme. If all the firms (including those which emitted carbon dioxide in the past) were to buy permits in an auction, new firms would not be at a disadvantaged position. Therefore so-called newcomers are likely to prefer auctions rather than "grandfathering".

8.10 What mechanisms does the European Commission apply in order to increase permit prices in ETS?

It wants to decrease the supply of permits. The most important mechanism is so-called "backloading", i.e. lowering the quantity of allowances to be auctioned by EU governments. The allowances removed by this method are transferred to so-called *Market Stability Reserve*.

8.11 Can emission trading co-exist with subsidy instruments?

It does in Europe. However, from the point of view of climate policy the co-existence is a waste of budgetary money. Subsidies may go to projects that would have been carried out anyway, as a result of emission trading. For instance, ETS results (at least theoretically) in a cost effective allocation of abatement efforts. It provides incentives for switching from fossil fuels to renewable energy sources, but – by definition – it cannot lower the total emission of carbon dioxide below the level indicated by the sum of permits. Thus subsidies for renewable energy sources go to projects that could have been carried out anyway, and therefore they do not have to result in lowering the emission.

8.12 Is it possible that emission reduction carried out by one country can motivate another country to emit more?

Unfortunately, yes. This is why carbon leakage takes place. If a reduction carried out in one country is costly (as it is usually), then the production in this country becomes more expensive. This may provide an incentive for another country to enter competition leading to the growing emission of carbon dioxide.

8.13 Why is the formal definition of carbon leakage (CL) so complicated?

It cannot be simplified. In broad terms, it tries to capture reactions of a non-abating country to what an abating country does. Please note the difference between the two scenarios: $f_N(GDP_N,P_N,GDP_A(R_0+\Delta R))$ and $f_N(GDP_N,P_N,GDP_A(R_0))$. The first two arguments of the f_N function are the same (GDP_N and P_N). However, the third argument (GDP_A) is different in these two expressions: it is $GDP_A(R_0+\Delta R)$ in the first expression and $GDP_A(R_0)$ in the second one. If the abating country moves from R_0 to $R_0+\Delta R$, then its GDP will probably go down.

What will be the reaction in a non-abating country? Its economy may have incentives to shrink (as a result of lower demand from the abating country), or – on the contrary – to grow (as a result of higher demand for products whose domestic production in the abating country became more expensive). Which tendency prevails is an empirical question. Please note once again that GDP_N and P_N are the same in both expressions. In calculating carbon leakage, it is assumed that what happens in the abating country does not have a direct impact on the non-abating country's GDP, and its abatement policy. Taking into account such a direct impact would make the formula even more complicated.

8.14 Can carbon leakage coefficient be higher than 1 (i.e. 100%)? If yes, what would be its interpretation?

Yes. It can be higher than 1. If this happens, it means that moving from R_0 to $R_0+\Delta R$ in the abating country leads to an increase of emission in the non-abating country by more than ΔR. In the end, the total emission will be higher than before.

8.15 Is a Border Tax Adjustment (BTA) an effective instrument of preventing CL?

No. The definition of CL implies that a change in emission in the N region depends on changes in GDP_A. Switching from R_0 to $R_0+\Delta R$ is likely to decrease the GDP_A. Nevertheless the emission from N may increase anyway, especially if – despite the decreased GDP_A – the demand for imports is higher than before.

8.16 What sectors are considered Energy Intensive Trade Exposed (EITE)?

EITE includes energy intensive and trade exposed sectors (energy intensity is linked to carbon dioxide emission). For instance, electricity and chemical fertilisers are energy intensive. However, electricity is less exposed to trade than chemical fertilisers (it would be difficult to imagine electricity import from distant countries, but this may happen to fertilisers). Consequently, chemical fertiliser plants may expect stronger protection against carbon leakage than power plants.

8.17 How can a carbon footprint be defined?

According to the most popular definition, carbon footprint is the total amount of greenhouse gases emitted in order to support human activities (either directly or indirectly), usually expressed in tonnes of carbon dioxide. This definition captures the global emission of carbon dioxide. In addition, carbon footprint can be defined and calculated for countries, sectors, people, and specific products or services. Direct emission is fairly easy to calculate. For instance, carbon footprint of one kilometre driven in a car is equal to (more or less) 0.12 kg; in an obvious way, this is based on fuel consumption of a typical gasoline-powered car. It would be more difficult to estimate carbon footprint of potatoes eaten by an average Polish consumer. Growing potatoes requires certain amount of fertilisers and energy; their application implies emission of carbon dioxide (but its calculation can be controversial). Yet everything can be calculated with some accuracy. How about using a mobile phone? Its operation is very difficult to be linked to emission. Nevertheless, its production requires small quantities of so-called rare earth metals: cerium (Ce), dysprosium (Dy), erbium (Er), europium (Eu), gadolinium (Gd), holmium (Ho), lanthanum (La), lutetium (Lu), neodymium (Nd), praseodymium (Pr), promethium (Pm), samarium (Sm), scandium (Sc), terbium (Tb), thulium (Tm), ytterbium (Yb), and yttrium (Y). These are often found in minerals with

thorium (Th), and less commonly uranium (U). Their extraction is linked to enormous environmental disruption. Mobile phones use cerium, gadolinium, and neodymium intensely. In principle, everything can be recycled, but do we recycle? I am afraid that calculating carbon footprints is often misleading.

9. Biodiversity

Biodiversity has become a very fashionable term. To a large extent, it is a descendant of "nature protection". What in the 20th century was called "nature protection" is called biodiversity now. Not many people are aware of the fact that ecologists make a distinction between three layers of biodiversity (biology students should be aware):

- Species diversity
- Genetic or population diversity
- Landscape diversity

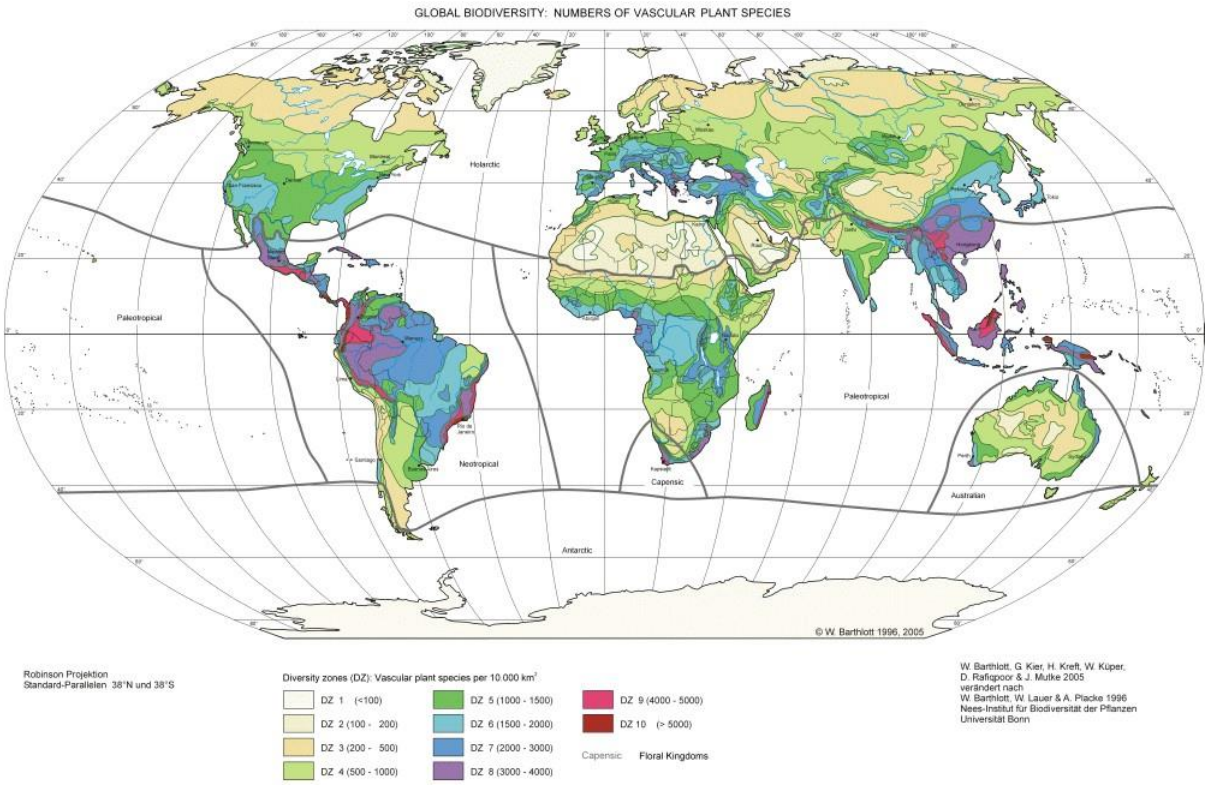
Let me explain briefly the meaning of these three layers. Species diversity is perhaps something that most people associate biodiversity with. We are concerned whenever we learn that a species was driven to extinction. It is obvious for everybody that biodiversity is impaired then (even if we lose a mosquito). The more species we have the larger biodiversity is. Some scientists make this pattern somewhat more complicated. If a species becomes extinct, but another closely related species survives, the loss is not that acute. However, if a species becomes extinct, and no close relatives survive, the loss of biodiversity is more acute. Consequently, species diversity can be measured not only by the number of species, but also by some relationships between higher order taxa (biological classification units).

This has to be distinguished from genetic or population diversity. We all belong the same species (*homo sapiens*), but we differ in terms of genetic material. Only identical twins have the same genetic material. Everybody else has a unique one but some genetic material is common. Populations found in one region may have genetic material very much different from what can be found in another region. This applies not only to human populations, but also to populations bred in agriculture. In an area one single variety or race can be dominant, while in another area different varieties or races can be easily found. The more varieties or races coexist in one area the better. If there is a pest infestation attacking a specific variety or race, then other varieties and races have a chance to survive. Consequently, farmers who maintain genetic diversity are less vulnerable to pest infestation and they can save on pesticides.

Landscape diversity is another layer of biodiversity. Here the word "landscape" is understood as ecologists understand the concept, that is as a web of connections between soils, plants, and animals. Let us assume that every species is protected in a zoological or a botanical garden. Thus species (and perhaps even population) biodiversity can be preserved. Nevertheless the relationships occurring between various organisms in the natural environment cannot be preserved in this way. We need to have real ecosystems in order to preserve landscape diversity.

That is why biodiversity should not be reduced to species diversity – something we often think of whenever the term is mentioned.

Biodiversity is differentiated geographically. In many regions it is not spectacular. The following map gives an orientation of what it looks like in the world. We see that some tropical regions – especially in Latin America, South-East Asia, and Indonesia – are particularly rich in biodiversity (they are called mega-biodiversity areas).



Nature protection has a long history, but traditional conservation measures were found to be insufficient to allow future generations to benefit from the Earth's living resources.

The preamble to the Convention on Biological Diversity (CBD) states:

- There is a *general lack of information and knowledge regarding biological diversity*
- There is an *urgent need to develop scientific, technical and institutional capacities to provide the basic understanding upon which to plan and implement appropriate measures*

Before we analyse the CBD in more detail, let us observe (once again) that what we talk about is a public good. It satisfies the two textbook criteria:

- Non-rivalry principle (many simultaneous users can benefit from the same information); and

- Non-exclusion principle (those who do not contribute to biodiversity preservation can also benefit from the information preserved)

As a result we can expect (as usually):

- Free-riding, and
- Under-supply of the good

Whenever this happens we know, that in order to overcome these public-good problems, an international convention is needed. We have such a convention – CBD. It was prepared by the United Nations Environmental Programme (UNEP) in Nairobi, and signed in Rio de Janeiro in 1992 (another "Rio Convention" from that year). Soon it came into force (in 1993). Now it has almost universal acceptance (193 parties to the convention).

When you see a great number of signatories you are curious whether the convention has teeth at all. The original convention did not bite. It stated merely that biodiversity is precious and has to be preserved. It started to get teeth gradually. In Cartagena in 2000 a protocol on biosafety was adopted (it has 172 parties now). The objective of the protocol is to ensure the safe handling, transport and use of living modified organisms (LMOs) resulting from modern biotechnology that may have adverse effects on biological diversity, taking also into account risks to human health. The 10th Conference of Parties to the CBD in Nagoya (Japan) in 2010 adopted a binding protocol, and non-binding *Aichi biodiversity targets* (the official name of the former reads: *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity*). The protocol has 124 parties now. Aichi is the name of prefecture (municipality) where the city of Nagoya is located.

The Nagoya Protocol does not have rigorous quantified targets, but it is fairly specific, and it contains certain recommendations for signatories. More importantly, it was accompanied by the Aichi biodiversity targets. These have five strategic goals (A through E). Below they will be listed and characterized briefly.

Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society

Specific recommendations include items 1 through 4, such as:

1. By 2020, at the latest, people are aware of the values of biodiversity and the steps they can take to conserve and use it sustainably.

I do not quote items 2 through 4, because they do not introduce a very different flavour. As you can see, the target is rather general, but it does include some deadline (2020). "Mainstreaming" means placing on the agenda of what we do and what we think of. Until recently, biodiversity was not on the agenda (it was not in the "mainstream"). It was mentioned by professionals, but for most people this was an alien term.

Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use.

Items 5 through 10, such as:

5. By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.

Not only is there a deadline (the same year 2020), but there are also two numbers: 50% and zero. For instance, deforestation can proceed, but its rate should be at least halved. Thus if it was, say, 2% per year, it should be no more than 1% per year. This is not a very ambitious target, but – apparently – this was the only feasible one given the political preferences of signatories who need to adopt targets unanimously.

Strategic Goal C: To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity

Please note that all the three layers of biodiversity are mentioned (landscape – the first term, i.e. "ecosystems", includes landscape – species, and genetic diversity). This strategic goal has three targets only: items 11 through 13. Item 11 reads:

11. By 2020, at least 17 per cent of terrestrial and inland water, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes.

It contains several numbers. Please note the numbers: 17% (the terrestrial protected areas), and 10% (the marine protected areas). It has also a recommendation that protected areas should be "well connected". They should provide species with a possibility of safe migration from one protected area to another. There is one more remarkable word. Namely, protected areas should be equitably managed, that is they should be managed in a way which makes the local population better off rather than worse off.

Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services

Items 14 through 16:

14. By 2020, ecosystems that provide essential services, including services related to water, and contribute to health, livelihoods and well-being, are restored and safeguarded, taking into account the needs of women, indigenous and local communities, and the poor and vulnerable.

This is important, because in many cases it is the rich rather than the poor, and developed countries rather than developing countries who benefit from biodiversity protection. Item 14 emphasizes that those who have been excluded from benefitting should be taken care of too. It

may look strange that women are listed among those excluded, but in fact in many places, more than 50% of benefits of whatever societies do go to men. At the same time it is women who suffer from inadequate ecosystem services (think of women who are responsible for providing households with water; they look charming when – on their heads – they carry pots filled with water, but this is a hard job).

16. By 2015, the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization is in force and operational, consistent with national legislation.

Item 16 recommends that by 2015 so-called ABS (*Access and Benefit Sharing*), as outlined in the Nagoya Protocol becomes fully operational. I will explain the ABS mechanism later on.

Strategic Goal E: Enhance implementation through participatory planning, knowledge management and capacity building

Items 17 through 20:

17. By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.

Item 17 may seem to be a purely bureaucratic statement. Indeed it refers not to specific protection activities, but rather to planning. Nevertheless one should not neglect the importance of official documents. If there is no document to refer to, environmentalists can be ignored by the government. If there is a document to refer to, then environmentalists can press the government to explain what specific steps it took in order to accomplish something. For instance, if there is an official document which listed certain actions to reduce deforestation, then environmental NGOs can even effectively sue the government for not complying with its own plans.

Now let us move to the profound problem of access and benefit sharing (ABS). It was present in the CBD (art. 15.7) from the very beginning. The relevant article reads:

> *Each Contracting Party shall take legislative, administrative or policy measures, as appropriate, and in accordance with Articles 16 and 19 and, where necessary, through the financial mechanism established by Articles 20 and 21 with the aim of sharing in a fair and equitable way the results of research and development and the benefits arising from the commercial and other utilization of genetic resources with the Contracting Party providing such resources. Such sharing shall be upon mutually agreed terms.*

These two convoluted sentences simply say that if somebody makes a profit from biodiversity then he or she should pay to those who have protected this biodiversity. This is a fairly obvious principle, but – by far – it is not a simple one.

First of all, let us think how one can benefit from biodiversity. I have a very warm sleeping bag filled with a plastic material called hollofil (patented by a chemical giant DuPont – you remember this company from the lecture on the ozone layer). This is an excellent thermal insulation material which looks like miniature spaghetti. But if you take a microscope in order to see how these small hairs (bristles) look, you will see that each of them is empty inside. In other words, they are pipes. They are extremely light, because they have air inside. This is what polar bears are equipped with. Their body is covered with beautiful white hair which keeps them warm because of the unique thermal insulation capacity. Moreover, if the sun shines, the energy can easily penetrate the body like through a fiber-optic cable. The producer of hollofil was proud to claim that inspiration for inventing the material came from observing polar bears. Thus the inspiration came from biodiversity.

According to the CBD, should DuPont pay something to those who protect polar bears? It would be very difficult to calculate how much they are supposed to pay, and to whom. But hollofil is not a typical example of ABS. A more typical example is when a pharmaceutical company sends a botanist to a tropical forest to find a herb which can be used in order to produce a medicine or a cosmetic. Quite often the botanist comes back and brings a promising chemical substance. The company studies the substance in its laboratory, patents an appropriate chemical compound, and manufactures a drug. Should they pay something to those who made it possible to collect the herb and – in the end – to develop the drug?

Several problems emerge. The most important one is how much they should pay. Let us assume that the profit from selling the drug is 100 million USD. But the company may claim (perhaps honestly) that most of it is due to their laboratory work. Let us assume that 98 million USD can be attributed to the laboratory, and 2 million USD to the raw material collected in the forest. Accordingly, the benefit from the access to biodiversity is just 2 million USD; the rest comes from the laboratory.

Another big problem is whom to pay this amount to. In general those who preserved the biodiversity should be rewarded. One solution would be to pay the money to the guide who brought the botanist to the place where the herb could be found. Nobody takes seriously the idea to pay 2 million USD to a local guide. Perhaps the village where the guide was recruited should benefit? Or maybe the government of the country where biodiversity was preserved should claim the money?

None of these solutions seems to be good. An idea that proved to be successful is to give the money to an NGO which can be regarded as an institution linked to biodiversity preservation and – at the same time – linked to a local community that should benefit from the biodiversity preservation.

There is plenty of anecdotic evidence on what successful arrangements can look like. Formalized in the Nagoya Protocol, the CBD did not introduce regular reporting. Local communities can claim some benefits, and chemical companies should pay, but nobody knows exactly how much they do. There is one well documented success story that everybody refers to in this context. This is the famous Merck's arrangement in Costa Rica. Let us look at the story.

In 1991 Merck – the largest pharmaceutical company in the world – acknowledged that it was interested in Costa Rican biodiversity. It donated 1.135 million USD to a local NGO called InBio. The InBio is a scientific institute with a chemical laboratory capable of analysing local botanical resources. The institute committed itself to send to the Merck laboratory 10,000 samples collected in Costa Rican national parks. If any of these samples proves valuable as an inspiration for drug development, Merck would pay some royalty fee to InBio.

An enthusiastic interpretation of the deal is that a large company pays for biodiversity prospecting, and as a result, local capacity is developed. Given the fact that in 1991 Merck's revenue was 8.6 billion USD, and GDP of Costa Rica was 5.2 billion USD, analysts estimated that in the future the country may earn from biodiversity more than from any of its economic activities. The agreement has been referred to as a shining example of what benefits can be expected if biodiversity is preserved by a low income country.

Sceptics, on the other hand, indicate that the price paid by Merck was in fact very low. If you confront the donation of 1.135 million USD with 10,000 samples to be received, the price of one sample is just 113 USD which is less than 400 USD (a typical price paid to a local guide). Moreover, nobody knows what are the royalty fees to be paid if a sample proves to be commercially attractive. A suspicion is that they are not to be very high, because Merck can afford hiring more excellent patent lawyers than any Costa Rican authority. The bottom line is that the "success story" is a publicity event for the company rather than for biodiversity.

In the 1990s there was even a conjecture that the entire ABS idea is dangerous. Think of a pharmaceutical company which collects a sample, develops a drug, patents it, destroys the sample, makes the plant extinct, and enjoys a monopolistic position in the market. No other company has an opportunity to develop the drug; if they want to produce it, they need to buy the patent. This is a frightening scenario, but there is no evidence that it was ever attempted.

Coming back to the Merck-InBio deal, the cooperation seems to be rewarding for the Costa Rican scientists. Not only do they have a well-equipped local laboratory, but they can also benefit from visiting Merck laboratories in other countries. I think that the deal is beneficial for both sides. My concern, however, is whether it provides adequate incentives for biodiversity protection in Costa Rica, and whether it can be easily replicated.

The Nagoya Protocol compiled extensive lists of benefits from biodiversity exploration. These lists include twenty-seven categories classified either as monetary benefits or non-monetary benefits. The protocol states:

1. Monetary benefits may include, but not be limited to:
(a) Access fees/fee per sample collected or otherwise acquired;

and other items (b) through (j);

2. Non-monetary benefits may include, but not be limited to:
(a) Sharing of research and development results;

and other items (b) through (q).

The protocol serves as a reference for what prospecting companies can offer, and what local communities can demand. The "access fees" are perhaps the most obvious benefits these communities can expect when sharing their natural inheritance. However, "sharing of research results" is valuable as well. In plain language it means that a pharmaceutical company (like Merck) may give (for free?) some outcomes of research carried out not where the samples originated (e.g. not in InBio nor elsewhere in Costa Rica), but in its headquarters. If this happens, local communities will benefit, even though it is difficult to judge whether what they get corresponds to the value of biodiversity they preserved.

The CBD tries to overcome problems caused by the public good aspect of biodiversity. In short, for instance, Belgium benefits from what Indonesia does. If Indonesia pays something to preserve its biodiversity, the benefits may go to Belgium as well. The convention tries to create some mechanisms (such as ABS), so that beneficiaries can contribute financially.

The CBD is not as popular as UNFCCC, but it includes some characteristics which are common. In particular, it makes a distinction between the "rich" and the "poor" inherited from the Montreal Protocol. However, it uses somewhat less rigorous language. In particular, it avoids making a strict distinction like Annex I and non-Annex I countries. It prefers to refer to "developing countries" as those who need to be subsidized and "developed countries" as those who should pay. There are several articles (9, 12, 18, and 19) where developing countries are mentioned as those that have special needs. They expect to have easier access to modern technologies, international assistance in capacity building, and carrying out research. At the same time the convention (in art. 20.2) introduces the category of "economies in transition" which can take commitments like developed countries, but on a voluntary basis. Subsequent protocols allow for such a flexibility too.

The convention has not resulted in solving the problem of biological diversity, but it created a number of mechanisms that help countries to proceed with nature conservation and to let the rich pay for what the poor do.

Questions and answers to lecture 9

9.1 Does biodiversity confine to species diversity?

No. Species diversity is just one of three layers of biodiversity.

9.2 Why is the genetic diversity called population diversity?

Individuals making a population (like people living in Poland, pines growing in a specific forest, or algae prevalent in an aquifer) are often related to each other (have common ancestors) and hence they may have similar genetic material. Therefore population diversity or genetic diversity are considered synonyms.

9.3 Do zoological gardens and botanical gardens protect landscape diversity?

No. They can protect species diversity (perhaps even population diversity, if efforts are made to include not only individual species, but also different races and varieties). Nevertheless they cannot protect landscape diversity. Landscape diversity can be protected in national parks or other large scale protected areas.

9.4 Why is there such a drastic distinction between biodiversity found in central Africa and North Africa?

Thanks to sufficient precipitation, Central Africa hosts tropical forest which is particularly abundant in plant and animal species. In contrast, because of insufficient precipitation, North Africa is mainly a desert (Sahara). Consequently not many species can be found there.

9.5 Does the CBD have "teeth"?

No. The Convention on Biological Diversity (CBD) is toothless. It says that biodiversity is precious, it is poorly understood, and signatories should change this situation. However, it does not impose specific commitments. It vaguely says that those who benefit from biodiversity should pay to those who preserve it (*Access and Benefit Sharing*, ABS), without indicating any instruments to be used for this purpose.

9.5 What specific problems are addressed in protocols to CBD signed in Cartagena in 2000, and in Nagoya in 2010?

The protocols added "teeth" to the convention. The first one, signed in Cartagena, establishes certain principles that should be respected when manipulating with genetic resources. The second one, signed in Nagoya, expands principles of *Access and Benefit Sharing* (ABS). In particular, it states that developing countries (where attractive biodiversity has been preserved) should be compensated by developed countries (who benefit from this biodiversity, even though they did not participate in its preservation).

9.6 How many strategic goals (policy objectives) were included in *Aichi biodiversity targets*? What are these strategic goals?

There are five strategic goals (policy objectives) included in *Aichi biodiversity targets*:

- *Strategic Goal A: Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society*
- *Strategic Goal B: Reduce the direct pressures on biodiversity and promote sustainable use.*
- *Strategic Goal C: Improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity*
- *Strategic Goal D: Enhance the benefits to all from biodiversity and ecosystem services*
- *Strategic Goal E: Enhance implementation through participatory planning, knowledge management and capacity building*

9.7 Strategic goal E includes the target 17 which reads: *By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.* It sounds like a purely bureaucratic statement. Does it have any meaning for biodiversity?

Yes, it does. Despite negative feelings we may have with respect to bureaucracy, adopting a policy document is useful. The lack of such a document does not allow to press the government. Besides, the target 17 includes several details that are important for biodiversity. Take the word "participatory". This implies that the document must be prepared by citizens – not only by administrators. If a document is "participatory", then there is chance that it will be of interest not only to administrators. Now, let us look at an "action plan". This expression is more specific than just a "plan". It suggests that this plan includes specific tasks to be allocated to specific administrative or economic agents. If read carefully, the target turns out important, despite the first impression sensed by many of us.

9.8 What do you think about ABS? In its preamble, the CBD confirms that "States have sovereign rights over their own biological resources." Thus if you collect a sample, you should pay to the State. Is this a solution to free riding?

This is a difficult issue. The Irish are concerned about what the Brazilians do with the Amazon forest. The Brazilians insist that biodiversity preserved in the Amazon forest is their property, and the Irish should not interfere with what happens in another sovereign state. The preamble to the CBD confirms this sovereignty. On the other hand, biodiversity is a public good with all the problems linked to *free riding*. The convention requires that when a beneficiary takes advantage of biodiversity a payment should be made. This is justified, but it does not eliminate *free riding*. It is still possible that somebody does not pay, and yet takes advantage of the information somebody else paid for. State sovereignty and the *ABS* payments are justified, but they do not eliminate the public good aspect of the problem.

9.9 Do you think that the 1991 Merck-InBio deal is a fair one?

Probably yes. The implied price per sample 113 USD (lower than one could expect) may be justified by economies of scale. If you pay for a single sample (typically 400 USD), the calculation can be quite different from what is fair when you plan to collect thousands of them. I think that the deal is beneficial for both sides.

9.10 The Nagoya Protocol lists 27 types of benefits that can be claimed by the countries which allow so-called biodiversity prospecting. Do you think that non-monetary benefits are valuable?

I think so. Of course, there is a tendency to put emphasis on cash (monetary benefits). Nevertheless, non-monetary benefits can be valuable as well. If a European pharmaceutical company invites a Latin American biologist to an internship in its laboratory, then both sides can benefit from this.

9.11 Are there any similarities between CBD and UNFCCC (apart from the date of signature – 1992)?

The most immediate similarity is that both conventions address a global public good problem. Both of them are "toothless" in a sense that they do not force signatories to take any binding commitments. Both make a distinction (inherited from the Montreal Protocol) between the rich and the poor. Both identify the rich with the developed countries and the poor with the developing ones.

10. Rio de Janeiro 1992

United Nations (UN) Organisation convenes various conferences. Some of them – attended by heads of state, kings, queens, presidents and other VIPs – are called "Earth Summits". The word "summit" suggests that they are important, since they are attended by high-level officials. The word "earth" implies that the meeting is about the natural environment. "Earth Summits" have been convened every ten years since the 1972.

Here is their list:

- Stockholm 1972
- Nairobi 1982
- Rio de Janeiro 1992
- Johannesburg ("Rio+10") 2002
- Rio de Janeiro ("Rio+20") 2012
- Stockholm ("Stockholm+50") 2022

The first one was organised in 1972, following the so-called U Thant report – *The problems of human environment* (UN resolution 2398) – prepared by the United Nations in 1969 (Mr. U Thant was the UN Secretary General at that time). The report characterised the predicament as serious, and called for an international action.

The Stockholm conference was prepared professionally. Participants received materials supporting the claim that an immediate international action was necessary. An important book – *The Limits to Growth* by Denis Meadows *et al*. – was just published and triggered heated discussions about what the 21st century would look like. The organisers planned that two German states (West Germany and German Democratic Republic, DDR) would be represented by a single delegation. The government of the DDR felt offended and, as a result, all the Soviet bloc countries did not send their delegations to Stockholm.

The next summit was convened in Nairobi ten years later. Developed countries realised that developing countries (i.e. most of the world) were not interested in environmental protection *per se*. They were interested in how to improve their welfare. They argued that developed countries became wealthy in the 19th century, and they did not care for the environment at that time. The developing countries want to replicate this pattern; they will start to be interested in environmental protection once they get rich.

The argument is not quite correct. It is true that rich countries did not care about the environment in the 19th century. But the world was different at that time. Now it is impossible

to replicate this pattern, because the global environment is devastated and abused to a much larger extent than it was earlier. In other words, the development is not possible, unless people acknowledge that it has to be consistent with what the environment can cope with.

A special UN commission was established, called World Commission on Environment and Development, to look at the problem of how to convince the developing countries that the 19th century pattern cannot be replicated, and it is impossible to develop now, unless the environment is protected adequately. The commission – established in 1983 – was chaired by Ms. Gro Harlem Brundtland, the Norwegian Prime Minister; please see her picture below. She earned a reputation of one of the "greenest" officials, and – at the same time – she proved to be a skilled politician. In 1987 the commission published a report, entitled *Our Common Future*, which was translated into many languages. For obvious reasons, it is often called "Brundtland report". It is best known for the definition of "sustainable development" (SD) – a concept likely to be considered more attractive for developing countries than "environmental protection" is.

The definition of SD reads:

> *To meet the needs of the present without compromising the ability of future generations to meet their own needs.*

A large number of definitions of SD were suggested by academics and practitioners. They are much longer typically. The Brundtland definition is called classic, and I think that it deserves this. It is very succinct, it does not refer to environmental protection, but its consequences are

fundamental for the environment. Why should people be involved in environmental protection? If they are not, then they compromise "the ability of future generations to meet their own needs". But at the very beginning, the definition says "to meet the needs of the present". This is what developing countries are preoccupied with. On the other hand, they should not "meet the needs of the present" in a way which affects the future generations adversely. Unless they protect the environment, they will live at the expense of the future generations.

This is a very clever concept. Yet it is extremely difficult to operationalise. We will look at this later on. For the time being, it is important to emphasise that the concept became widely known and used (perhaps even abused) at the "Earth Summit" convened in Rio de Janeiro in 1992. Once again Poland could not play a political role it planned; this time, however, not because of a boycott of the event, but because of unfortunate internal political developments. The summit took place in June, right after a Polish political crisis which was linked to a change of the government. Consequently the Polish delegation was headed by the fired Environment Minister; this did not contribute to the prestige of the delegation.

By people who prefer pragmatism and simplicity the conference was a disgusting show (please look at the photograph below to see a group of self-confident men who applaud each other), but it resulted in adopting several important documents:

- UNFCCC
- CBD
- Convention to Combat Desertification
- *Agenda 21*
- Rio Declaration on Environment and Development
- Forest Principles

You know the first two conventions mentioned above (climate and biodiversity). I explained that the first one was signed in New York, and the second was written in Nairobi.

Nevertheless they are referred to as "Rio conventions". There was yet another convention adopted, namely the Convention to Combat Desertification (that will not be analysed in this class). There were hopes to adopt a convention on forestry, but it turned out that countries could not agree on its provisions to be binding. Consequently the text is called "Forest Principles". Also the "Rio Declaration on Environment and Development" does not have a strong legal status. It affirms the concept of SD from its classic "Brundtland" definition.

Agenda 21 is another important result of the Rio summit. The word "agenda" has two meanings in English: an official institution, or things to be done. Here it means the list of things to be done in the 21st century. The list includes 40 chapters (problems to be addressed). Chapter 24 is on the role of women in SD. Please recall my explanation from the biodiversity class (lecture 9) that women – especially in developing countries – do deserve a special status in this context.

Let us come back to the problem of sustainable development. This is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". In other words, it says that the present generation cannot leave the world in a worse shape than what was inherited from the previous generation. Economists say that the capital to be left to the descendants cannot be lower than the capital inherited from the ancestors.

The capital is whatever can provide us with benefits. Economists recognize three major types of capital:

- man-made,
- human,
- natural

Man-made capital is what was produced and what can be used by us whether directly or indirectly. Cars, computers, and buildings are examples of this type of capital.

Human capital is what we have in our brains and hearts. Engineering knowledge is an obvious example of it. But also trust and honesty belong to this category. Think of how our daily life would look if we did not trust each other. When we make shopping, the buyer gives the money to the counter clerk, and the seller gives the product we asked for. There is a moment such that the buyer got the product already and did not pay, or – conversely – the payment was done before getting the product. We do this, because we trust each other, and do not treat each other as thieves. If I suspect that the person I give my money to, or I get the money from, is a thief, then the transaction becomes much more cumbersome.

Natural capital is what we can use (directly or indirectly), but was not necessarily produced by us. Trees in a forest or fish in a pond are examples of the natural capital.

Based on distinguishing between these three types of capital, there are two fundamental concepts of sustainability:

- Weak sustainability: all capital types are substitutable,
- Strong sustainability: all capital types are complementary.

Substitution and complementarity are two important concepts used in economic analyses. If something can be replaced by something else, economists say that substitution is possible. Substitutability is thus the ability to be changed for something else. In contrast, complementarity means that things cannot be changed for each other; they need to be applied together, sometimes even in fixed proportions; please recall the concept of the limiting factor (lecture 2).

Herman Daly, a prominent environmental economist, suggests that in many cases the three types of capital are complementary rather than substitutable. Think of building a house (in USA, where he lived, most houses are wooden houses). You need to have a saw, engineering knowledge, and timber. Saw is an example of man-made capital, engineering knowledge is an example of human capital, and timber is an example of natural capital. In order to build a house, you need to have certain amount of timber. If your engineering knowledge is poor, you will probably use too much timber (boards could have been thinner, if you knew how to calculate their width in order to support the construction). Thus you can save on natural capital, if you have a better human capital. Likewise, you can save on timber, if you use a better saw. When you cut boards, some wood is wasted in the form of chips. A very sophisticated saw (a laser instrument or something like that) can cut boards almost without any waste. Thus it is possible to save on natural capital by applying more man-made capital. But is it possible to substitute the natural capital with other types of capital fully? The answer is obviously "no", because some timber is always necessary in order to build a house.

Let us come back to discussing the two concepts of sustainability, that is whether various types of capital are substitutes or complements. The definitions above can be reworded in the following way:

- Strong sustainability:
  - no natural capital (especially no exhaustible resources) can be depleted

- Weak sustainability:
  - depletion of exhaustible resources should be offset by investing in other types of capital (perhaps in renewables)

But there are fundamental problems with either of these concepts. Take strong sustainability first. What if a country uses its oil resources? The next generation will inherit less oil. This contradicts the principle of non-depletion. But, on the other hand, can you think of a political leader who advises his (or her) constituency not to use the oil, because the amount of oil to be handed over to the next generation would be lower than inherited? This makes the strong sustainability impossible to be implemented.

Now, take weak sustainability, and please refer to a hypothetical conversation between myself and my grandchildren. My grandson complains that he has less trees than what I could enjoy when I was young. I confirm that, indeed, two trees are missing from what I inherited from my ancestors. If a tree is worth, say 400 €, it means that I depleted the natural capital by 800 €. Yet, I inherited no computers, and he has one. Thus his man-made capital is increased by 1000 € (assuming that this is the value of his laptop). In other words, the loss of natural capital was more than compensated by the accumulation of man-made capital. However, my grandson says that his value of a tree is 600 €. Thus the loss of natural capital corresponds to 1,200 €, which is less than what the previous generations accumulated in the form of new man-made capital for him. According to my assessment, (weak) sustainability was satisfied.

According to my grandson, the development was not sustainable; not only strong sustainability was compromised, but even weak sustainability was.

Who is right? It is difficult to judge, but probably I am wrong. I put the value of 400 € on a tree, while my descendants evaluate it higher. The definition of SD includes the words "without compromising". Apparently my descendants who place a higher value on the natural capital than I did, may feel that their welfare was compromised. Weak sustainability involves values to be placed on various types of capital (otherwise it would be impossible to assess substitution). In the case of a single generation it is possible – at least in principle – to agree on values the society places on various goods and services. In the case of analyses involving different generations there is no method to arrive at values to be agreed upon – even in principle – by those who live in different times. Economic values reflect people's preferences as revealed in their choices. No generation can guess what will be the preferences of its descendants (say, 100 years from now).

There is one more reason which makes weak sustainability difficult to operationalize even if the controversy about people's future preferences can be resolved somehow. This is uncertainty about the fate of the natural capital. Its depletion may cause irreversible damages whose consequences nobody can predict. For instance, cutting trees in a forest is consistent with the weak sustainability principle as long as the revenues are invested in other types of capital. Deforestation, however, can lead to biodiversity loss (which is irreversible) with much more acute adverse consequences for welfare.

Problems with weak sustainability can be summarised in the following way:

- Irreversibility of environmental damages
- Uncertainty of societal preferences
- Economic valuation of non-market goods

Each of these issues casts doubts whether the weak sustainability concept can be operationalised in a reasonable way.

Hence there are fundamental problems with SD. Yet sustainability has been a reference for numerous economic analyses. In addition it has been a hope for developed country politicians to convince developing country citizens about the necessity to protect the environment even before other (justified) needs are met.

Herman Daly suggested how to operationalise the SD concept in a way which is free from theoretical shortcomings of both weak and strong sustainability definitions. Here is the summary of his proposal (published before the Rio summit).

- With respect to the physical volume of inputs into the economy and its outputs: by consciously limiting the overall scale of resource use, shift technological progress from the current pattern of maximizing throughput to maximizing efficiency understood as the ratio of economic effects achievable from a given throughput.

- With respect to renewable resources: by exploiting these on a profit maximizing sustained yield basis prevent them from being driven to extinction. More specifically this means that:

- with respect to resources serving as inputs such as plants and animals, harvesting rates should not exceed regeneration rates;
- with respect to resources serving as "sinks" such as the atmosphere of the Earth, waste emissions should not exceed the assimilative capacity (which is renewable).

- With respect to exhaustible resources: maintain the total stock of natural capital by depleting non-renewable natural components (such as mineral deposits) at a rate corresponding to the creation of renewable substitutes.

Let us explain all the items of this proposal. There is the word "throughput" in the first bullet. This is not a common word in English, but everybody knows what input and output mean. Throughput – a combination of input and output (not an average!) – can be best translated as a flow of resources. For example, modern agriculture applies chemical fertilisers which include, among other things, phosphorus mined in Morocco (and elsewhere). Extractive industries degrade the environment and should be limited. Fertilisers imported from Morocco are used in Latvia (and – of course – in other countries). Some of them are washed out from the fields, and contribute to the Baltic Sea eutrophication. Environmentalists struggle against the eutrophication of the Baltic Sea (lectures 2 and 3), and they try to limit the emission of phosphorus from agriculture. The idea of "throughput" is to link "inputs" and "outputs". Instead of looking at the problems in Morocco and Latvia separately, i.e. how to protect the landscape in Africa, and how to reduce the eutrophication of the Baltic Sea, Herman Daly explains that both can be addressed by simply looking at the phosphorus flow through the global economy.

Our efforts are aimed at maximising the throughput presently. Please recall what we are exposed to every day: "if you buy two units instead of one, you will save"; "spend your next holiday in another continent"; "change your old car for a new one"; etc. Instead of maximising it, the throughput should be limited to what the environment can cope with. This does not imply that there is a limit to economic welfare. No. Material welfare can grow by maximizing the efficiency understood as the ratio of economic effects achievable from a given throughput. Technological progress can lead to such an outcome, but – for the time being – it is focused on something else (the technological progress is focused on maximising the throughput).

The second bullet provides recommendations with respect to renewable resources. These should be managed on a "profit maximizing sustained yield basis". This means that these resources cannot be driven to extinction. There are two types of renewable resources: those which serve as "inputs" and those which serve as "sinks". The examples of the former are plants and animals; their harvest level cannot exceed their natural regeneration rate. For instance, in Poland, the forest increases its biomass by around 4-5 m^3/ha per annum; thus timber harvesting should be limited by this number. The example of the latter is waste absorption capacity of the environment. For instance, a lake can absorb a certain amount of nutrients without deteriorating its quality; thus the load of these nutrients should not exceed this number.

The third bullet refers to exhaustible resources, like natural gas. According to the strong sustainability concept, exhaustible resources should not be used at all. According to the weak sustainability concept, they can be used, but the depletion of the natural capital has to be substituted by an adequate accumulation of other types of capital. Herman Daly combines both principles by recommending that not only the total stock of the capital, but also the total

stock of the natural capital should be preserved. This does not mean that its composition has to be kept unchanged. If natural gas is burnt (many people consider it a necessary source of energy), then its stock is depleted obviously. The third bullet states that this stock depletion has to be accompanied by investment in renewable energy (photovoltaics, windmills, etc.). If this principle is complied with, the total stock of the natural capital will not be depleted.

Sustainability is an important concept. It is a reference for attempts to free economic development from environmental disruption. SD was not invented in 1992 (it was defined already in 1987), but it was launched at the Earth Summit in Rio de Janeiro. Since that event, SD has become one of the most popular terms in environmental debates.

Despite its popularity, it is affected by several misconceptions. The most important one is a confusion with environmental protection. Quite often, instead of claiming environmental friendliness, firms, cities, and consumers try to prove their alleged "sustainability". It is impossible to apply the classical definition of sustainability ("meeting the needs of the present without compromising the ability to meet future needs") to individual firms, cities, and consumers, but the term is so popular that people abuse the word commonly. They think that they move towards sustainability whenever an action is taken to protect the environment.

An important example of abuse is an attempt to declare "sustainability" at a local scale. The definition of SD makes sense at the planetary level only. At any smaller scale it is not possible to prove that "present needs were met without compromising the ability to meet future needs". For instance, I read a number of "sustainability reports" written by firms which claim that they develop sustainably. A typical claim is supported by some evidence of a prudent use of raw materials, recycling, and caring for local populations in order to maintain good public relations. The firms use energy and imply (perhaps indirectly) certain carbon dioxide emission, but this is allegedly "offset" by planting trees. They create an impression that they do not deplete the natural capital, which is not true. If a depletion occurs, the firm who declares sustainability can attribute it to somebody else, even though it is doubtful whether one does not benefit from what this "somebody else" makes while depleting the capital.

On top of that there is a confusion with other terms, such as balanced development (growth) and eco-development. Sustainability is about intergenerational fairness. Balanced development implies that everything should be counterbalanced with something else: small with large, new with old, wet with dry, and so on. This perhaps makes sense, but it has nothing to do with SD. Likewise SD is not synonymous with eco-development. The latter is identified as development making use of biological (or – more generally – ecological) resources available. It is nice if you wear a cotton shirt rather than a nylon one, but cotton plantations do not have to be "sustainable" in whatever sense. There are scientific dissertations on links between SD and other terms, but one has to keep in mind that sustainability was defined in a succinct way in 1987, and it conveys an important message. Other related concepts are more vague and they have been researched less thoroughly.

Questions and answers to lecture 10

10.1 Why is the 1992 Rio de Janeiro conference called "Earth summit"?

It is called "Earth summit" for two reasons. First, it was attended by heads of state (kings, queens, presidents) and other high-level officials. Second, it addressed key problems of how to protect the earth's environment.

10.2 How and why did the United Nations system work on the concept of "sustainable development"?

Following the Stockholm 1972 and Nairobi 1982 conferences, many activists realised that the idea of environmental protection is not interesting to low income countries. These countries declare a priority to develop their economies first. Consequently environmental protection makes sense for them only when they are convinced that it is a prerequisite for economic development. Hence the establishment of the World Commission on Environment and Development (chaired by Ms. Gro Harlem Brundtland) in 1983. The commission – called the Brundtland commission – worked out a definition of sustainable development (SD) as "meeting the needs of the present without compromising the ability of future generations to meet their own needs". Since the publication of *Our Common Future*, which contained the definition, the UN system has emphasised the necessity of promoting the SD rather than environmental protection.

10.3 Should the concept of intergenerational fairness appeal to low income countries?

In principle, yes. The very definition of SD starts with words "to meet the needs of the present" – something which is the obvious priority of low income countries. Intergenerational fairness is included in the next words, i.e. "without compromising the ability of future generations to meet their own needs". There are two problems though. The first problem is caused by a doubt whether the present high income countries did or did not compromise the ability of future generations to meet their own needs. They did not compromise for the sake of their own societies, but – of course – they compromised it for others. The low income countries see this and they state that the present high income countries did not develop sustainably. The second problem is caused by the fact that in low income countries short term considerations are given priority. If basic needs are unmet, and if many people are not certain if they are going to survive the next year or so, it is unrealistic to expect that they care for future generations. Thus intergenerational fairness may be understood, but it is unlikely to drive political decisions.

10.4 What were the most important documents adopted in Rio de Janeiro in 1992?

In my lecture I listed:

- UNFCCC
- CBD
- Convention to Combat Desertification
- *Agenda 21*
- Rio Declaration on Environment and Development
- Forest Principles

Hence these are 3 conventions, an important book (*Agenda 21*) which translates the SD idea into practical activities, and two declarations which – unlike conventions – are not legally binding.

10.5 Why did the *Agenda 21* devote an entire chapter (Chapter 24) to the role of women?

Because women are likely to appreciate environmental improvements more than men. In many countries of the world it is the women who perform more than 50% of the work, and they are worst hit by inadequate quality of the environment (like the lack of safe potable water, or scarcity of fuelwood).

10.6 Is the knowledge of environmental protection a part of the natural capital?

The knowledge of anything is a part of the human capital. It can be argued, however, that the knowledge of environmental protection may influence the natural capital. For example, let us assume that there is a lake which is used as a sink to discharge wastewater. If the pollution load is moderate, then the lake does not lose its assimilative capacity, and it can be used – as their "natural capital" – by the local population. However, if the pollution load is excessive – which may happen as a result of poor knowledge of environmental protection – it will become dead. Consequently a part of the natural capital will be lost. In this sense, the knowledge of environmental protection may influence the availability of the natural capital. Nevertheless it has to be included in the human capital; otherwise double counting will occur.

10.7 What makes the concept of "weak sustainability" controversial?

"Weak sustainability" relies on the assumption that various types of the capital can substitute for each other. There are several problems with this assumption. First – as Herman Daly argues – the three main types of capital are substitutes to some extent only; it is impossible to substitute the natural capital fully. Second, irreversible effects of depleting the natural capital are hard to predict, and thus they cannot be compensated by an adequate supply of other types of capital. Third, in order to check if a depletion of the natural capital is compensated by an adequate supply of the man-made capital, the former has to be evaluated; yet the next generation may have different values than the generation which made the valuation.

10.8 What makes the concept of "strong sustainability" controversial?

"Strong sustainability" is politically infeasible, since it precludes using exhaustible resources at all.

10.9 How does Herman Daly try to combine weak and strong sustainability?

He allows using exhaustible resources at a pace corresponding to investing in renewable substitutes. For example, copper can be used if an adequate supply of fibre-optic is made available; oil can be used if an adequate supply of energy from renewable sources is made available. The difference between his principle no. 3 (pages 108-109 above; IEC-10-11 in my overheads) and weak sustainability is that the latter relies on monetary valuation, while the former – on comparisons in physical units (such as the length of cable or the number of kilowatt-hours).

10.10 Why is it better to analyse the throughput rather than input and output of a given resource separately?

Let us refer to the phosphorus flow example (page 109). Modern agriculture applies chemical fertilisers which include, among other things, phosphorus mined in Morocco. Extractive industries degrade the environment and should be limited. Fertilisers imported from Morocco are used in Latvia. Some of them are washed out from the fields, and contribute to the Baltic

Sea eutrophication. Now let us assume that for landscape protection reasons Morocco decided to limit the mining of raw phosphorus. As a result, the supply of mineral fertilisers goes down. Is it sufficient to solve the eutrophication problem? Or let us start from the other end of the flow. Let us assume that – for the Baltic Sea protection reasons – Latvia decided to constrain the application of phosphorus fertilisers. As a result, the demand for raw phosphorus went down. Was this sufficient to solve the landscape disruption in Morocco? In both cases the answer is: not necessarily. In order to solve both problems consistently, it is better to control the throughput rather than input and output separately.

10.11 Are we encouraged to limit throughput in our daily life?

No. On the contrary, we are encouraged to maximise the throughput. Please recall what we are exposed to every day (page 109).

10.12 Can rural populations – as opposed to urban populations – demonstrate sustainability of their developments?

No. Over the last several thousand years rural populations lived in areas that were larger than what they required in order to survive, while urban populations relied on areas larger than what they owned. This resulted in an opinion that rural populations lived sustainably, while the urban ones did not (they relied on more resources than they owned). This opinion is justified to some extent, but the sustainability question is a more complex one. Both populations required each other in order to survive and develop. Urban populations relied on food produced on land which did not belong to them, and rural populations relied on goods and services produced in cities. This is how the division of labour functions. Neither population (whether urban or rural) can demonstrate sustainability of their operations as long as they exchange certain things between them. Sustainability can be checked at the planetary level only (assuming that the planet does not exchange anything with the rest of the Universe – which is only approximately true).

10.13 Please argue whether an airlines company which offsets its carbon dioxide emissions by planting trees can be considered sustainable?

No. Offsetting carbon dioxide emissions by planting trees does not imply sustainability. First of all – despite what is believed – trees do not produce oxygen. Thanks to photosynthesis, trees convert carbon dioxide into oxygen during the day, and breathe (convert oxygen into carbon dioxide) during the night. While they are young the first process is stronger than the second one. When they are old, it is the other way around. The mature forest (ecologists call it a "climax ecosystem") has a neutral balance in terms of oxygen and carbon dioxide. Thus planting trees cannot offset carbon dioxide emission caused by burning fossil fuels. This process can only store (sequestrate) carbon temporarily. Besides, often "offsetting" does not imply more trees planted; those who plant the trees on their land would have planted them anyway. They are just pleased to earn extra money for the investment.

11. International environmental assistance

Sustainable development is a great concept. Unfortunately not everybody takes it seriously and in many places, the natural capital has been depleted to a catastrophic level. Developing countries prefer to maximise economic growth even at the expense of future generations. It is

expected that developed countries should protect the environment everywhere, and – to some extent – they do. Developed countries subsidise environmental protection in developing countries for several reasons. First of all, they do it for humanitarian reasons; without the subsidies the standard of living in developing countries would have been even lower. Besides, in some cases developed countries "buy" an additional supply of public goods (such as global climate protection or global biodiversity) if they feel that developing countries are less sensitive to the problem. Moreover, an important motive for assistance is the promotion of domestic products: developed countries hope that when their experts establish successful relations with local administrators, the latter will import from firms identified by the former.

There is no official statistics of international assistance. Most of the data come from so-called Development Assistance Committee (DAC). This is a club of 29 countries and the European Union. DAC data do not exhaust what is spent by one country in order to assist another one, but they outweigh anything else. If there are assistance projects undertaken by countries which do not belong to DAC, their contribution to the total is small.

The DAC definition of development assistance includes four conditions. They read:

- Undertaken by the official sector (rather than private entities)
- With promotion of economic development and welfare as the main objective (even though they may serve other purposes as well)
- At concessional financial terms (in the case of a loan, the pay-back terms should be more favourable than the standard 10% interest, and no grace period; a grant element of these terms should be equivalent to at least 25%)
- grants, loans and credits are not for military purposes

The first condition seems fairly obvious, but it creates distortions in how the generosity of various donors is perceived. For instance, most Europeans prefer to have their governments active in this field. In contrast, Americans prefer to donate through private rather than public entities. As a result, in the case of USA, DAC numbers are little relevant, since most donations are channelled not through the government.

The second condition is not very important, since almost any purpose can be seen as linked to economic development and welfare. A project which hampers economic development and lowers the welfare of citizens would not qualify, but it is difficult to contemplate such an endeavour.

The third condition needs to be explained. Let us say that a donor offers a loan to a prospective beneficiary. 1 million € is to be given, interest rate is 5%, the grace period is two years, and the money is to be paid back in two instalments. The first instalment covers just interest (5% of 1 million, i.e. 50,000), and the second one – interest plus the capital. The *Net Present Value*, NPV, of this arrangement (using the standard 10% discount rate; $1/1.1^3=0.75$, and $1/1.1^4=0.46$) can be calculated as follows.

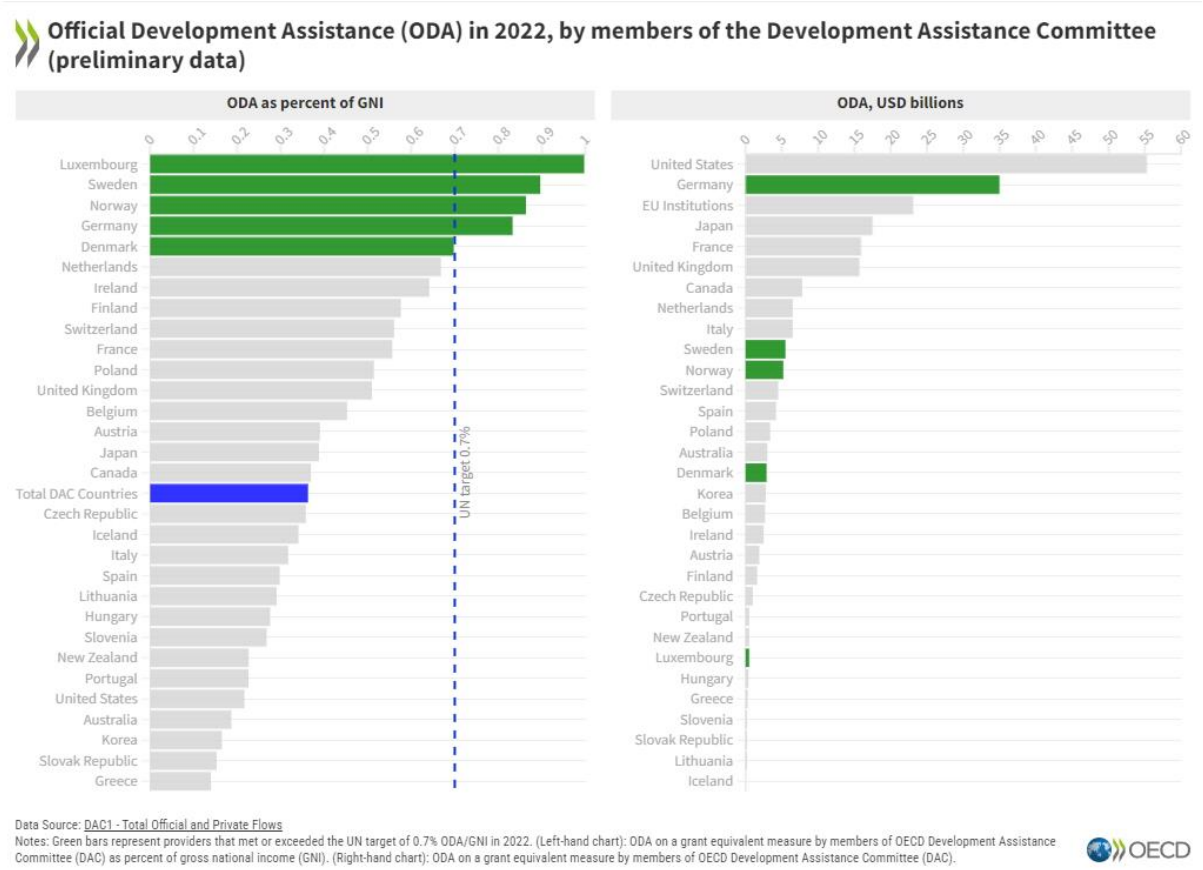
NPV = 1,000,000-50,000x075-1,050,000x0.46 = 1,000,000-37,500-483,000=479,500.

This is 48% of the original amount, i.e. more than 25%. Please also note that eliminating the two-year grace period would bring the NPV down to

NPV = 1,000,000- 50,000x0.91-1,050,000x0.83=1,000,000-45,500-871,500=83,000

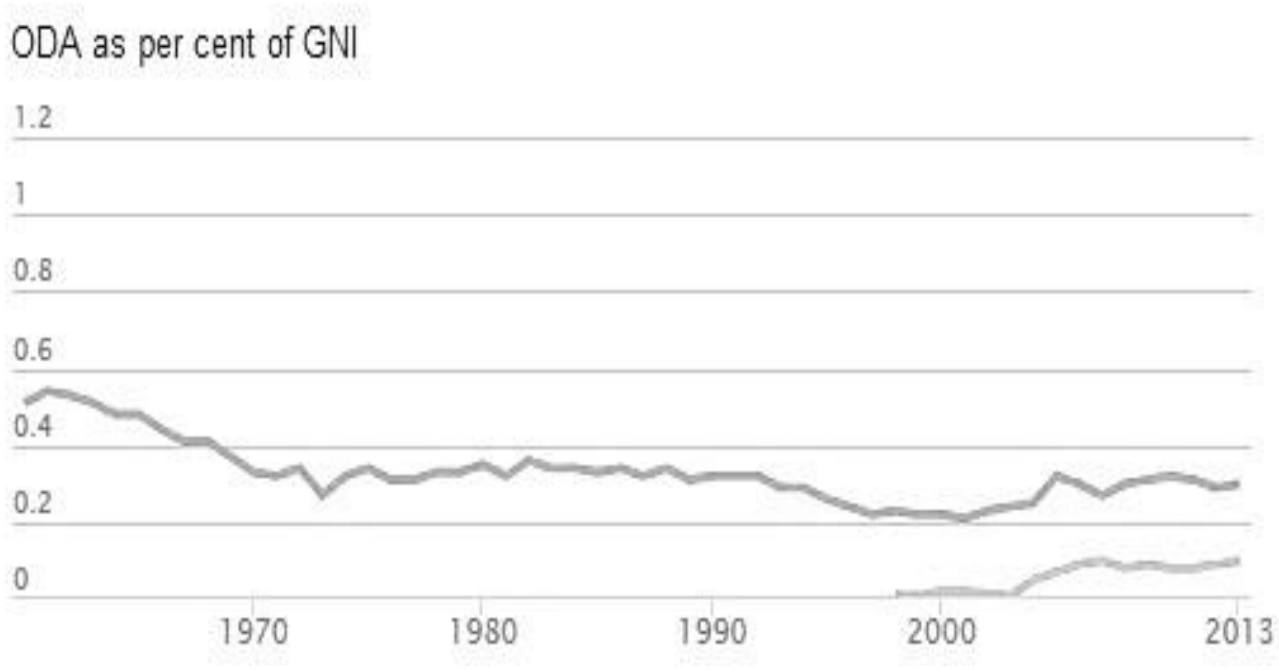
(since 1/1.1=0.91, and $1/1.1^2$=0.83), that is 8.3% of the original amount. Then the grant component would be lower than the required 25%. Technical details of how to calculate the *Net Present Value* of complex payment plans is beyond the scope of this class. You simply have to remember that not every loan has a sufficient grant component in order to be considered "assistance".

The last condition is fairly obvious again. Any money spent on military equipment is not considered development assistance.



Pictures above provide an illustration of what transfers we talk about. They refer to the (preliminary) 2022, but the statistics is fairly stable. In absolute terms, the USA is the largest single donor, and Luxembourg is one of the smallest ones (see the right panel). In relative terms, i.e. in relation to GNI (*Gross National Income*, an aggregate similar to a better known *Gross Domestic Product*), Luxembourg – accompanied by Sweden, Norway, Germany, and Denmark – emerges as one of few countries in the world which spend on ODA at least 0.7% of their respective incomes. An average for the entire DAC is less than a half of this UN target. USA is also below this target, although – as I indicated earlier – this is because of the attitudes of Americans who prefer to donate through private organisations rather than the government budget. Poland is not a very generous donor, but because of the size of its economy, in absolute terms it donates more than Luxembourg. In terms of GNI, the average for DAC countries used to be higher in the 1960s (0.5% or more). Later on it went down, and it has oscillated between 0.2% and 0.4% over the last 50 years (see picture below). The Polish statistics is much lower (the lower line in this picture). It corresponds to 0.1% of Poland's GNI

with a slight upward trend. Nordic countries (Norway, Sweden, Denmark and Finland) rank the highest which reflects two circumstances. First of all, they are more generous than others. On top of that, Nordic citizens put exceptional trust in their governments. They assume that their officials can spend the money more efficiently than anybody else. As a result, unlike Americans, they support private organizations to a lower extent.

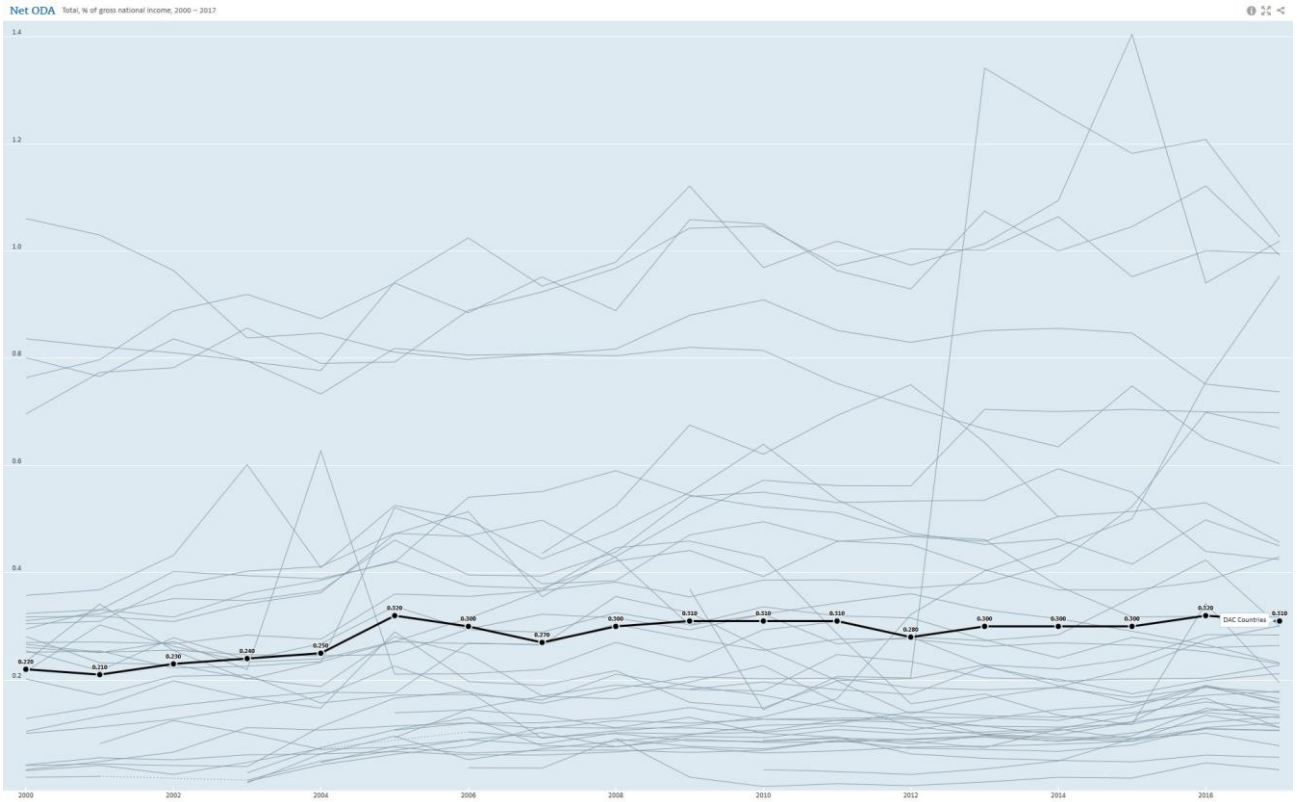


The most recent statistics in terms of GNI (without indicating specific countries) is given in the upper picture on page 117. The graph is difficult to read, but you will find six countries identified in the lower picture. For obvious reasons, among the identified ones, there are four Nordic countries (Denmark, Finland Norway, and Sweden). There is also a diagram for Poland, as well as for United Arab Emirates. The latter is not a DAC country, so its contribution is not included in DAC statistics. It is remarkable though, since its contribution exceeds that of Nordic countries. There were two non-DAC countries – Turkey and UAE – whose contributions (per unit of GNI) exceed that of the DAC average.

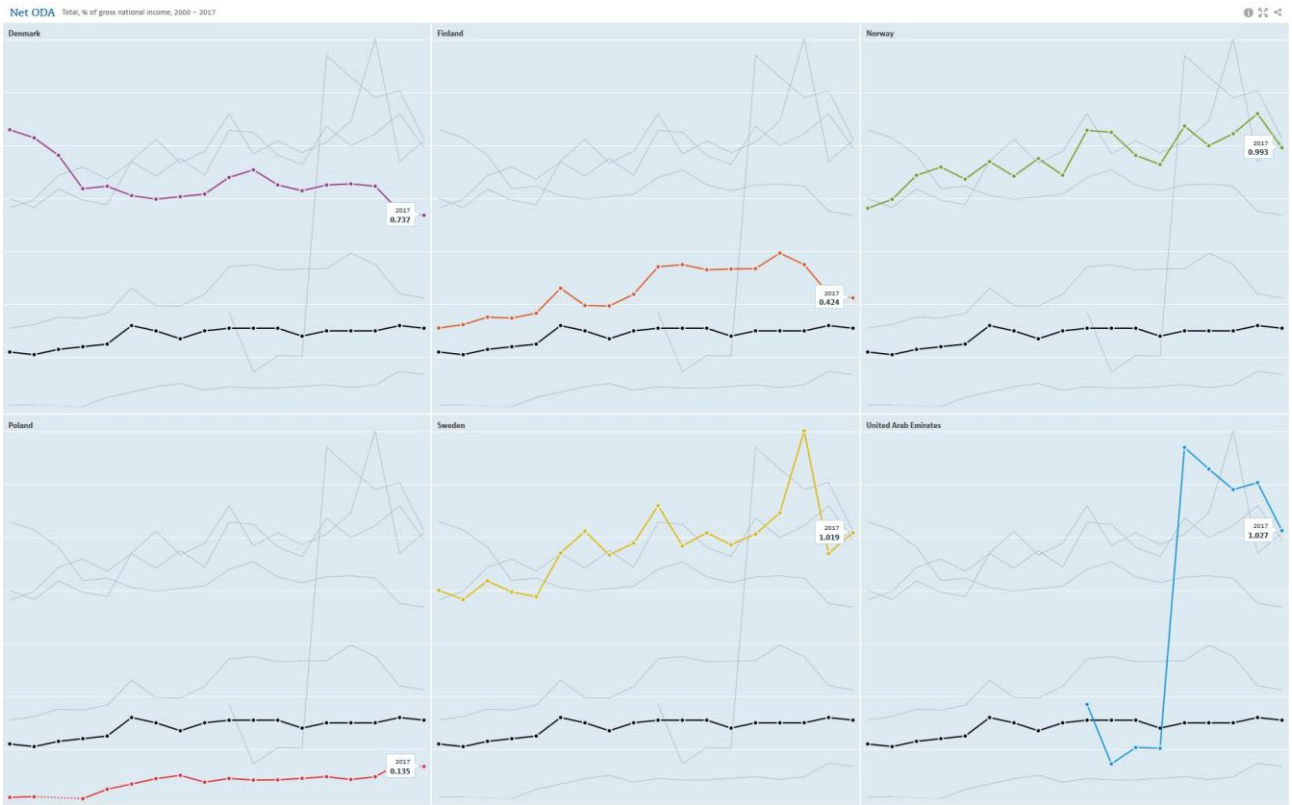
In total, DAC countries' contributions made roughly 180 billion dollars in 2012. The population of the world could be estimated at somewhat more than 7 billion people. Out of this amount 1 billion can be considered the "rich" (developed country citizens), and 6 billion – the "poor" (developing country citizens). In other words, 1 billion people donate, and 6 billion people benefit. This is a very rough approximation, but it gives an order of magnitude. On a per capita basis, the rich spend 180 dollars per year, and the poor receive 30 dollars per year.

This quantitative assessment can be summarised as follows:

- Total ODA was almost $180 billion in 2012 (now it is more)
- In current prices, it has grown by 3%-4% annually
- Growth has been slower in real terms
- The total corresponds to
  - $180 per head in donor countries
  - $30 per head for an average recipient of ODA



DAC trend (thick black line)



Six countries identified (thick black line is the DAC total)

These are average numbers. More detailed inquiries reveal large geographical and time variations. Let us look at the following two examples:

- Iraq received over $20 billion in 2005, but between 2009 and 2012 it got less than $2 billion per annum
- In contrast, between 2009 and 2012, Afghanistan received more than $6 billion each year, while between 2000 and 2008 the assistance was several times less

You do not have to be a sophisticated political analyst to explain these variations. In 2003 Saddam Hussein was overthrown and in 2004 many American and European leaders hoped to establish a Western-like democratic system in Iraq. Consequently a large flow of assistance money was directed to this country in 2005. Later on, between 2009 and 2012 Iraq received less than 10% annually, once donors realised that the process is more difficult than expected. Likewise in Afghanistan. In 2000-2001 the country received less than 500 million dollars per annum. In 2009-2012 the assistance grew, but after 2012 it declined again. Neither Iraq, nor Afghanistan faced significant changes in economic welfare. It was the political situation that changed and triggered changes in donors' attitudes.

The numbers quoted so far referred to the total ODA, but in this class, we are interested in environmental protection. There are no good statistics to capture this area separately. According to OECD statistics, water and sanitation, energy, agriculture, forestry, and fishing – a category somewhat broader than environmental protection – may serve as its upper estimate. It grew from $15.5 billion in 2006 to $35.7 billion in 2012, i.e. from 12% to 20% of ODA. Hence one can estimate that environmental protection attracts around 15% of the total ODA.

While there are no possibilities to analyse the environmental component of ODA for the entire world, fairly detailed statistics is available for Poland. In the 1990s Poland was an important recipient of environmental assistance. It may seem odd, that Poland – even though it was better off than many developing countries – attracted more assistance than others. There were two reasons behind this unprecedented situation. First, taxpayers in many developed countries were inspired by news about environmental disruption in the former Soviet bloc. Poland belonged to this bloc and its environment was perceived as an unprecedented victim of the central planning regime. Second, unlike many other post-communist countries, Poland offered a fairly stable administrative infrastructure, promising much less corruption than in alternative destinations. As a result, Poland received quite sizable environmental assistance. The amount pledged for 1991-1996 was $230.1 million, i.e. $46 million per annum – slightly over $1 per head. The amount did not make a dramatic change. It accounted for 1%-2% of environmental investment in the early 1990s. Despite its moderate quantity, the assistance was important from the point of view of environmental protection in Poland.

Quantitative assessments for 1991-1996 in Poland can be summarised as follows:

Areas of expenditure
- 39% spent on air protection
- 26% spent on water protection

Types of expenditures
- Investment expenditures – 57%
- Pre-investment expenditures (e.g. technical projects, analyses, etc.) – 22%
- Other (such as training) – 21%

In terms of areas of expenditure, air protection received more money than water protection. The difference can be explained in two ways. One explanation is that air protection was better prepared to absorb the assistance. Another one refers to externalities: donors could have been more interested in the acid rain (lecture 4) than in the eutrophication of the Baltic Sea (lectures 2-3).

Many Polish environmentalists complained that the money spent on investment expenditures ("real" projects) accounted for just 57%. They were upset by the fact that 21% of the money was spent on "unnecessary" projects such as training. A common opinion was that domestic experts know very well what the money should be spent on, and foreign donors should finance investment expenditures only. This was not quite correct, since several technical projects and analyses revealed important errors in the domestic plans. A typical error of a plan to build a sewage treatment plant was an overestimation of the number of people to be served. The plan could have based on an outdated projection of the number of inhabitants, while a drastic correction was in fact necessary. Also trainings turned out to be necessary in some cases when there was a lack of human capital needed to make a proper use of the man-made capital to be received. All in all it was not so much the quantity of assistance but rather the cooperation between Polish and international experts which made the assistance a valuable component of the country's environmental recovery after decades of the central planning system.

The last important topic of this international environmental assistance class is "tied" procurement. This term means that money must be spent on purchases from the donor country. A donor simply states a condition that the beneficiary must use the money received in order to import goods or services from the country the money comes from. The idea is justified. Taxpayers are more satisfied when they see that assistance money flows back in the form of new contracts.

On the other hand, according to studies carried out by the World Bank, "tied" procurement increases the cost of purchases by 15%-30%. This is caused by the fact that without "tied" procurement buyers can compare offers from various sources and select the cheapest one. If the procurement is "tied" then the buyers have to stick to just one group of potential sellers. In particular, if there is just one seller from a given country, the firm, which is not afraid of being outcompeted by anybody else, may charge a price much higher than in a competitive market.

As a result of studies which demonstrated that "tied" procurement leads to higher prices, in 2001, OECD issued guidelines to "untie" development assistance. Following efforts exerted by international organisations, the share of "untied" assistance grew from 46% to 82% by 2008.

Nevertheless this outcome cannot be seen as a fully successful one. Even though the "untied" share of ODA increased significantly, still there are informal mechanisms to confine the list of potential suppliers to what a donor prefers. When beneficiaries ask about the stability of the assistance flow, donors may rightly say that the future depends on politicians. If they are pressed to continue, they will do so. Yet if they sense that taxpayers complain about the money supporting export of their foreign competitors, they will not. Thus, even if there is no formal "tied" procurement, the message beneficiaries get is to better buy from where the money comes from.

To sum up: international environmental assistance has not been spectacular. It corresponds roughly to the amount of 25-30 billion dollars per year (15% of 180 is 27), which makes 25-30 dollars per donor (citizen of a donor country) and 4-5 dollars per beneficiary. On the part of donors there is a tendency to support activities that their experts and manufacturers can profit from. On the part of beneficiaries there may be a preference for hardware rather than software projects.

Questions and answers to lecture 11

11.1 Why do developed countries subsidise environmental protection in developing countries?

There are several motives to subsidise developing countries – including altruistic feelings. When it comes to environmental protection, two other motives may be added. One is similar to the *Victim Pays Principle*. This applies to situations where the beneficiary imposes an external cost on the donor. It may be relevant for some Southern European countries when they try to protect the environment in Northern Africa. Perhaps a more important motive is to improve the supply of a public good which is not appreciated by recipients of the assistance. Money spent on renewable energy sources in developing countries can be interpreted as an investment in climate protection (see lecture 6).

11.2 Does DAC (*Development Assistance Committee*) statistics cover all the development assistance money available?

No. It does not cover the development assistance financed by countries which were not involved in this activity earlier. For instance United Arab Emirates started to disclose the relevant statistics as late as 2009. Turkey started in 1991. The assistance originating from either country is about 4 billion dollars now. These countries are not members of the DAC. In addition, assistance financed not by official budgets is not included in DAC statistics. This is particularly important in the case of USA where citizens prefer to act through private entities rather than government channels.

11.3 Can an export promotion loan be considered an ODA (*Official Development Assistance*)?

Yes. As long as the grant component exceeds 25% of the loan, it is considered assistance.

11.4 Can grace period make a credit an ODA?

Yes. Please consider the following arrangement (referred to in the lecture). Let us say that a donor offers a loan to a prospective beneficiary. 1 million € is to be given, interest rate is 5%, and the money is to be paid back in two instalments. The first instalment covers just interest (5% of 1 million, i.e. 50,000), and the second one – interest plus the capital. The *Net Present Value*, NPV, of this arrangement (using the standard 10% discount rate; 1/1.1=0.91, and $1/1.1^2$=0.83) can be calculated as follows.

$$NPV = 1{,}000{,}000 - 50{,}000 \times 0.91 - 1{,}050{,}000 \times 0.83 = 1{,}000{,}000 - 45{,}500 - 871{,}500 = 83{,}000$$

that is 8.3% of the original amount. The grant component is lower than the required 25%, and hence the arrangement cannot be considered an ODA.

Now let us add a two-year grace period (the first instalment is postponed for two years). The NPV reads:

NPV = 1,000,000-50,000x075-1,050,000x0.46 = 1,000,000-37,500-483,000=479,500.

This is 48% of the original amount, i.e. more than 25%. Therefore the arrangement can be considered an ODA now.

11.5 In 2019 the UK was ranked among the very few countries that spend on ODA more than 0.7% of GNI (the target set by the UN for developed countries). Can you speculate why?

An important reason is that in the 19th century UK had a large number of colonies – mainly in Africa, but in Asia as well. India was called the "jewel in the crown". Ties with the old empire territories can be a significant factor of international trade which is probably supported by export promotion loans. If the loans have a sufficient grant component they are considered assistance.

11.6 Military purchases are excluded from ODA. What are the reasons for this?

Excluding military purchases is fairly obvious since they do not contribute to the development. However, it can be argued that under some circumstances they can be positively correlated with development. I think that there is a pragmatic reason to exclude them from the statistics. If they were to be included in certain cases, donors would put a lot of effort into arguing that military exports are justified by the importer's welfare.

11.7 Why do some countries experience wide variations in the availability of ODA?

Because of political reasons. If donors wish to support a government in a developing country, they pour a lot of money. If they are disappointed with it, they decrease the assistance.

11.8 Why was Poland an attractive ODA destination in the early 1990s?

Poland was considered one of the most polluted countries in the world. At the same time, it was the leader in leaving the Soviet bloc. Therefore in many countries taxpayers were willing to offer environmental assistance. There were many other countries emerging from the collapsed Soviet empire, but Poland was considered more advanced in transition towards a democratic state with predictable policies. Consequently in many countries politicians (on behalf of taxpayers) considered Poland to be best prepared to absorb foreign aid.

11.9 Was the opinion of some Polish environmentalists asking to minimise the assistance aimed at "soft" projects (such as training or feasibility studies) justified?

In many cases – no. Donors have a tendency to "tie" their assistance. However, "tied procurement" affects not only services, but products as well. Therefore "hard" projects such as scrubbers, waste water treatment plants, etc. could imply flows of money back to where it came from. "Soft" projects such as consulting services are sometimes commissioned from local experts, so in that case not all the money flows back to where it came from. Many Polish environmentalists advocated for minimising the assistance aimed at "soft" projects, but they

were wrong. Trainings and feasibility studies were often necessary to carry out "hard" projects efficiently.

11.10 Why has "tied" procurement been promoted by some donors?

Because this is what the taxpayers (acting through politicians) prefer. If the procurement is "tied" then the assistance money will flow back in the form of contracts.

11.11 Why does the World Bank advocate against "tied" procurement in ODA contracts?

The World Bank and other institutions demonstrate that under "tied" procurement with a given amount of money – because of higher prices – less products and services can be purchased.

11.12 Do you think that ODA makes a substantial contribution to Sustainable Development?

I think it does. Even though there is a lot of PR, and hidden politics, development assistance programmes really do contribute to Sustainable Development. Often the justification of a given project is controversial or insincere. Nevertheless, ODA programmes force people – both in the donor and recipient countries – to talk about sustainability goals. In the long run they contribute to creating human capital necessary in order to depart from the present development patterns. Non-government organisations (who participate in the assistance, or at least watch it) have a particularly important role to play in this process.

12. Debt for environment (DFE) swaps

Debt-for-environment (DFE) swap means forgiving a debt in exchange for environmental protection. An indebted country offers a deal: "instead of paying back the debt, we will spend the equivalent amount domestically in order to protect our nature". If the creditor agrees to such a deal, financial analysts say that a debt-for-environment (or debt-for-nature) swap takes place.

There are two major obstacles to economic development that low income countries face: indebtedness, and natural capital disruption. The latter was discussed in the last two lectures (10 and 11). These countries desperately want "to meet the needs of the present", and they try to use whatever there is available for using, irrespective of whether the next generations can "meet their own needs". As a result, trees are cut, soil is eroded, raw materials are extracted and the natural capital is depleted ruthlessly.

In addition, developing countries are heavily indebted in developed countries. Their indebtedness was estimated at 7.8 trillion USD in 2018 – a figure hard to imagine. First symptoms of the problem showed in the 1970s, after the first oil crisis in 1973. In the 1980s it became clear that some creditors would never get their money back. Despite this, many banks continued to lend money hoping that they would be repaid if not by the debtors themselves then at least by the governments who guaranteed a lot of loans.

A heavily indebted country can announce a bankruptcy and stop paying the debt. Nevertheless governments who take such a step understand that their credit rating goes down and no financial institution is willing to invest anymore. At the same time, they need foreign capital

and technology desperately, if they are to meet the needs of their citizens. Therefore they prefer not to declare bankruptcy, but rather reschedule the debt service or take a new loan to repay an old one. The predicament aggravates.

In 1984, Tom Lovejoy, a biologist and an activist of the WWF (*World Wild-Life Fund*) invented a debt-for-nature swap – an idea of debt forgiveness in exchange for domestic spending. The idea seemed to solve two major problems of developing countries: indebtedness and nature disruption. It was brilliant indeed, but the problem was that banks – say, in Italy – might not be interested in nature protection – say, in Nigeria; they were interested in getting their money back. Therefore somebody was supposed to pay the banks, if debtor countries were to be relieved from their commitments.

In 1987, the first arrangement of this sort took place in Bolivia. Environmentalists were enthusiastic: at last something happened that makes sense! Instead of paying to foreign banks, Bolivia can invest in its depleted natural capital. Even though traditional nature protection was involved (in Bolivia), a more general name – debt-for-environment swap – started to be used.

The swap was not very spectacular. The volume of the transaction was small. Only 650,000 USD of Bolivia's debt (a fraction of a percent of the country's substantial indebtedness) was bought. By the way, the price of the transaction was rather low. Conservation International (CI), an American NGO paid 100,000 USD to buy the debt of 650,000 USD (roughly 15 cents for the dollar) in the secondary financial market and retired (announced that it would not approach the debtors). In exchange, the Bolivian government agreed to expand protected areas around the Beni Biosphere Reserve by 1.5 million hectares. It contributed 100,000 USD (exactly the amount paid by CI) to the protection programme. CI could have insisted that the Bolivian government spends 650,000 USD on the Beni reserve rather than 100,000 USD (the nominal rather than market value of the debt just retired), but it did not press. The Bolivian government budgetary money was accompanied by an additional grant of 150,000 USD received from the United States Agency for International Development (USAID). Hence, in fact, the reserve was better financed than what CitiCorp and CI paid.

In the secondary financial market, the price of the debt reflects creditors' expectations of getting back the money. Thus if the Bolivian debt was priced at 15 cents for one dollar, it means that the probability of getting the money back was estimated at 15% only. In other words, no financial analysts hoped to recover the money borrowed to Bolivia.

Despite its small scale, the Bolivian DFE swap was precedent-setting and it received a lot of media attention. Its environmental aspect was very important, since Beni Reserve protects valuable ecosystems in the upper Amazon watershed.

After a couple of years, the initial enthusiasm cooled down, and second thoughts started to be raised. The most important doubts can be summarised as follows:

- Do creditors have environmental interests?
- Direct payments are more efficient than DFE swaps
- Social / financial mechanisms are ambiguous
    - DFE swaps serve First World banks' bottom lines
    - DFE swaps ignore Third World people preferences

- Creditors prefer debt-for-equity swaps over DFE swaps (99% of all debt rescheduling arrangements were debt-for-equity swaps)

Let us address these doubts systematically.

How can environmental interests be categorised? Country *A* can be said to have an environmental interest in country *B* when

1. *B* is an "upstream" (or "upwind") polluter affecting *A*
2. *B* is a provider of a public good whose supply is of interest to *A*
3. *A* and *B* exploit the same common resource stock (e.g. the earth atmosphere)
4. *A* and *B* consume services provided by the same common environment, but the value attached to these by *A* is higher than that attached by *B*
5. *A* cares for the value of natural resources owned by *B* (perhaps for humanitarian reasons)

As explained in earlier lectures, the indebtedness problem affects developing countries:

- who control biodiversity (type 2)
- who can offer inexpensive carbon sinks (type 3)
- whose production and development plans do not undergo the same domestic checks in both countries (type 4)
- whose survival very much depends on saving their resource base (type 5)

Consequently country *A* may have environmental interest in country *B* (country *A* can be interested in environmental protection of *B*), although this is not an obvious pattern.

The second doubt is based on the fact that a DFE swap subsidises environmental protection in a very convoluted way. An environmentally oriented agent in the creditor country approaches the financial institution involved, and tries to convince it not to claim the money. If successful, then it approaches the debtor country government to convince to spend the money (which otherwise should be spent on the debt service) on the environment. Surely a more straightforward way to proceed would be to subsidise environmental protection directly.

The third doubt is about the financial mechanism of a DFE swap. It is seen as a way to allow creditor countries subsidise environmental protection in debtor countries. Let us look at the Bolivian transaction though. Citicorp, a large American bank donated 100,000 USD to CI (which bought 650,000 USD of the Bolivian debt in the secondary market), and announced that it lost 650,000 USD in Bolivia. As a result, it paid a lower Corporate Income Tax. In other words, average American taxpayers (mainly less wealthy people) had to compensate for the lower budgetary revenues. At the other end of the deal: the Bolivian government has a fairly tight budget. It has to choose between subsidising medical care, education, citizens' safety, and many other sectors. Yet it decided to allocate certain money to establish a better protection in the Beni Reserve. Was this consistent with local preferences? This was probably not what the Bolivian people preferred.

Critics point out that there was no money flow from USA to Bolivia. On the other hand, DFE swap prevented the money to flow from Bolivia to USA. But if you take into account that in the secondary market the Bolivian debt sells at 15% of the nominal value, the likelihood of

such a flow is not very high. To sum up: the DFE swap implied two separate internal flows – one in the USA, and another one in Bolivia. In the first one money flew from the poor to the rich (the Citicorp pays lower taxes and the loss of budgetary revenues is compensated from other sources). In the second one the domestic budgetary money was directed to environmental protection, even though there were other unmet needs. Consequently, the financial mechanism of such a DFE swap is controversial.

The fourth doubt refers to the fact that by and large creditors are not interested in DFE swaps. A lot of credits turned out to be "non-performing" (money was impossible to be claimed). As a result, a lot of creditors asked debtors for so-called debt-for-equity swaps. The word "equity" in English has several meanings. The one used in this context is synonymous with an "asset". A bank which realises that the debtor does not have money to repay the debt, asks for something else: real estate, factory, mine, or anything else that might have some commercial value. By demanding a piece of property belonging to the debtor, at least some money can be claimed. 99% of all debt rescheduling agreements in the 1980s were debt-for-equity swaps. This demonstrates that creditors do not reveal environmental interests very often.

Second thoughts about DFE swaps cooled some enthusiastic feelings, but they did not stop economists to study the phenomenon. In particular, economists looked at conflicting preferences of creditors and debtors. The former preferred debt-for-equity swaps. The latter were not necessarily pro-environmental, but they would prefer to spend the money domestically – even on nature protection – rather than on debt service.

A number of game-theoretic models were analysed in order to study international conflicts around exploitation of the natural capital. Many of them looked at various public good aspects, and especially at free riding. For instance, attempts were made to explain why the Baltic countries hesitate to take effective measures against the sea eutrophication (recall lectures 2 and 3). A concept of a "self-enforcing agreement" was developed in order to explain the success of the Montreal Protocol (lecture 5). The problem of "issue linkage" (recall the US-Mexican agreements discussed in lecture 1) was studied as well. Yet another model looked at a debt-for-nature swap as a second-best (i.e. not theoretically optimal) solution of imperfect enforcement.

I developed game-theoretic models in order to check (I) whether a DFE can be expected as an outcome of a dispute between creditors and a debtor, and (II) how many creditor countries will turn the DFE swap into a self-enforcing agreement.

As mentioned earlier, creditors prefer debt-for-equity swaps. On the other hand, debtors do not want to pay anything; but if they are forced to, they prefer a DFE swap over a debt-for-equity swap. Creditors are aware of this preference of debtors, but they may expect that if pressed in negotiations, a debtor may agree to a debt-for-equity swap finally. On the other hand, every debtor is aware of the fact that creditors prefer debt-for-equity swaps, but if pressed in negotiations, they may agree to a DFE swap (which is better for the creditors than no swap at all).

Formally, in game-theoretic language, this game I (Environment *vs*. Equity) can be described in the following way. The main options available to the players (a debtor and a creditor) are:

- No swap (NS);

- Debt-for-equity swap (EQ); and
- Debt-for-environment swap (EN)

Their hypothetical outcomes ("payoffs" in the game-theoretic language) – understood as incremental to the no-swap option (0,0) – are:

		Creditor		
		NS	EQ	EN
Debtor	NS	0,0	0,0	0,0
	EQ	0,0	*a*,*b*	*c*,*d*
	EN	0,0	0,0	*e*,*f*

The table (in game theory language called "payoff matrix") consists of pairs of numbers. The first one is interpreted as the payoff which goes to the debtor (the player who controls rows), and the second one – as the payoff which goes to the creditor (the player who controls columns). For instance, if the debtor and the creditor agree to a debt-for-equity swap, the former will earn *a*, and the latter will earn *b*. If there is no swap (either because both agreed to NS, or one chose NS while the other negotiator chose EQ or EN), then each player earns 0. They are also left with nothing (0,0) if the debtor sticks to EN while the creditor sticks to EQ. If the creditor insists on EN and the debtor insists on EQ (a very unlikely combination) then an agreement is possible, since the latter can allow the former to invest, for instance, in environmental protection (e.g. to build a wastewater treatment plant) and enjoy the outcome; the payoffs will be (*c*,*d*).

The most important concept in game theory is so-called Nash Equilibrium. The simplest definition of Nash Equilibrium is a result of the game in question such that no player has an incentive to unilaterally change the decision. It is assumed that Nash Equilibrium reflects what can be found in real life situations if economic agents do not control the outcome fully; the outcome depends on their joint decisions. But they do not know their decisions *a priori*. For instance, the debtor may claim that the only acceptable decision is EN, and the creditor claims that the only decision to accept is EQ, but they do not know if their positions are rigid or perhaps they were announced just for the sake of negotiations.

The main purpose of this game theoretical framework was to check whether EN-EN (that is when the creditor and the debtor agree to a DFE swap) is a Nash Equilibrium. A condition for EN-EN to be a Nash Equilibrium is: $e \geq c$, and $e,f \geq 0$. If these inequalities hold then the debtor does not have an incentive to unilaterally (i.e. assuming that the creditor sticks to EN) switch from EN to EQ or NS (since neither 0 nor *c* is higher than *e*). Likewise the creditor does not have an incentive to unilaterally (i.e. assuming that the debtor sticks to EN) switch from EN to EQ or NS (0 is not higher than *f*). By the way, if, in addition $a<0$, then EN-EN is the only non-trivial Nash Equilibrium (NS-NS is an example of a "trivial Nash Equilibrium", i.e. an equilibrium where the players receive zero payoffs obviously, but if either switches to other decision unilaterally, the payoff will not increase).

Those of you who are not afraid of mathematics may check that the game has another Nash Equilibrium EQ-EQ when $a,b \geq 0$, and $b \geq d$. Additionally – for a solvent debtor – the following inequalities can be observed:

- $a < 0$
- $e \geq c$, and $e > 0$
- creditor's "environmental bias" implies $c > 0$

The first inequality states that for a solvent debtor a better opportunity is to sell an asset in a competitive market and to pay the debt rather than agree to a debt-for-equity swap where the same asset is likely to be sold at a lower price. The other inequalities are somewhat more difficult to justify. In addition, one can argue that the creditor's general preference implies $b \geq d \geq f$. Substantial environmental benefits of the creditor (i.e. when the creditor is interested in environmental protection in the debtor's country – see pages 123-124) imply $f \geq 0$.

Let me summarise the model for those of you who are not so much interested in details of game theory. The model predicts a DFE swap as a Nash Equilibrium in a game between a solvent and environmentally conscious debtor and a creditor without a strong established presence in the debtor's market. It anticipates that no swap will take place if the creditor is successful in debtor's market anyway. It also explains why the debtor may be better off without a swap rather than with a precedent-setting debt-for-equity arrangement which makes other creditors expect a departure from the debt-for-environment preference. If the debtor agrees to a debt-for-equity swap with one creditor, then no attempts to make a DFE swap with other creditors will be considered credible by them.

Now let us assume that a debtor succeeded to negotiate a DFE swap with one creditor. How many other creditors are likely join the agreement, and how many of them will find it more beneficial to stay outside? Game II was designed in order to address these questions. It starts by observing that the debtor proved strong preference for debt-for-environment swaps as opposed to debt-for-equity swaps. Other creditors (who contemplate whether to join the swap) are likely to scrutinise non-environmental (mainly financial) benefits from the swap. At the same time, "tied" procurement (see lecture 11) is an important issue to be taken into account when deciding whether to join the agreement.

The following compromise between "tied" and "untied" procurement was analysed. In principle the procurement is "tied" to creditor countries who participate in the DFE swap. However, those who do not participate may also compete for some contracts, since – for pragmatic reasons – a part of the swap money (perhaps a small part) should be allocated to products found to be crucial for the success of the programme even if they come from countries that do not participate in the swap. In a sense, countries which do not participate in the swap can "free-ride" on those which do.

Let us note that even for participating countries, a DFE swap may imply contracts higher than their respective contributions. This is caused by the fact that typical environmental projects require so-called co-financing. Very often environmental financiers require that purchases need to be financed from additional sources too. Thus if there is a creditor country which devoted X to finance a project which costs Y (Y>X), then the difference Y-X must be financed from another source. The firm which wins the contract will get Y rather X, that is more than what was originally devoted by the creditor country. Financiers talk of a "leverage": every sum allocated to something will bring an additional revenue if co-financing is required.

In game theoretic language this second round can be modelled as follows. Let us assume that **s** is the number of participants in the swap, and an additional creditor country contemplates whether to join (as the participant number **s**+1), or to stay outside. The payoff functions (revenues) are assumed to depend linearly on the number of participants:

- $R_p(\mathbf{s}) = g - h\mathbf{s}$ (for participants)
- $R_n(\mathbf{s}) = j + k\mathbf{s}$ (for non-participants)
- $g, h, j, k > 0$ are constants

The formulae assume that countries which participate (those with subscript p) receive less if the number of participants increases (-), and those which do not participate (those with subscript n) receive more if the number of participants increases (+). According to these assumptions, participation pays if $R_p(\mathbf{s}) > R_n(\mathbf{s}-1)$, or $R_p(\mathbf{s}+1) > R_n(\mathbf{s})$, i.e. if $\mathbf{s} < (g-j-k)/(k+h)$. It does not pay if the inequality does not hold. Therefore $\mathbf{s}^* = [(g-j-k)/(k+h)]$ is the largest number of countries that the DFE can sustain ([.] is called "*entier*", the integer part of a number; the number of participants has to be an integer).

The model is very simple. In more realistic analyses creditors are not perceived as identical. Some of them are large and some of them are small. Perhaps one way to take into account their differences is to define **s** as the amount of money contributed to the DFE swap rather than the number of countries. Then the equilibrium condition for $\mathbf{s}^*$ can be reinterpreted as a condition for increasing a creditor's contribution to the DFE swap (e.g. between zero and some percent of the total debt; it does not have to be an integer number any more).

Additional refinements of the model take into account two observations. Downwind or downstream creditor countries enjoy higher benefits from participation, because they have a possibility to reduce negative externalities imposed on them. Creditor countries having strong established presence in the debtor's country market perceive higher benefits from non-participation, because they are likely to win contracts that are not entirely "tied" to participants.

Game II analyses a DFE swap as a self-enforcing agreement. It develops certain conditions characterising the number of countries that are likely to participate. The agreement is purely voluntary. Participants find it beneficial to participate, and non-participants find it beneficial not to participate.

In the next class we will apply the framework referring to Game I and Game II in order to analyse the success of the Polish government to negotiate a DFE swap rather than accepting debt-for-equity swaps (preferred by creditors), and to explain why the participation in the arrangement – despite expectations – was confined to few countries rather than all the creditors.

Questions and answers to lecture 12

12.1 Why are many developing countries trapped in a vicious circle of international borrowing and indebtedness?

Irrespective of the origins of the problem (for some countries it started in 1973), the fact is that many developing countries took loans from banks affiliated in developed countries. The

loans were expected to finance investment projects aimed at manufacturing commodities likely to be exported and contributing to paying the money back. In most cases these expectations proved futile. It is irrelevant whether debtors failed because of corruption or because of bad luck. The fact is that they failed. As a result, they are unable to service the debt. One way to solve the problem is to declare bankruptcy. But if a debtor declares bankruptcy, then nobody wants to offer any new loans, and – consequently – its firms cannot obtain funds that are necessary in order to survive. Therefore debtors hesitate to declare bankruptcy. Instead they prefer to postpone debt service payments (this is called "rescheduling") or they take new loans to have the money to repay old ones. These desperate steps do not solve the problem, because they simply postpone the moment to pay what they promised to. In the end the backlog of unpaid commitments increases.

12.2 Whose idea was to link a solution to indebtedness problem with investing in natural capital?

The idea was raised by professor Tom Lovejoy, a director of the conservation programme at World Wildlife Fund-US, the American part of WWF.

12.3 Conservation International (CI) retired 650,000 USD of the Bolivian debt having paid only 100,000 USD. How was this possible?

This was possible, because in the secondary market, 1 dollar of the Bolivian debt was selling at the price of $ 0.15 only. Therefore the Bolivian debt of the nominal value of 650,000 USD was bought for 100,000 USD only. The discrepancy between the nominal and the actual (market) value of the debt leads to diverging interpretations of what a DFE swap means. If CI paid only 100,000 USD, should the Bolivian government spend the same amount on environmental protection, or the nominal value (i.e. 650,000 USD). In the deal we analysed in the class, CI did not insist that Bolivia spends the equivalent of the nominal value of the debt forgiven. The Bolivian government spent 250,000 USD, that is the 100,000 USD (corresponding to what CI paid) and 150,000 USD received in the form of an USAID grant.

12.4 Did the US government support the Bolivian arrangement?

Yes. An additional grant of 150,000 USD for the Beni Reserve proved that the American government supported the initiative.

12.5 Please speculate about hypothetical negotiations between CI and Bolivian government.

The negotiations between CI and Bolivian government could be whether $100,000 or $650,000 should be spent on the Beni Reserve. $100,000 is what CI actually paid to buy a portion of the Bolivian debt (in the secondary market), and $650,000 is the nominal value of the debt purchased. From the American point of view (in general: from a non-Bolivian point of view), the more Bolivia spends on Beni the better. From the Bolivian government point of view, the less Bolivia spends on Beni the better for other sectors like hospitals, schools, police, etc. Thus, from the Bolivian government point of view, it would be better to stick to $100,000 rather than $650,000. I think that the most convincing argument is that CI spent $100,000, not $650,000. The discrepancy between the two numbers has been caused by the fact that the price of the Bolivian debt was $0.15 per $1.00. In other words, financial markets expected that there was only15% probability that the money would be paid. Hence, Americans should not expect that the deal corresponds to $650,000; it corresponds to

$100,000 only. The fact that the US government allocated a separate grant of $150,000 for Beni was perhaps another argument for CI not to press the Bolivian government. The Beni reserve is going to be supported even if the Bolivian government allocates only $100,000 from its budgetary sources (and $150,000 comes from elsewhere).

12.6 Sceptics of the DFE idea point out that creditors are not interested in environmental protection in debtor countries. Are they right?

99% of all debt rescheduling deals involved debt-for-equity swaps rather than DFE swaps (i.e. claiming not cash but assets owned by the debtor). This demonstrates that – by and large – creditors are not interested in environmental protection in debtor countries. Nevertheless, sometimes interest can be expected, as explained by the game-theoretic model on page 126 (or in my overheads IEC-12-8, IEC-12-9 and IEC-12-10).

12.7 Can a direct subsidy be more efficient than a DFE swap?

Yes – especially in the short run. If one is interested in financing a specific project then it is easier to pay for it directly rather than doing all the transactions necessary for a DFE swap. However, if one is interested in creating institutions in the debtor country to care for environmental protection in the long run, a DFE swap can be useful. DFE swap demonstrates to the Minister of Finance (who is responsible for debt problems) that the Minister of Environment may have something interesting to offer. Besides, everybody is made aware of the fact that nature may be precious. And – what is perhaps the most important long-run consequence of a DFE swap – local environmental activists become visible.

12.8 By referring to the Bolivian DFE swap, please explain financial flows implied by the deal.

They are controversial. A quick reaction to the news that a DFE swap was agreed is equivalent to expecting that there will be a money transfer from a rich country to a poor one. As illustrated by the Bolivian deal, this is not necessarily true. In fact there was no flow from the US to Bolivia (other than the grant made by the USAID (a US federal agency) which, strictly speaking, is not a part of the DFE swap). There were two separate internal flows: one in the US, and one in Bolivia. The American flow was between Citicorp, CI, government budget, and taxpayers. Citicorp donated 100,000 USD to CI (and declared a loss caused by the inability to get the money back from Bolivian borrowers). The profit of Citicorp went down, and they paid a lower Corporate Income Tax (CIT). In order to make up for the loss, the government budget had to collect more taxes from other taxpayers or – which implies the same thing – had to cut some of its spending programmes. In the end the American taxpayers subsidised (indirectly) the Citicorp corporation. The Bolivian flow was confined to beneficiaries of the state budget. There are many entities financed by the state budget: hospitals, schools, police, national parks, etc. The Bolivian government agreed to increase the money spent on nature protection. As the budget constraint is hard rather than soft, this implied that other objectives received less financing. Therefore, in the end, some sectors (in Bolivia) subsidised indirectly other sectors (in Bolivia). There were no international flows

12.9 Game theory describes situations where two economic agents take decisions independently, and they cannot control the outcome fully. The outcome depends on what they decide jointly. What sort of decisions are to be taken by creditors and debtors?

In debt rescheduling negotiations, creditors want to get the money back, and debtors do not want to pay. These two goals cannot be achieved simultaneously, so the creditors would like to get as much as possible, and debtors would like to pay as little as possible. Both would like to swap a part of the debt, but they negotiate the terms (see pages 125-127, or IEC-12-6 – IEC-12-10). There are three options to be negotiated: no swap (NS), debt-for-equity swap (EQ), and debt-for-environment swap (EN). In order to conclude, both parties should agree to something. There is always a possibility to fail to agree on anything (NS); neither of the parties gets anything out of this. Creditors prefer debt-for-equity swaps (EQ), since they get something tangible out of this – a piece of real estate, a mine, or a factory. Debtors try to avoid such a deal, since they prefer to sell the same thing in an open market (not necessarily to the creditor), get the money, and pay the debt. But they can do so if they are solvent. If they are insolvent, they are forced to confine the offer to the creditor and lose a possibility to negotiate a better price. They prefer a debt-for-environment swap (EN), because in such an arrangement they do not lose any asset, and – in addition – they solve a domestic environmental problem. Unfortunately, creditors prefer EQ, so as long as they see prospects for persuading the debtor to abandon the idea of EN, they will not agree to what the debtor prefers. If the debtor sticks firmly to the original position, i.e. to EN, creditors may lose the opportunity to negotiate anything, and NS happens. Creditors agree to EN only when they feel that the debtor is serious about the environment (the debtor does not bluff), and when they see that – as a result of a DFE swap – they will gain more than from failing to reach any agreement. Debtors agree to EQ only when they feel that their creditors insist on getting the money back, and the gain from EQ (lower for the debtor than the gain from EN) is better than nothing (that is the gain from NS). It is up to negotiation skills of both sides to see when it is a time to yield to what the other side asks for, rather than to end up with a failure (NS).

12.10 The definition of Nash Equilibrium states that no player has a motivation to unilaterally change his (or her) decision. And what if they both agree to change their decisions?

This is about the definition of Nash Equilibrium. In order to explain this concept, I have to introduce the so-called prisoner's dilemma – a game which is referred to in every game theory textbook. The story goes as follows. Two criminals are caught on a minor offence, like stealing a purse from an old lady. You go to prison for one month for this. However, both criminals are responsible for something more serious they committed earlier; something that – if convicted – you go to prison for one year. But the earlier crime has not been detected, as there are no witnesses. Thus, unless they confess (individually or jointly) they will never be convicted for it.

The police do not like to have unsolved problems, so whenever they interrogate suspects (caught on anything else) they ask about all the earlier crimes. The two criminals are interrogated in two separate rooms (so that they cannot communicate with each other), and they are asked questions about all unexplained crimes. In many cases they obviously answer: no – we did not do it. But when the question is asked about the crime they actually did, what are they likely to respond? The following payoff matrix refers to this situation. Will anyone of them confess (C), yes – it was us; or will he deny (D), no – we did not do it?

		Second	
		C	D
First	C	(-12,-12)	(0,-18)
	D	(-18,0)	(-1,-1)

Why do we see the numbers that we see. Let us start with cell (D,D). The payoffs are -1 for the first and for the second. This refers to the fact that if both of them deny, then the earlier crime remains unsolved (the criminals are not convicted), and the police send them to jail for one month for the minor offence they were caught on. Now let us check what happens if the first criminal confesses and the second denies. Then the first one is freed, and the second one goes to jail for 18 months. This asymmetry is caused by the fact that the first one cooperated with the police (so they forgive him both crimes), while the second one lied (they know that he lied, because the first one confessed that they did it; the police have a witness). If the second confessed while the first denied, then the roles are reversed: the second is freed, and the first goes to jail for 18 months since he did what he did and – in addition – he lied to the police. There is also a possibility that both of them confess. The asymmetry disappears and both of them go to jail for a year.

A good outcome for both criminals would be to deny. This is probably what they intended to do originally. "If I deny, and the other guy does the same, then we cannot be convicted for the earlier crime, since there are no other witnesses. But shall I trust him? After all he is a criminal (like myself). What is worth the word of honour given by a criminal? He promised to deny, but I cannot be sure that he sticks to his promise." As a result, they both may choose to confess rather than to deny. This is Nash Equilibrium. To see this, let us look at the outcome (C,C) with the payoffs of -12 for each of them. Assuming that the second sticks to C, what is the payoff for the first one if he switches from C to D? The payoff will be -18, that is even worse. So the first decides not to switch. Now let us look at how the second may reason if he assumes that the first one sticks to C. If the second switches (unilaterally) from C to D, then his payoff will be -18, that is even worse. Please note that the outcome (-12,-12) is a very bad one for both of them, but neither has an incentive to move away unilaterally.

When John Nash explained his concept of equilibrium (i.e. what we call Nash Equilibrium now) in the middle of the 20th century, economists were shocked. For more than a century they were sure that an equilibrium is synonymous with an optimum. In equilibrium there are no incentives to change anything, so the outcome must be an optimal one. And yet there is John Nash who defined a strange equilibrium concept such that it violates optimality. Moreover, this strange equilibrium gives the very worst joint outcome that players can get. Indeed, for CC it is 24 months, for DC and CD it is 18 months, and for DD it is 2 months.

If kept in two separate rooms they are likely to choose CC (the Nash Equilibrium). But if they chose DD, they would get 2 months jointly, i.e. a better outcome than 24 months jointly. Thus if both of them switched from C to D (if they switched jointly), they would be better off. This is probably what they would have done if they could communicate with each other. But if they are interrogated in two separate rooms, they cannot communicate and they may end up in this unfortunate (for them) predicament.

The logic of "prisoner's dilemma" applies to swap negotiations as well. If partners stick to their negotiation positions (EQ for the creditor, and EN for the debtor), then they may end up with a bad outcome, not because they cannot communicate physically; they can. But they do not know whether what the partner says is the final offer or not. When they learn, it may be too late to agree on something which is beneficial.

12.11 Is it credible, when a debtor announces to stick to a DFE swap rather than a debt-for-equity swap?

No, it is not. Any debtor prefers a DFE swap over a debt-for-equity swap, so it is predictable. Creditors suspect, that after a while – especially when they make a strong impression of expecting a debt-for-equity only – debtors will give up, and they will agree to a debt-for-equity swap. If a debtor has a very strong reputation of being environmentally sensitive, the DFE swap makes a credible offer. Environmental reputation will be strengthened, if the debtor succeeded at negotiating a DFE swap with another creditor.

12.12 In the payoff matrix on page 126 (or in IEC-12-8), $a<0$ for a solvent debtor. Is the solvency assumption necessary here?

Yes, it is. If the debtor is not solvent, i.e. the debt has not been serviced, then the only way to survive is to offer creditors some form of reimbursement. If the creditor offers to buy a factory for the price of 3 million USD (even though the factory is worth 4 million USD), the debtor has to agree to such a deal in order to avoid an even greater scandal. Thus the debtor can agree to EQ which gives a negative payoff ($a<0$). A solvent debtor would not agree to such a deal.

12.13 A creditor who does not have an established presence in a debtor's domestic market may have an incentive to join a DFE swap. Why?

If a creditor has an established presence in a debtor's domestic market, then incentives to join a DFE swap are weak. New contracts can be awarded to firms from the creditor country, but they could be awarded anyway, because the firms are known. At the same time, joining the DFE swap is not free, since – if the debt is to be forgiven – somebody has to reimburse those who gave the money. Consequently, expected benefits can be found lower than costs. But if the creditor does not have an established presence in the local market, then the cost may turn up to be lower than expected benefits. Firms from the creditor country may sense an opportunity to be awarded contracts in the market where they had not been known before.

12.14 Please explain the "leverage" phenomenon in environmental financing.

The "leverage" appears whenever a contractor can expect to be awarded more than a financier allocated for a project. Let us suppose that a financial institution allocated the amount of 5 million USD. Let us assume additionally that an investor is going to undertake a project worth 8 million USD. The contract awarded to a firm will be 8 million USD, and the difference, i.e. 3 million dollars, is the "leverage" obtained from the initial allocation of 5 million USD. The "leverage" logic is anticipated by countries participating in a DFE swap. They buy (perhaps with their taxpayer money) a portion of a debt. Let it be, say, 5 million USD. Co-financing may result in a project worth of, say, 8 million USD. Then firms from the creditor country can expect to be awarded a contract worth of 8 million USD. The "leverage" of 3 million USD can be seen as a net benefit above what the country paid in order to join the DFE swap.

13. Polish EcoFund

DFE swaps make interesting examples of international environmental cooperation. As explained in my previous lecture, the idea emerged in 1984, and the first deal was implemented in Bolivia in 1987. A debt-for-environment swap means that a creditor forgives (a part of) the debt in exchange for increased domestic expenditures on environmental

protection in the debtor country. Poland makes an interesting case in the history of DFE swaps.

In 1989 Poland managed to escape from the Soviet bloc, and started to abandon the central planning regime. There were many consequences of this fact. The first one was disclosure of the horrible environmental disruption caused by several decades of inefficient economic development. Air was contaminated, and water was poisoned with toxic substances. The knowledge of the disaster was constrained by the overwhelming censorship enforced by the communist government. Once the censorship was abandoned, the scale of disruption could have been ascertained. It became clear that Poland requires billions of dollars in order to recover environmentally.

At the same time Poland was a heavily indebted country. The communist government borrowed large amounts of money, even though it should have been clear for everybody that its investments would not result in creating adequate manufacturing capacity. Problems with debt service implied debt rescheduling negotiations and/or new loans. The Polish indebtedness problem resembled those typical for developing countries.

The difference, however, was that unlike in many developing countries, most of the Polish loans were negotiated by the government, not by private firms. As a result, most of the Polish debt was considered "official" rather than private. This classification was not just about who negotiated loans at the Polish side. It also referred to the fact that these loans were guaranteed by creditor countries' governments. Hence, if the debtor does not pay on time, creditor banks could turn to their governments (not only to the debtor government) for compensations.

By the way, this was an important argument used by the Polish non-communist government when asking about debt forgiveness. It was not just the stupidity of the former Polish communist government who borrowed the money. It was also the stupidity of creditor countries' governments who guaranteed such loans. They should have known that the money could not result in creating adequate export capacity to repay the debt. If they guaranteed such loans they are partially responsible for the indebtedness. Thus Polish debt negotiations were a matter of official political (i.e. government-to-government) debates rather than commercial ones.

There were more than 33 billion USD at stake. This was the Polish indebtedness to the Paris Club in 1991. The Paris Club is the name of the group of 17 countries (Austria, Belgium, Brazil, Canada, Denmark, Finland, France, Germany, Great Britain, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, and the United States) which guaranteed loans. In addition, Poland owed some money to the so-called London Club, i.e. a group of banks which gave loans privately (without government guarantees). The London Club indebtedness was not a matter of the negotiations leading to the DFE swap.

The ambition of the Polish government was to ask for an 80% debt forgiveness. This was acceptable for some creditors (e.g. US), but some countries (e.g. Germany) admitted that this would be impossible to be "swallowed" by their economies. At the turn of 1990 and 1991 it became clear that Poland could count on 50% forgiveness at most. The difference between 80% and 50% implied that the Polish government started to look for a possibility to close the gap between 6.6 billion USD (the expected amount of debt to be paid under the 80% forgiveness scenario) and 17.6 billion USD (the amount to be paid if the creditors forgive 50% only). In other words, the government looked at how to "claim" 10-11 billion USD.

A DFE swap was identified as an instrument of serving the debt domestically rather than transferring the money abroad. In the previous lecture, I introduced the idea of a DFE swap as a means of solving two problems at once: indebtedness and natural capital disruption. The original idea referred to the predicament of developing countries. Poland did not belong to this group, but it shared some of their characteristics – namely, high indebtedness and unprecedented environmental devastation.

The Minister of Finance approached the Minister of Environment informally, and asked to prepare a plan for a DFE swap. Having been charged with this task, I consulted some of my professional colleagues in WWF and other international NGOs to check what spending areas in Poland are attractive from the global perspective. As a result of these consultations, the 1991 Memorandum of the Minister of Environment – called *Redirecting debt service for environmental protection purposes* (drafted on March 5) – identified four international priority issues:

- Long range transboundary air pollution
- Eutrophication of the Baltic Sea
- Climate change
- Biodiversity

The *Memorandum* was circulated informally, and on April 4, 1991, the Prime Minister appointed *Interim Interministerial Committee* in charge of the debt-for-environment swap. The *Committee* consisted of officers working in several ministries (Finance, Foreign Affairs, and Environment), and it developed the *Memorandum* into a more elaborated spending programme.

Soon a decision of the Paris Club was announced. On April 21, the Club declared that 50% of the Polish debt was forgiven. In addition, up to 10% can be swapped in voluntary bilateral agreements between the Polish government and creditor countries (potentially up to $ 3.3 billion). At the same time, the Paris Club indicated no environmental preference. The additional swaps could be of any type, in particular, they could be debt-for-equity swaps.

First of all, I would like to comment on the 50% number. From the Polish government perspective, it was less than the preferred 80%. Perhaps 80% was not realistic. The Paris Club emphasized that only two countries received 50% (nobody received more than that). These were: Egypt and Poland. Egypt was rewarded for its participation in the Gulf War, and Poland was rewarded for its role in dismantling the Soviet bloc. Anything more generous was not conceivable.

Now regarding the issue of additional bilateral swaps. As a rule, Paris Club does not allow bilateral swaps. If bilateral swaps between a creditor and a debtor were allowed, then some creditor countries could compete with other creditor countries for getting more of their money. This would be unacceptable from the point of view of the Club as a whole. The provision saying that "up to 10% can be swapped in voluntary bilateral agreements" was thus an exception from the general rule, and a favour for Poland. The Polish government insisted that some possibility of going beyond the 50% of unconditional forgiveness was necessary.

Finally – the issue of environmental protection. The Paris Club did not indicate any environmental preference. In particular, the additional swaps could be debt-for-equity swaps – something that many creditors would prefer. It was the Polish government preference to choose DFE swaps rather than anything else. But most creditors did not believe that the preference for DFE swaps (and hence exclusion of debt-for-equity swaps) was serious. They expected that the Polish government tries to negotiate better terms of its debt rescheduling, but when it realises that creditors do not go for DFE swaps, it will agree to standard debt-for-equity swaps which allow creditors to acquire some assets (like real estate, mines or factories).

Once the decision of the Paris Club was announced, there was an eruption of debt-for-something swap proposals. The Minister of Health asked for a debt-for-hospitals swap, the Minister of Transport asked for a debt-for-highways swap, the Minister of Agriculture asked for a debt-for-pesticides swap, the Minister of Privatisation asked for a debt-for-equity swap, and so on. The Prime Minister requested that within the next couple of days, all ministers submit their swap proposals, and the government will select the best one. The Prime Minister was not quite fair, since he knew that one minister (namely the Minister of Environment) had much more time to elaborate on his proposal. When all the proposals were presented, everybody had to agree that the proposal of the debt-for-environment swap was the most comprehensive, mature, and convincing one.

Thus the Council of Ministers decided that from this moment on, the Polish government would implement the Paris Club decision by negotiating DFE swaps only. To this end, Ms. Gro Harlem Brundtland, the Prime Minister of Norway (please recall the lecture on Rio de Janeiro and sustainable development) was asked to assist the Polish government in preparing its position and discussing it with creditors in an international conference in Oslo.

The essence of the Polish proposal consisted of the following four ideas on how to create an EcoFund to implement the Paris Club decision:

- The fund spends on 4 priority areas based on the March 5 *Memorandum*
- The fund – a multilateral facility to coordinate all bilateral swaps – is located in Poland
- There is a collective minority representation of creditors on the supervisory board (but: a 2/3 majority voting rule)
- Project selection is according to cost-effectiveness criteria

As far as the substance goes, EcoFund was supposed to finance environmental protection projects from the four priority areas identified earlier (air pollution, Baltic eutrophication, climate, and biodiversity). These are environmental protection problems which are important for Poland, and – at the same time – identified as international priorities. It would be very difficult for any creditor country to suggest that some of them are not.

An important dispute between some creditors and Poland was about where the fund should be located. Some of them recommended that it should be affiliated with one of the existing financial institutions, like the European Bank for Reconstruction and Development (EBRD) located in London. This would have some advantages. Nevertheless the Polish government insisted that it should be located in Poland, in order to create a competent domestic institution capable of playing an important role in developing local organisations.

The Paris Club decision was that additional swaps should be negotiated bilaterally. This was a binding constraint. Yet it was up to a specific design whether these bilateral swaps were to be administered bilaterally by several institutions or multilaterally, through a single institution. The Polish preference was to create a single institution, to avoid tied procurement. It was explained earlier (see the lecture on international assistance) that tied procurement leads to inflating costs. If there was a series of bilateral swaps administered bilaterally, it would be quite natural to tie purchases: if there is an entity that administers, say, Swiss money (a part of the debt swapped by the Swiss government), then it should buy from a Swiss firm. It would be very difficult to argue that even though the money comes from Switzerland, it should be spent on purchases imported, say, from Sweden. In order to avoid tied procurement, the Polish government insisted that the EcoFund administers money on the multilateral basis, that is it mixes the money from bilateral swaps, and selects suppliers from all the countries involved, i.e. all the countries which participate in the DFE swap. Hence there are no projects that can be affiliated with any specific creditor country, but rather there are "EcoFund projects" financed from the pool that all the participating creditor countries contribute to.

It was expected that most of the seventeen Paris Club countries would participate. At the same time, a supervisory body of the EcoFund cannot be too large. Hence an idea emerged that not necessarily all creditor countries sit in this body, but rather their collective minority representation is present there. This is a solution replicated from other international financial institutions, where a single member of a supervisory body may represent several countries. Later on, when it became clear that membership in the EcoFund was confined to 6 creditors only, every creditor country had its representative in the supervisory body (called EcoFund Council). It would be good to arrive at all decisions unanimously. But unanimous voting is not very effective. Thus the EcoFund Council was supposed to arrive at decisions by the 2/3 majority vote (while the creditors make more than 1/3 of the total). This provision was offered to make sure that non-creditors (Polish members of the Council) cannot outvote the creditors.

Finally, it was emphasised that the EcoFund operates on a cost effectiveness basis. It means that if a project is to be financed, it must be the cheapest out of those that meet certain requirements. This principle was closely related to the lack of tied procurement. It anticipated attempts of creditors to push projects which involved significant expensive purchases from their own countries. For instance, a representative of the French government may push for a project if it involves many components to be imported from France. If the French suppliers offer competitive prices, then it is justified obviously. But if there are other suppliers, say, from Italy who offer cheaper purchases, then the "French" project fails to be cost effective and it should not be financed.

On July 1, 1991 there was an international conference organised by the Norwegian government in Oslo to let the Polish government present and discuss its EcoFund proposal with the Paris Club members. The proposal boiled down to the following three principles:

- Purchases to be (co-)financed on a "club basis"; no *ex ante* tied procurement
- Periodic analyses of the geographical distribution of contracts in order to *ex post* approximate the distribution of commitments
- Additionality of EcoFund's expenditures

The Polish government insisted that the procurement should be untied. This means that whatever money is available through DFE swaps, it is to be spent on a "club basis". If the EcoFund finances a project, this is not an American or a French venture, but rather something that all creditor countries undertake. Cost effectiveness calls for such a solution, but creditor countries may expect that "their" firms will benefit from it; otherwise their taxpayers can be disappointed. In order to reconcile cost effectiveness with creditors' expectations, the Polish government offered periodic analyses of so-called geographical distribution of contracts. When summed up over two or three years, contracts awarded to firms from a given country should be commensurate with what a given country contributed to the EcoFund. If such an analysis demonstrates that the geographical distribution of contracts approximates the distribution of commitments of respective creditor countries, then no corrective measures are necessary. If the analysis demonstrates that, say, Swedish firms get much less than what they expected based on the Swedish contribution to the EcoFund, then some corrective measures are necessary. It would be useful to see where the Swedish firms can make competitive offers, and to attach a higher weight to this area in the EcoFund's future activity, so that these firms are more likely to win contracts. Geographical distribution of contracts was carried out several times, and it demonstrated that US firms were somewhat discriminated, i.e. they received relatively less contracts than firms from other participating countries. Nevertheless the asymmetry was not very large, and the American government never complained about this small discrimination. Consequently there was no need to correct anything.

A representative of the Swiss government in Oslo wanted to confirm that EcoFund spending would be additional with respect to what Poland is going to spend on the environment. There are several ways to define this additionality. One way would be to list all the projects to be financed from Polish sources, and to make sure that the Ecofund never spends money on such projects. If it did, then there would be no additionality in the sense that creditors' money substitutes for what was planned to be financed from Polish funds. This concept of additionality does not make much sense, since it is impossible to make such a list for an 18-year time period (the time period covered by the Paris Club decision). A more practical macroeconomic test of additionality was suggested instead. Namely the Polish government promised to spend on the environment not less (in real terms) than it spent in 1991. Poland complied with this promise, since until 2010 (the last year covered by the Paris Club decision) environmental expenditure was higher (in fact, much higher) than it was spent in 1991.

Having defended its DFE swap idea, the Polish government started to negotiate with the creditors. Their preference were debt-for-equity swaps, and the Polish preference were DFE swaps. Negotiations can be interpreted as two games defined in the previous lecture:

- Game I – to convince about DFE
- Game II – to maximize membership of the EcoFund

In the first one the government had to convince the creditors about the stability of its choice to stick to the DFE swap. As explained earlier, creditors suspected that this was just a negotiating position, but if pressed, Poland would finally agree to debt-for-equity swaps. Initially there was only the American government who confirmed its willingness to do the DFE swap. In fact the American government was ready to swap even more than 10%, but the Paris Club decision did not allow this. The French government agreed to the DFE swap, but it committed only 1% of the debt. The Swiss government leaned towards the decision to swap the allowed 10% of the debt through a DFE swap. Switzerland provides a good example of a

creditor country without an established presence in the debtor's market. Its government judged that by committing 52.8 million USD, it would benefit from establishing its presence in the Polish market. Switzerland is located too far to benefit from environmental protection in Poland (see analyses of whether country *A* may have environmental interest in country *B* on page 124), but it benefitted commercially by promoting its firms and technologies in the Polish market.

Other creditors joined the EcoFund a couple of years later, once they realised that the Polish government is serious about the environment. Most creditors never joined the EcoFund. Germany is a good example of a creditor country with an established presence in the debtor's market. An important reason for Germany not to join the EcoFund was that their firms were well known and successful in the Polish market. The fact that two countries are close to each other and share the same environment was of secondary importance. Apparently, the German government judged that its hypothetical commitment to the EcoFund would not pay back in terms of new contracts, since German firms have been successful in Poland anyway. Norway provides an interesting case of a country which supported the initiative from the very beginning, but joined the EcoFund as late as in 1997. The reason for the delay was its disappointment with unstable politics in Poland in the early 1990s.

The table on page 140 encapsulates the outcome of the two games played by the Polish government. Its preference for DFE swaps was firm, and it did not yield to pressures of some governments to accept debt-for-equity swaps. In terms of membership, the outcome was somewhat disappointing. Only 6 creditors joined the DFE swap, and most stayed outside. There were numerous attempts to free-ride on participants. Perhaps the most striking one was a fraud by an Austrian company (not allowed to be awarded a contract) who pretended to be a Swiss company. In many cases, however, free-riding was legal if a contractor was to sell a small but crucial component of a project.

The experience of the EcoFund can be summarised as follows:

- Multilateralism, elimination of tied procurement, and emphasis on cost-effectiveness have proved to be successful design characteristics of the EcoFund
- Outstanding performance of the EcoFund (confirmed by the OECD and KPMG in 1997) has led to renewed interest in debt-for-environment swaps
- A "creditor" is a heterogeneous entity with some interest groups advocating for debt-for-environment swaps and others insisting on debt-for-equity swaps

Multilateralism (precluding tied procurement), and emphasis on cost effectiveness are perhaps the most important lessons learnt from the EcoFund's experience. EcoFund has proved to be a competent Polish institution appreciated for its professionalism. Its emphasis on cost effectiveness "spilled over" other funds which started to ask about the environmental outcomes of projects, not only about their technical solutions to be applied. Its performance was judged outstanding not only by domestic experts, but also by international organisations, such as the OECD (*Organisation of Economic Cooperation and Development*). In 1997 EcoFund asked KPMG, a well-known consulting company, to prepare a report on its organisational performance. The report was an important step in the renewed interest in DFE swaps. As I explained in my previous lecture, DFE swaps were fashionable in the late 1980s, but then sceptical questions were raised. The idea was revived in 1997 as a result of the EcoFund's success.

Poland's debt owed to Paris Club countries

Rank		Debt (as of April 1, 1991)		Debt-for-Environment Swap	
		Million USD	%	Year	Million USD
3.	Austria	3719	11	-	-
13.	Belgium	336	1	-	-
5.	Brazil	3403	10	-	-
6.	Canada	2899	9	-	-
15.	Denmark	243	<1	-	-
16.	Finland	143	<1	-	-
2.	France	5171	15	1992	51.7
1.	Germany	6000	18	-	-
7.	Great Britain	2762	8	-	-
8.	Italy	1647	5	1998	32.6
9.	Japan	1276	4	-	-
11.	Netherlands	662	2	-	-
14.	Norway*	322	1	1997	0.1
17.	Spain	96	<1	-	-
10.	Sweden	613	2	1997	6.6
12.	Switzerland	528	2	1993	52.8
4.	United States	3538	11	1991	367.0
	Total	**33358**	**100**	**x**	**510.8**

* Having been satisfied with the EcoFund's operations, Norway increased its contribution to 10% of debt due after 1998.

An additional experience from the EcoFund's activity was a recognition of creditors' heterogeneity. In game theoretic models described in my previous lecture, a creditor was typically understood as a single entity. Thus it is assumed that a creditor has interest or does not have interest, and it has an established presence or does not have an established presence. For many years, EcoFund tried to convince additional creditors to join the swap. It turned out that in every country there were institutions who pressed their governments to join the swap in order to enjoy some benefits (both economic and environmental), and other entities that emphasised the costs of such a decision, and opportunities lost when choosing DFE rather than debt-for-equity. The result of these conflicting tendencies is the final decision to join or to stay outside.

Attitudes of creditor countries can be summarised as follows:

- Strong pressures for bilateralism and tied procurement

- Participation in the Polish swap initiative reflects financial rather than environmental considerations of the creditor countries
- Participation is more likely for creditors without a strong established presence in the Polish market
- Confining procurement strictly to the EcoFund "club" – justified by the "club's" diversity – could have weakened *free-rider* motivation not to join the "club"

Let us explain these conclusions. Contrary to what the Polish government insisted on, creditor countries pressed for bilateralism. They preferred to have funds dedicated to projects identified with their countries. Perhaps the most important reason for this preference was expectation that such bilateral funds must be organised around tied procurement which results in immediate financial benefits for the creditor. It also demonstrated that financial rather than environmental considerations were more significant for swap decisions. Swiss participation served as an example of an incentive to join the EcoFund by a country without an established presence in the debtor market. German non-participation served as an example of a very weak incentive to join the EcoFund by a country with a strong established presence in the debtor market. By adopting a rule that imports from a non-participating country can be financed (if they are proved to be inevitable for a project to be undertaken), the EcoFund created *free-rider* motivation not to join the "club". Given the heterogeneity of the "club" (which consisted of 6 different creditor countries), this rule could have been eliminated probably.

The long-term impact of the EcoFund on Poland's environmental protection can be characterised as follows:

- Modest financial contribution to Poland's environmental protection
- Lasting contributions:
  - Establishing a domestic institution to address international priorities
  - Promoting the concept of cost-effectiveness, then taken over by other Polish financial institutions

The total spending of the EcoFund – determined by the availability of swapped funds – was not very spectacular – 512.8 million USD. It was less than theoretically resulting from the Paris Club decision – i.e. 3.3 billion USD, and mush less than what the Polish government hoped for earlier. Dividing this number into 18 years, i.e. the time horizon of the Paris Club decision, it is 28.5 million USD per year. This was a very small fraction of what was spent on environmental protection in Poland between 1992 and 2010. Nevertheless the contribution of the EcoFund is not confined to what it spent.

Perhaps the most lasting contribution of the EcoFund is raising the awareness of international priorities such as transboundary air pollution, the Baltic Sea eutrophication, climate, and biodiversity. These problems have always been grasped by experts, but – thanks to the EcoFund – they were brought to the awareness of the state administration as well. A contribution to the environmental sector is linked to the concept of cost effectiveness. All financiers claimed to be sensitive to cost effectiveness criteria, but reviews of project application forms revealed that in fact information required by the financing entities was not sufficient to assess the cost effectiveness of projects. Replicating requirements practiced by the EcoFund helped other financial institutions to apply cost effectiveness criteria in practice.

The success of the Polish DFE swap revived international interest in this mechanism. Heavily indebted countries wanted to learn how a DFE swap should be prepared and organised. Some analysts expected that the EcoFund experience can be repeated by other countries. The success of the Polish DFE swap required a strong commitment from the debtor and a fair degree of trust on behalf of participating creditors. Neither of these factors can be easily replicated.

Encouraged by the Polish example, the Swiss government established a similar DFE swap facility in Bulgaria, but no other creditors were willing to participate. It is beyond the scope of this lecture to analyse the reasons thoroughly. An important motive voiced by creditors was the fact that the charter provisions adopted by the Bulgarian government for the local DFE swap facility were insufficient to make sure that its funds are spent on what the creditors prefer. Another reason was the lack of strong pressure from the Bulgarian government. Yet one should not exclude the motive of *free-riding*. Some creditors could prefer not to join the swap (if they expected to win contracts anyway) and prevented this initiative from developing into a larger-scale arrangement.

Questions and answers to lecture 13

13.1 The idea of a DFE swap was adopted as a solution for heavily indebted developing countries. How was it possible for Poland to apply for this instrument of debt rescheduling?

Even though Poland was not a developing country, it was obvious in the early 1990s that its environment was devastated heavily as a result of several decades of the communist mismanagement. At the same time, its economy collapsed as a result of the development patterns implemented by the previous government. Like in many developing countries, Polish economy was not innovative, and its development depended crucially on imported technologies. The government borrowed money from foreign creditors, tried to modernise the economy, but failed to trigger stable economic growth to repay the loans. Consequently the economy embarked on a trajectory leading to a serious indebtedness problem. Both prerequisites of DFE swaps – i.e. natural capital disruption and indebtedness – were well documented in Poland in the early 1990s.

13.2 Why was the Paris Club – i.e. the "club" of governments which guaranteed money borrowed by debtors – involved in the Polish DFE swap proposal?

Most of the loans received by Poland were guaranteed by creditor country governments. These governments agreed that they would repay the debt if Poland fails to pay. They guaranteed the loans for economic and political reasons. One reason why they did so was that they expected their firms to get contracts. Additionally, some of them were probably impressed by the fact that many countries of the Soviet bloc abandoned the hard-core communist ideology in the 1970s and 1980s, and offered some hope for establishing more rational and democratic systems. Hopes for establishing more humane regimes proved premature, but formal guarantees signed by creditor country governments were used by the post-communist Poland in order to negotiate debt forgiveness.

13.3 Was the Polish government satisfied with the 50% debt forgiveness offered by the Paris Club?

No. The government – encouraged by the United States – hoped for 80% debt forgiveness. This, however, proved unrealistic. The government accepted the 50% forgiveness, but tried to pay less than the remaining 50%. That is how the idea of 30% DFE swap emerged.

13.4 Why were the four areas of environmental protection referred to in the *Memorandum* identified as international priorities? Were they accepted by the international community?

The *Memorandum* was drafted after several weeks of consultations involving important environmental organisations, such as the *World Wildlife Fund* (WWF), *Environmental Defense Fund*, and others. The Ministry of Environment thought of many areas of environmental protection in Poland, seen as domestic priorities. Yet it knew that some of them – like cleaning up local rivers or lowering the exposure to noise – might not be attractive outside of Poland. It looked for environmental protection problems that are both relevant for the Polish citizens and for the international community. After a lot of deliberations, it decided that the following four areas:

- Long range transboundary air pollution
- Eutrophication of the Baltic Sea
- Climate protection
- Biodiversity protection

have the desired characteristics. They are crucial for the Polish environmental recovery, and – at the same time – they are seen as priorities internationally. They were applauded by key environmental NGOs, and therefore they could not be rejected by creditor country governments.

13.5 In principle, the Paris Club does not allow its members to negotiate bilaterally debt rescheduling deals. Why? And why did it decide to let Poland negotiate bilaterally?

The Paris Club is supposed to act on behalf of the creditor country governments. Let us assume that it negotiated a debt rescheduling agreement with an indebted country, say, X. Creditor countries can be pressed by X to accept some further deals. If one creditor country accepts a deal, then this can be used as a precedent in a later negotiation process with another creditor. The Paris Club does not want to let its members be played against each other and hence – by default – it does not allow any bilateral negotiations. It made an exception for Poland for two reasons. First of all, the swaps allowed were fairly small (up to 10% of the original indebtedness). Besides, perhaps it yielded to the Polish government idea of implementing a DFE swap (a fairly fashionable notion at that time). Nevertheless the Club was aware of the fact that creditor country governments had very different opinions on that, and it could not act on behalf of all of them. Consequently it let decisions be arrived at in bilateral negotiations.

13.6 How do you view the decision of the Polish Prime Minister to compare alternative debt-for-something swap proposals in April and May 1991?

It was smart, but not quite fair. It was smart, because the Prime Minister did not want to take an authoritarian decision to announce the environmental preference. Yet it was not fair, because the Minister of Environment had several weeks to prepare his proposal. In contrast everybody else had just few days to draft something. Thus it was predictable that DFE swap proposal has to be judged as the best thought through and the most convincing one.

13.7 How did the Polish government try to convince the creditors about its firm commitment to negotiate DFE swaps only?

The most likely alternative to a DFE swap is a debt-for-equity swap. As argued in the lecture IEC-12, creditors prefer debt-for-equity swaps, while debtors prefer DFE swaps. Historical records of debt rescheduling negotiations indicated that 99% of them resulted in debt-for-equity swaps. Thus it was very difficult to convince creditors that asking for a DFE swap is not just a negotiation bluff. Many officials (also within the Polish government) expected that sooner or later Poland would accept a debt-for-equity swap. An important argument was that one creditor – namely the United States – accepted a DFE swap. Backed by the American government, Poland was also happy to receive the Norwegian assistance to hold a meeting in Oslo in order to present its plans. The plans were well prepared, and the Polish government responded to all specific questions raised by creditors (in Oslo and on other occasions). Some creditors chose not the join the EcoFund, but those who did were convinced that the DFE swap proposal was not just a negotiation bluff, and they stopped pressing for a debt-for-equity swap.

13.8 Why did some creditors agree to the Polish DFE swap proposal, and some did not?

In the case of some countries, like Austria, the Polish debt was high and the creditor's economy was too small to bear an additional burden. Brazil is a large, but – at the same time – a heavily indebted Paris Club country. It was interested in the Polish proposal not as a potential contributor though, but as a country that may try to replicate the idea. According to game-theory considerations (see IEC-12), creditors with an established successful presence in the debtor market are less likely to join, while those without such a background are more likely to join. Germany is a prime example of the former, while Switzerland is an example of the latter. Hence it is not surprising that Austria, Brazil, and Germany did not participate in the Polish DFE swap, and Switzerland did.

13.9 Why did the Polish government insist on the "multilateralism" of the EcoFund?

The Paris Club decision to allow Poland to seek swaps in voluntary bilateral negotiations could result in establishing a series of bilateral funds to administer whatever money is available from a given creditor. If such bilateral funds were created then each of them was likely to operate on a "tied procurement" basis. If, say, a Polish-American fund was established, it would be very difficult to accept that the fund finances contracts awarded to, say, Swiss firms; it would be natural to limit its operations to what can be imported from the United States. It has been known that "tied procurement" leads to inflated costs of purchases (IEC-11). In order to avoid pressures for "tied procurement", Poland insisted that the swaps are administered multilaterally. If the procurement is open to all countries which participate in the swap, no potential contractor can enjoy a privileged position and dictate excessive prices.

13.10 How many members can a supervisory body of a financial institution consist of?

In order to proceed smoothly: less than 15. If there are more than 15 members, then it is difficult to discuss and to arrive at a conclusion. There are organisations with larger supervisory bodies, but – as organisation theory predicts – their members have problems to get involved in interactions and to develop mutual trust.

13.11 What does the criterion of cost effectiveness in selecting projects require? How can biodiversity projects be assessed in terms of cost effectiveness?

Cost effectiveness means selecting a project which is cheaper than any alternative available. In order to check the cost effectiveness, two numbers must be known: the cost X and the effect Y. This is easy in the case of projects where the effect is unambiguous. For instance, in the case of air protection the effect can be a number of tonnes of a pollutant abated. The relevant criterion looks at the ratio Y/X, and if no alternative project can abate the emission at a unit cost lower than Y/X, then the cost effectiveness is demonstrated. In some environmental protection sectors effects are ambiguous. Biodiversity provides an illustration. Nevertheless it is possible to assess cost effectiveness for such projects sometimes. Restoration and/or protection of stork nests is an example of how cost effectiveness can be attempted. Let us assume that 100 stork nests are to be restored. Several competent organisations are asked if they could do the job. Let us say that three of them agreed to carry out this task. One asks for 20,000 €, the second – for 25,000 €, and the last one – for 22,000 €. Assuming that all three of them have appropriate credentials, the first one should be selected as the cheapest one (200 € per nest). The example above is an easy one. Other biodiversity projects – e.g. restoring a wetland – are more difficult to assess since their effects are more difficult to be quantified. And yet, quantification is a prerequisite for the cost effectiveness to be checked.

13.12 Why was the Polish EcoFund experience difficult to replicate in other countries?

As explained earlier, DFE swaps have to compete with much more common debt-for-equity swaps. There were unique circumstances in Poland in the early 1990s responsible for the fact that a DFE idea emerged. The most important one is the commitment of the government. Politicians know that creditors prefer debt-for-equity swaps, so they are reluctant to advocate an idea which is likely to be rejected. As a result, DFE swaps are almost never asked for. And if they are, debtors withdraw quickly, once they sense that creditors press for something else. The commitment demonstrated by the Polish government in 1991 cannot be found elsewhere easily. Besides, EcoFund had a carefully drafted charter which ensured that projects are selected prudently, and – at the same time – creditors can be confident that their interests are recognised. I am afraid that neither of the circumstances was present in countries which tried to replicate the EcoFund experience. The governments were not committed to press for DFE swaps, and insufficient effort was put into designing an institution to coordinate interests of the debtor and the creditors.

13.13 Why did other creditors of Bulgaria hesitate to join the Swiss initiative to replicate the Polish experience?

As earlier game theoretic analyses suggest, not all the creditors find it beneficial to join the swap. Some are better off when they stay outside. In addition, creditors judged that the Bulgarian fund's charter did not guarantee that their preferences are taken care of adequately.

14. Trade and Environment

This was a fashionable topic in the early 1990s. There were numerous reports and conferences asking whether international trade was good or bad for the environment. Wide interest in the topic was triggered by an internal memorandum circulated by Larry Summers, a chief

economist in the World Bank in 1991. The famous words, which caused Larry Summers to be fired, read:

> *The economic logic behind dumping a load of toxic waste in the lowest wage country is impeccable and we should face up to that.*

The sentence seems arrogant and unethical, but it addresses a serious problem. Let us assume theoretically that Nigeria adopts Irish environmental standards. Hence the Nigerians are protected as strictly, as the Irish are. Let me admit that an average Nigerian enjoys less than 3% of GDP per capita that an average Irish does (8% if one takes into account purchasing power). I suspect that Nigerians would not be happy to apply the Irish standards, since their products would be even less competitive in international markets, and their well-being would be even lower. Hosting dirty industries in low income countries – something we oppose to on ethical grounds – may be an economic opportunity these countries are reluctant to lose.

International trade seems inevitable. But there is a serious question whether it is good or bad for the environment. In 1993 the Swedish government commissioned a special report to answer this question. The report is comprehensive and competent, and its conclusion is that trade is neither good nor bad for the environment; it is neutral. It can be either good or bad – everything depends on the quality of your government. If your government is clever, i.e. it establishes certain constraints on trade by environmental regulations, then you will gain from trade. If your government is stupid or corrupt, you will lose.

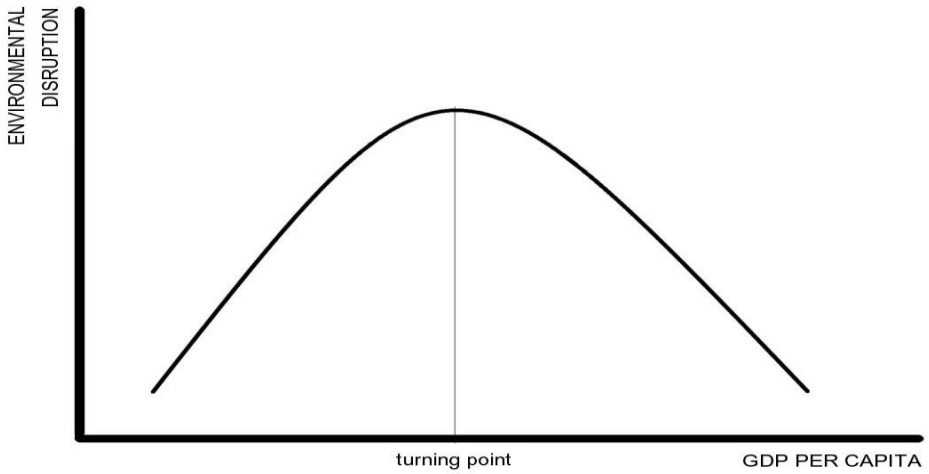
Every country depends on international trade. It is difficult to think of an economy which develops in an autarkical way, that is in isolation from foreign markets. Swedish government report analyses this global network of trade relationships and concludes that countries may gain from it, even though it is possible to lose out of it either.

Many people see this report as somewhat hypocritical. Its main conclusion is that economies may gain from trade, and this is correct. However, they can lose if their governments fail to establish appropriate regulations. It has been known that – unfortunately – many governments are stupid or corrupt. If they open up their economies for international trade, societies can be worse off. If people see the two problems separately, there is a temptation to liberalise the trade no matter what and then to struggle for better governance. Meanwhile the environment will be devastated. Conclusions of the Swedish government report do not link these two aspects sufficiently strongly.

While many analysts see that poor environmental protection is correlated with openness to international trade, the causality in this relationship is by far not obvious. This controversy can be summarised as follows:

- Why are dirty industries found in countries with lax environmental regulation?
- One may argue that dirty industries go where environmental regulation is not strict
- But it can be also argued that strict environmental regulations are not adopted in countries where dirty industries exist, since politicians would hesitate to struggle with their lobbyists

Let me explain the argument. It is a common knowledge that dirty industries are found in countries with lax environmental regulation. But mechanisms leading to this fact are not clear. A popular reasoning indicates that dirty industries go where environmental regulation is not strict. Examples can be found that investors choose economies where low prices of production factors imply low production costs. There are obvious incentives to move production where environmental assets are less expensive. In particular, if there are weaker regulations, abatement required by law does not have to be very expensive. Indeed, some developing countries compete for foreign investors by declaring low environmental requirements. But the direction of causality is not always obvious. If there are no dirty industries, then politicians do not hesitate to adopt stricter regulations since they are not afraid of any resistance. For instance, it is not surprising that countries which do not have their own coal mines are ready to pass regulations against using solid fuels.



Being aware of the fact that there is some correlation between environmental protection and international trade, let us analyse how they may influence each other. So-called Environmental Kuznets Curve (EKC) makes a good starting point for such an analysis. Simon Kuznets, an excellent economic historian and Nobel laureate in 1971, found an inverted U-shape relationship between GDP per capita and income inequality. The latter goes up when the former increases. Then it stabilises and starts to go down when GDP per capita increases further. This is called Kuznets Curve for income inequality. Economists discovered that many other indicators go up if the country becomes wealthier, then they stabilise and they go down once the country becomes sufficiently rich. In particular, environmental disruption follows this pattern (see picture above). If the country is poor, the environment is pristine. Once its economy starts to develop, environmental disruption grows, then it stabilises, and goes down when GDP per capita is high.

EKC implies that environmental disruption is a sort of a "child sickness"; everybody has to pass through it. At the same time, environmental protection policy is not that important – people will protect the environment anyway when they become sufficiently rich. In many sectors EKC proved to fit the statistical data fairly well. For instance, deforestation rate is close to zero if a country is very poor. Once it begins to grow economically, forests are cut or burned, and deforestation rate goes up. However, once the people start appreciating their natural environment, deforestation rate goes down. Likewise river pollution. It goes up, then it stabilizes at a high level, and eventually it goes down.

The argument based on EKC can be summarised in the following two implications:

TRADE ⇒ ECONOMIC SURPLUS ⇒ ENVIRONMENTAL PROTECTION

For more than 200 years economists have observed that trade may increase economic surplus. If international trade develops, people become richer. Once they become richer, they start to care for environmental protection. Therefore trade is good for the environment. Yet neither of these implications is indispensable; either can be questioned.

So-called specialisation trap demonstrates that international trade does not have to result in a higher economic surplus. Before they opened up for international trade, many developing countries were more or less self-sufficient in producing whatever they wanted to meet their (basic) needs. They realised, however, that they can gain by specialising in some products, selling these products in international markets, and buying whatever they did not produce before the specialisation. For various reasons, prices of these products tend to decline (at least in relative terms). If the price of a product goes down, a profit maximising producer should seek alternative opportunities. As many producers in developing countries cannot find easily alternative specialisations, they increase the production of the less attractive good to keep imports. Consequently, economic surplus may go down, contrary to what the first implication claims.

The second implication is ambiguous either. Let us assume that economic surplus increases, and let us assume that it corresponds to what can be expected beyond the turning point in the EKC (before reaching the turning point, growing affluence is environmentally harmful for sure). According to the EKC theory, people who are better off demand better environmental protection. Nevertheless, this is not inevitable. To see this, we can try to speculate about environmental preferences of a rich person in a developing country. The EKC theory predicts that such a person will demand a better water quality. But even if its quality is poor, the demand can be met by buying bottled water imported from elsewhere. EKC predicts that such a person will demand a better air quality. But if the air quality is poor, children can be sent to a boarding school abroad. If the landscape is ugly then – instead of lobbying for its protection – perhaps building a tall fence will prevent from being exposed to its ugliness. In other words, increased economic surplus does not have to translate into better environmental protection.

In addition to income based doubts, critics point at two specific environmental aspects:

- Export specialisation favours monoculture
- "Race to the bottom" argument

The first one refers to the specialisation argument outlined earlier (except that our previous argument focused on economic considerations). Specialisation has a purely environmental dimension as well. It leads to monoculture, that is to an attempt to eliminate all but one species and varieties. This compromises biodiversity, as explained in one of the earlier classes. It also leads to increased demand for chemical inputs, such as pesticides, which add to environmental disruption.

The second one looks at something which is not inevitable, yet often observed in countries that want to excel in international trade. "Race to the bottom" is a common name for the process of relaxing environmental requirements. In order to attract investors, developing

countries try to convince that their economies offer cheaper production factors than the neighbours do (I often refer to Bolivia-Ecuador example in the class). This "competition" is difficult to win unless a country "frees" its economy from any environmental requirements. This is the essence of the "race to the bottom". A country which introduces some environmental requirements risks that its neighbour will use this as an argument to let an investor leave that country and lower its production cost by moving elsewhere.

Critique of trade liberalisation is summarised in the following two concepts:

- *Pollution Haven Hypothesis*
- *Ecological dumping*

The first one states that countries which compromise environmental regulations serve as "Pollution Havens" for firms that try to minimise the cost of their operations by choosing economies with low requirements. The hypothesis predicts that globalisation results in pollution moving to countries with lax environmental regulations.

Economists talk about "dumping" whenever they suspect that prices of imported goods are lower than they should be. For instance, an exporting country may subsidise its products to be sold abroad in order to meet some macroeconomic objectives. Or it may tolerate low wages in order to make its products cheaper than they would have been if workers were offered decent working conditions. In order to protect their own producers, importing countries impose so-called anti-dumping tariffs. In earlier lectures we analysed attempts to introduce border tax adjustments. "Ecological dumping" takes place when environmental assets are under-priced. A typical case is when an exporter fails to introduce adequate environmental protection. Analysts claim that international trade offers incentives for such "ecological dumping.

There were numerous attempts to analyse the nexus of environmental protection and international trade. Very few of them applied rigorous quantitative methods, because of measurement difficulties. Overall the empirical evidence is inconclusive. The best known results are those obtained by Jeffrey A. Frankel in 2008. Based on the 1990-2004 data, the calculations were supposed to answer the question whether international trade was positively correlated with environmental protection. In some cases it was. Namely, in the case of domestic environmental protection – e.g. against sulphur dioxide – the correlation was slightly positive. But in the case of global environmental protection – e.g. measures taken against carbon dioxide – the correlation was (slightly) negative. The latter can be interpreted as yet another aspect of the carbon leakage (recall one of the earlier lectures): if a country is involved in international trade, it may "export" its carbon dioxide emission abroad easier.

Measurement problems affect both variables, i.e. international trade and environmental protection. The ratio of trade-to-GDP was used as a measure of the role international trade plays in a given economy. Environmental protection is much more difficult to measure. Specific regulations cannot be referred to, unless enforcement is taken into account. Besides, regulations *per se* are not always a good indication of whether the population is protected satisfactorily. Frankel used pollution abatement as a proxy for environmental protection. This is perhaps the best available measure, but – like in the case of regulations – it is does not indicate whether citizens are protected adequately.

Conclusions from the empirical research can be summarised as follows:

- Based on empirical observations, it turns out that detecting a relationship between trade and abatement is very difficult and subject to technical econometric assumptions
- Detecting a relationship between trade and environmental protection would be even more difficult
- If at all, these relationships are very weak, i.e. at the border of statistical significance
- Yet they seem to be slightly negative for global pollutants, such as carbon dioxide emission (*carbon leakage*), and slightly positive for domestic pollutants, such as sulphur dioxide emission

If a skilled econometrician looks at these results, he or she realises that they are not very robust. Controversial statistical assumptions have to be made in order to verify the *Pollution Haven Hypothesis* or to detect *Ecological Dumping*. Contrary to numerous examples referred to, international trade cannot be easily indicated as a factor of environmental disruption. The most likely reason is that negative examples are sometimes counterbalanced by positive developments resulting from trade.

Questions and answers to lecture 14

14.1 Why was the Larry Summers' memo found to be intolerable?

Larry Summers' memo was circulated as an informal material to trigger discussion among the World Bank officers whether insisting on environmental protection requirements considered "standard" in high-income countries extrapolated to low-income countries makes sense. It leaked to the press, and resulted in firing Larry Summers from the World Bank (later on he served as an advisor to Clinton and Obama, as well as the President of the Harvard University). While he raised an important doubt, he used a language that was arrogant and unethical. In particular, he suggested that low-income countries may be treated as a sink for unwanted effects of economic activities.

He was not quite original in his statement. Several decades earlier, there was a discussion what to do with radioactive waste produced by German nuclear power plants. One suggestion was to bury the waste in the Gobi desert. This was a scandalous idea to take advantage of the fact that – indeed – Mongolia was much less densely populated than Germany (less than 2 people per km^2 *versus* more than 200 people per km^2). In addition, Mongolia was much less wealthy than Germany. These two facts combined resulted in huge differences in how the land is valued in the two countries. Nevertheless, the idea to take advantage of this for this particular purpose was scandalous. Larry Summers' suggestion was found to be similar to what some First World experts think of the Third World (as evident from the German discussion on the radioactive waste).

14.2 Should environmental regulations reflect the material welfare of a given country?

This is similar to what Larry Summers had perhaps in mind (see question 14.1 above). Citizens of a low-income country may have different preferences with respect to the quality of the environment than more wealthy people. The latter are not so much preoccupied with material consumption, since most of their basic needs are met. Therefore they attach a much higher weight to environmental quality. This does not mean that the natural capital in low-income countries is less important; it simply means that wealthy people are not overwhelmed

with meeting their basic needs, despite the fact that, say, cutting a tree may have even more disastrous results in a low-income country than in a high-income one. Nevertheless in a high-income country cutting a tree is likely to trigger massive protests, while in a low-income country it may go unnoticed. Given the fact that people may have different preferences, the same standards should not apply everywhere. If one country adopts different environmental regulations (in a democratic procedure) than the second one, the choice can be justified by the citizens who are affected. It would be unreasonable to claim that every country should adopt identical regulations. In particular, citizens in low-income countries may prefer to adopt less strict regulations than those favoured in high-income ones.

14.3 How can one defend the conclusion of the Swedish government report about the neutrality of international trade?

I think that the conclusion is justified. The argument developed by David Ricardo, a prominent English economist, some 200 years ago is based on a hypothetical trade between Spain and Scotland. Both countries can produce and consume wine and wool. If they do not trade with each other, then Spain produces and consumes, say, 3 thousand barrels of wine and 3 thousand tonnes of wool. Scotland produces 1 thousand barrels of wine and 5 thousand tonnes of wool. However, if Scotland specialises in wool production, and Spain specialises in wine production, then Scotland can produce 10 thousand tonnes of wool (and no wine), and Spain can produce 6 thousand barrels of wine (and no wool). If Scotland consumes 6 thousand tonnes of wool, and exports 4 thousand tonnes to Spain, in exchange, it can import 2 thousand barrels of wine. Both countries are better off if they specialise in what they can produce most efficiently: Spain enjoys 4 thousand barrels of wine and 4 thousand tonnes of wool, and Scotland enjoys 2 thousand tonnes of wine and 6 thousand tonnes of wool. If environmental (in this case: land use) regulations reflect citizens' preferences, then trading wool for wine, makes everybody better off.

If, however, Scottish environmental regulations do not reflect the fact that vineyards are less environmentally disruptive than grazing land for sheep, then the balance does not necessarily favour the trade. Changing the land use patterns may lead to losses that are not justified by gains from trade.

The Swedish government report separates two issues: (1) environmental neutrality of trade; and (2) adequacy (or inadequacy) of environmental regulations. If we look at the first issue only, then the conclusion is justified. Indeed trade is neutral.

14.4 Can simple assumptions (like linearity or proportionality of interactions) imply a non-linear (inverted U) shape of their combined relationship?

Yes. Let DIS be some indicator of environmental disruption, and POP – population. EKC explains why DIS/POP increases initially when GDP/POP increases and then – after a while – it starts to decrease. Let us observe that the expression DIS/POP can be multiplied by, and divided into, the same number (other than zero). In particular, the number can be IND/GDP, where IND is the industry production. Hence the following equality holds:

$$DIS/POP = DIS/IND * IND/GDP * GDP/POP$$

If one notes that DIS/IND and IND/GDP can follow very different trends (they can grow or decline at a different pace), their product will grow first, and then it will decline.

14.5 How do economists explain that trade does not have to be based on a fraud, but it can be beneficial for both the seller and the buyer?

For many centuries economists thought that trade was based on a fraud. If a seller sold a good to a buyer for the price of *x*, one of the following possibilities took place. The true value of the good was higher than *x*, but the seller was not aware of this. He (or she) lost as a result of the transaction. The buyer gained, because he (or she) paid only *x* while the value of the good was in fact higher. Alternatively, the true value of the good was lower than *x*, and thus the buyer lost while the seller gained. It would be impossible for both of them to gain. In the 18th century, Adam Smith (considered the father of the classic economics) observed that the good to be transferred from a seller to a buyer may provide both with a different utility. The former would be willing to accept *y* for the good while the buyer would be willing to pay *z* for the same good. If $y<z$, then any price *x* between these numbers (i.e. $y<x<z$) is satisfactory for both of them. As a result of the transaction, the seller is left with $x-y$, and the buyer received $z-x$. Both numbers are positive which means that both of them gained. Thus the trade was not based on a fraud.

14.6 Terms of Trade (TOT) are defined as the ratio of the export price index to the import price index. TOT for many developing countries were found to be declining. Why?

This is an empirical finding. For instance, the real price index (i.e. inflation excluded) for raw materials and agricultural products declines in the long term. But the price index of industrial products (e.g. pesticides) declines at a slower pace, so their ratio goes down. Many developing countries export agricultural products, and import pesticides, so their TOT go down too. Perhaps the most convincing interpretation of this empirical fact is that agricultural market is more competitive than the chemical one.

14.7 How can a successful exporter in a developing country satisfy his or her preference for a better environmental quality?

The successful exporter can "buy" a better environment by protecting himself (or herself) from what can be found in his (or her) country rather than demanding better environmental protection at home. Observing how wealthy people behave in low-income countries leads to the conclusion that they can afford (for themselves and their families) certain environmental benefits – like safe water and enjoyable landscape – even if the state of the domestic environment is unsatisfactory.

14.8 If a developing country produces something at a lower cost than in a developed country, analysts say that ecological dumping takes place. Are they right?

Not necessarily. Producing tomatoes in one country can be cheaper than in another country because of climatic factors, or different endowments of various types of the natural capital (soil, water, etc.) – not because of charging wrong (too low) prices. Ecological dumping takes place if the exporter lowers the production cost by under-pricing natural assets.

14.9 How does the European Union prevent trade in toxic waste?

Directive 2008/98/EC – called Waste Framework Directive – introduces (in art. 4) the European Waste Hierarchy. This consists of 5 steps: prevention, reuse, recycling, recovery,

and disposal. The meaning of some steps is obvious, but the difference between reuse and recycling should be explained. Reuse means giving the products a second life before they become a waste. Recycling means that waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes composting and it does not include incineration. Recovery (or energy recovery) means incineration. The Hierarchy implies that a step can be applied only when its predecessor turned out to be impossible or unpractical. For instance a waste should not be incinerated if it can be recycled. In art. 16 the Directive explains principles of self-sufficiency and proximity which call for limiting (but not banning) international transfers. Additional provisions apply to hazardous waste whose transfers are subject to specific requirements.

The following example demonstrates how toxic waste owners try to circumvent European regulations. A couple of years ago, a Dutch ship sailed to one of the Polish shipyards to be modernised. It was halted (before entering a harbour) by Polish environmental inspectors who discovered that the vessel contained a large amount of asbestos. It took several months before the European Commission confirmed that the attempted transaction was illegal, and the ship had to return to its Dutch owner.

14.10 Why were Frankel 2008 results found different for sulphur dioxide abatement and carbon dioxide abatement?

As explained in my earlier lectures on climate protection, carbon dioxide is a global pollutant, and no country has interest in abating it in order to protect its domestic environment; they will abate only if forced by an international agreement. In contrast, sulphur dioxide is not a global pollutant (even though it can migrate somewhat and damage someone else's environment too – see my lecture on acid rain); countries are willing to abate sulphur dioxide motivated by their own depositions, not only when they are forced by an international agreement. Therefore there is a difference in how countries look at carbon dioxide abatement, and sulphur dioxide abatement. In the case of the latter, there are some regulations to abate irrespective of whether international trade allows certain industries to move abroad. In the case of the former, countries have an incentive to reduce their emission by moving certain industries abroad. Thus more intensive international trade is correlated with more opportunities to move carbon dioxide abroad. Nevertheless these tendencies are weak and questionable. They seem to change over time.

14.11 Environmentalists often refer to the "Pollution Haven Hypothesis" in order to illustrate the claim that dirty industries migrate to developing countries. Does statistical data support this claim?

No. The statistical evidence is inconclusive, and one can find a number of examples which seem to support the Pollution Haven Hypothesis (PHH), and a number of examples which seem to contradict it. Many popular examples support the PHH, so I will refer to the one which does not.

In 1986 there was one of the largest environmental catastrophes in the world. A Union Carbide plant in Bhopal (India) exploded and toxic gases (mainly methyl isocyanate, C_2H_3NO) killed 3,800 people instantly. The total death toll is estimated at 15,000-20,000. The catastrophe was caused by negligence of local employees. The density of housing adjacent to the plant (*favela* type, i.e. slums) drove the number of deaths.

The American corporation Union Carbide was accused of locating an unsafe, dirty plant in a low-income country. But there is another identical plant in Eastern USA which has operated safely. Both plants apply the same technology and they meet the same safety standards. Should Union Carbide take into account that Indian employees are less accurate in complying with safety standards? Should Union Carbide take into account that a ban on building houses adjacent to the plant is not enforced in India (in the USA it has been enforced effectively)? The corporation must have been aware of differences in environmental enforcement in the two countries. Yet a decision not to build the plant in India would be interpreted as paternalistic. The case contradicts the PHH.

15. Environmental policy in the EU

Environmental policy makes an important component of the European Union (EU) agenda. It is included in hundreds of "environmental" directives. EU legal documents take the form of Regulations or Directives. The former are binding directly. The latter need to be transposed into national legislative systems, but before they become binding for everybody, they bind member country governments only. Directives make the major part of the *acquis communautaire*, in the field of environmental protection.

In addition, there are a number of environmental outcomes of non-environmental policies. For instance, EU may decide something on agricultural policy, and its implications are relevant for environmental protection. We will look at these other policies as well.

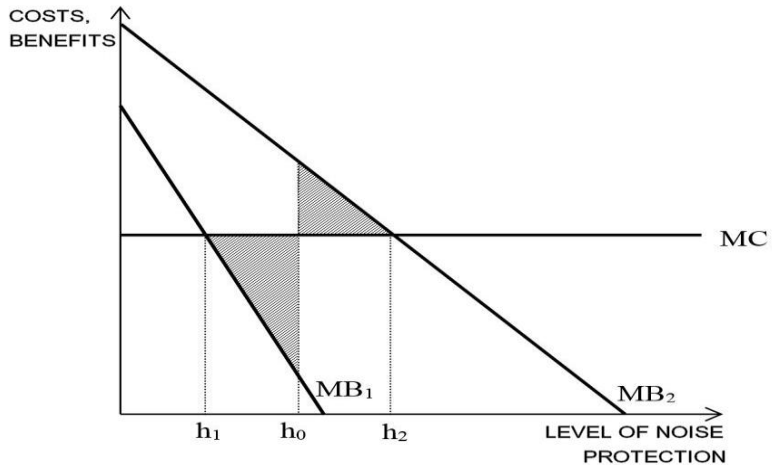
In the beginning, let me indicate that there are 5 directives aimed at regulating noise emitted by lawn mowers:

- 84/538/EEC
- 85/409/EEC
- 87/252/EEC
- 88/180/EEC
- 88/181/EEC

Their rationale is controversial, as the following analysis demonstrates. For simplicity, let us assume that there are two countries – 1 and 2 (see picture on page 155) – characterised by different preferences for protection against the noise. In country 1 citizens are not that sensitive to noise protection, and in country 2 they expect stronger protection against noise. This translates into two different "demand curves": MB_1 and MB_2 with MB_1 located below MB_2. Assuming that the marginal cost of adopting a unit of noise protection (say, an additional decibel) is illustrated by MC, the optimal level of noise protection in country 1 is h_1, and in country 2 – h_2. If one thinks of a compromise between the two countries, it would be natural to adopt h_0 (the average of h_1 and h_2) as the common level of noise protection.

Please note, however, that this common standard implies losses for both countries (shaded triangles in the graph). The lower left triangle illustrates the welfare loss in country 1 resulting from adopting a higher standard than the preferred one. The loss is caused by the fact that additional benefits from noise protection (MB_1) are smaller than the cost incurred (MC). The upper right triangle illustrates the welfare loss in country 2 resulting from adopting a lower standard than the preferred one. The loss is caused by the fact that benefits lost by insufficient

noise protection (MB_2) are higher than savings on the lower abatement cost incurred (MC). Hence the common standard cannot be justified by environmental protection.



Why does the European Union adopt common environmental standards like the one which regulates noise emitted by lawn mowers? Such unified standards are not justified by environmental protection. Nevertheless they help to create a common European market. If there were two different standards in these two countries – h_1 in 1, and h_2 in 2 – a producer who registered its product in country 1 would have to apply for a separate certificate in country 2. In order to simplify business procedures, a common certificate can be introduced if the standard is unified.

But there is an additional reason why the European Union tries to eliminate stark contrasts between its regions. European citizens expect to be exposed to similar circumstances in countries they visit. Lowering the development differences between various countries in the European Union is called a "cohesion policy". Cohesion is understood as making regions similar to each other (providing people with equal opportunities to support their aspirations). Enjoying similar environmental benefits is one aspect of improved cohesion, but increasing employment and innovativeness in depressed regions is perhaps the most important goal of policies pursued.

A question can be raised whether these policies are effective, i.e. whether European regions do or do not converge. There are two concepts of convergence:

- "Beta" convergence = faster change rate observed for units below the average than for those that are above
- "Sigma" convergence = lowering dispersion between the units
- $\sigma \Rightarrow \beta$, but not *vice versa*

The following example shows that "beta" does not imply "sigma". Let there be two countries with GDP per capita 8,000 € and 15,000 €, respectively. They are 7,000 € apart. Let the first number grow 4% per annum, and the second one at 3% per annum, as required by "beta". In the next year the GDP per capita will read 8,320 € and 15,450 €, respectively. They will be 7,130 € apart (more distant from each other than before), thus contradicting "sigma". The proof of the implication $\sigma \Rightarrow \beta$ is somewhat more difficult (please see question 15.5).

A number of studies were carried out in the European Union in order to check whether cohesion policies proved effective. Their conclusions can be summarised as follows:

- "Sigma" convergence is observed at the national level (i.e. among countries)
- At sub-national levels GDP per capita "sigma" diverged (i.e. among regions within a country)
- "Beta" convergence was observed internally in few countries only
- In most EU countries GDP per capita "beta" diverged (i.e. among regions within a country)

These conclusions demonstrate that cohesion policies bring different results at national and sub-national levels. At the national level "sigma" convergence is observed. This means that EU countries become closer to each other. Not only those wealthier ones reveal a lower growth rate ("beta" convergence), but their dispersion goes down ("sigma" convergence). At a sub-national level things look differently though. Several disaggregation levels are used in EU statistics. Large countries – such as Poland or Italy – are disaggregated into several lower units (so-called NUTS1); Poland has 7 NUTS1 units. They are disaggregated further into smaller geographical units (called NUTS2); in Poland there are 17 NUTS2 units (corresponding to official administrative units; only the Warsaw area is divided into two parts). They are disaggregated further into NUTS3. For instance, Poland consists of over 70 such NUTS3 units, typically corresponding to groups of counties regarded as similar, taking into account the level of economic development. It turned out that at subnational levels GDP per capita "sigma" diverged. This means that inequalities increased within countries. In most countries there was even "beta" divergence observed at the level of smaller regions. In other words, cohesion policies have been effective at the national level, while at subnational levels they failed.

One of the most interesting Europe-wide projects was called *Lisbon Strategy*. It was adopted at the EU summit in Lisbon in 2000, and sought synergies between various policies. Its aim was to "make Europe the most competitive and the most dynamic knowledge-based economic region of the world by the year 2010". People who remembered Soviet slogans to overcome the United States looked at this goal sceptically, but many European citizens felt inspired. A year later at a summit in Gothenburg the strategy was amended by adding that competitiveness and dynamism should be consistent with sustainability.

As amended in 2001, Lisbon Strategy had a strong environmental pillar, consisting of 4 components:

- Climate protection by slowing down fossil fuel consumption
- Conservation of natural resources
- Mitigating transport pressure
- Improving public health

The first one reflected the European ambition to become the world leader in protecting the global climate (see my lectures on climate change). To achieve this, *Lisbon Strategy* called for slowing down fossil fuel consumption. This would imply switching from fossil fuels to renewable energy sources. The second one included two aspects: conservation of living resources (enhancing biodiversity – see my lecture on biodiversity) and improving waste management (in order to save virgin raw materials). In addition, it was acknowledged in

Lisbon Strategy that mobility was responsible for a large part of pressure on the environment. Mobility contributed to the demand for oil, and it implied habitat fragmentation caused by highway networks. The last component of the environmental pillar envisaged improving public health. This is broader than just improving the air and water quality (it includes a better health care in general), but – to a large extent – it was an environmental objective.

Soon it became clear that the overall objective of "making Europe the most competitive and the most dynamic knowledge-based economic region of the world by the year 2010" was unrealistic, and the European Commission took a decision to carry out a mid-term review of the *Lisbon Strategy*. A committee, chaired by Willem Kok (a former Prime Minister of the Netherlands), was set up to review the Strategy and to recommend amendments for the second part of its period, i.e. for 2005-2010. To the regret of many environmental activists, the revised *Lisbon Strategy* was "freed" from most of its environmental ambitions. The entire environmental pillar was reduced to Guideline no. 14 (out of the total of 23) which boiled down to the following conclusion: *To encourage the sustainable use of resources and strengthen the synergies between environmental protection and growth*. More specifically, Guideline no. 14 recommended:

- Internalising external costs;
- Increasing energy efficiency; and
- Support for environmentally-friendly technologies (*Environmental Technologies Action Plan*, ETAP)

These recommendations were not entirely new. "Internalising external costs" (a version of the *Polluter Pays Principle*) has been called for since the beginning of the 20th century. Politicians always admitted that this principle should be complied with (i.e. the polluters should pay for whatever "external" effects they are responsible for), but social considerations forced this to be postponed until later. "Increasing energy efficiency" is an excellent slogan, but it cannot substitute for an environmental policy (recall the discussion of "McKinsey steps", and "rebound effects"); extensive use of devices which are more energy efficient does not imply a lower consumption of fossil fuels. The third recommendation was disappointing as well. ETAP was a plan based on identifying so-called *Best Available Technologies* (BAT), which were considered solutions to environmental problems. Economists demonstrated that they were not (because mandated technologies discourage engineers to work on better solutions), but their owners lobbied heavily to give them the status of mandatory environmental measures.

The overall message of the mid-term report was:

> *European Union and its Member States have clearly themselves contributed to slow progress by failing to act on much of the Lisbon strategy with sufficient urgency. This disappointing delivery is due to an overloaded agenda, poor coordination and conflicting priorities.*

The report anticipated that, once freed from an environmental ballast ("*overloaded agenda*"), the strategy would achieve its purely economic objectives. It did not. In 2010 it was declared a failure anyway by many European political leaders, but the result can be interpreted in a positive way. It has not failed because of "overloading" with environmental objectives. The

mid-term revision "freed" it from these objectives. Hence, environmentalists still believe, that it may be possible to combine environmental ambition with economic performance.

The *Lisbon Strategy* was an interesting experiment, and its objectives deserve to be analysed in detail. The environmental pillar consisted of four components: (1) climate change; (2) natural resources; (3) transport pressure; and (4) public health. The first component was the most visible one. The EU became an unquestionable leader in the area of the Kyoto Protocol. Because of the Berlin Mandate, global climate protection has failed (see my lectures), but the ambition declared by the EU is remarkable. The second component addresses two issues: living resources (including biodiversity), and waste management. The former has failed, since biological diversity is expected to deteriorate not only globally, but in Europe too. The latter is somewhat better, since the effectiveness of waste management improved. The last two components did not demonstrate any improvements, although because of different reasons. In the case of the transport sector, the failure was caused by the fact that no effective policies to control mobility were undertaken. As a result, environmental damages caused by the transport sector were not mitigated. In the case of public health, the lack of improvement was not caused by a failure, but rather because it was in a good shape to begin with. Health care systems were organised fairly well, so that their further improvement was very difficult.

Poland acceded to the European Union in 2004. As a new member, it had to comply with so-called *acquis communataire*. The elements of the *acquis* were negotiated on a sector by sector basis. Polish Minister of Transport negotiated with the EU Transport Commissioner, Polish Minister of Agriculture negotiated with the EU Agricultural Commissioner, Polish Minister of Environment with the EU Environmental Commissioner, and so on. There was a unique opportunity, to practise policy integration in a sense that whatever is negotiated in transport and agricultural sectors, has environmental impacts. Unfortunately, negotiation process failed to highlight this, and instead it focused on the *acquis* belonging to a specific sector rather than observing their interrelations.

The lack of policy integration manifests in many outcomes of European activities. Let me quote two of them.

Even before the formal accession in 2004, Poland tried to adopt as many European solutions as possible. It realised that road safety and air quality is compromised by Western European car wrecks imported as "used vehicles". After 1989, almost every Polish government introduced some constraints on this "trade". These constraints were then questioned by European lawyers as violating free trade principles, and lifted after some time. As a result, the import of car wrecks was resumed, but after a while another Polish government took similar measures that were questioned again, and the story repeated. While EU environmental commissioners are aware of the fact that free trade in car wrecks is detrimental, other officers insist that non-environmental principles are important as well; environmental protection should be addressed by other measures (but import of car wrecks should continue, according EU oficers).

EU environmental commissioners are sensitive to Poland's water management problems. For instance, the European Commission played an important role in forcing the Polish government to abandon its plans to sacrifice the famous Rospuda wetland (in North-eastern part of the country) for an ill-designed highway project in 2006. However, at the same time the Commission promotes a Europe-wide system of inland water transport which requires Poland to make its rivers navigable. There is an obvious contradiction between making these

rivers navigable (perhaps attractive for some European firms) and protecting ecosystems that disappeared in many places but survived along Polish rivers.

There are a number of other instances where European policies suffer from insufficient integration. Overall, EU plays a positive role in promoting, enhancing, and coordinating environmental policies in member countries. Yet it would have been more effective, if better integration was achieved. In many situations, whenever there is a clash between environmental and purely economic priorities, the former yield to the latter. European institutions are not unique in this respect; they replicate attitudes found in other social organisations throughout the world.

Questions and answers to lecture 15

15.1 Does it make sense to establish "average" standards to achieve a compromise between more and less ambitious environmental preferences?

From the environmental protection point of view it does not, unless citizens from one country suffer or benefit from what other country does. Let us stick to the example of two countries: 1 and 2. Let us talk about noise – i.e. an environmental nuisance that does not migrate. If there is too much noise in country 1, then country 2 is unaffected, and it should not be bothered by the fact that in 1 there is too much noise (according to what 2 prefers). Things may change, however, if we talk about a nuisance that migrates, like acid rain. Then a weak standard adopted in 1 has a direct impact on 2. Under these circumstances 2 can insist that 1 adopts a stricter standard. But a better solution to the problem will be to negotiate an international convention (like Geneva Convention). There is yet another aspect of adopting common standards. European citizens travel, and they would like to enjoy similar conditions everywhere they go to in the EU. From that point of view, it can be justified to have the same standards (like e.g. having safe potable water) in every country. I am not convinced that this argument applies to the noise.

There is yet another aspect of the problem. In every country, people may be more or less sensitive to noise. Hence adopting a common standard may be justified in country 1: h_0 is stricter than h_1, so citizens more sensitive to noise in this country are protected as well. But this argument does not work for the country 2: its citizens are exposed to more noise than they wish on average (h_0 is weaker than h_2). Besides, even from the point of view of country 1, adopting h_0 rather than h_1 is determined by what citizens in country 2 prefer, not necessarily by what the sensitive people in 1 would like to have.

15.2 Why may "average" standards decrease the welfare in countries affected?

The class example explains why this happens whenever the MB=MC criterion is violated.

15.3 Why does the European Union advocate for common standards in environmental protection?

There are several arguments that justify common standards. In the case of "migrating" environmental impacts (like acid rain, but unlike noise), common standards constrain the migrations (see 15.1). But international conventions are more appropriate then. In the case of very dangerous environmental impacts (like water contamination), a common standard (e.g.

for tap water) is justified by safety reasons. But I feel that the most obvious justification for the common standard philosophy is economic freedom. Without common standards, a firm accepted in one market (say, in country 1) would have to apply separately for acceptance in another market (say, in country 2).

15.4 Why does the European Union try to create similar life conditions everywhere throughout its territory?

Countries of the European Union aim at creating conditions that wherever we go, we are exposed to similar threats and we enjoy similar opportunities.

15.5 Are European cohesion policies effective?

No. Their effectiveness is limited to international differences. Intra-national differences still exist and they even grow. In other words, the difference between Portugal and Sweden is now lower than it used to be, but differences between, say, Northern Italy and Southern Italy are still large, and they do not shrink. Cohesion policies may have prevented to have them grown even more, but they did not revert the trend.

15.6 How to prove that $\sigma \Rightarrow \beta$ ("sigma" convergence implies "beta" convergence)?

A precise mathematical proof would be more complicated, but let us confine to the example of two countries only: 1 and 2. Let us assume that there were two numbers observed in these countries earlier: OLD_1, and OLD_2; and two numbers observed now: NEW_1 and NEW_2, (OLD and NEW may stand for GDP, or any other indicator) and let us assume that $OLD_1>OLD_2$; (if it is the other way around, country number 1 and country number 2 can be renumbered). If we have "sigma" convergence then $OLD_1-OLD_2 > NEW_1-NEW_2$, and thus $OLD_1-NEW_1>OLD_2-NEW_2$, or alternatively $NEW_1-OLD_1<NEW_2-OLD_2$. If we divide both sides into OLD_1 then we get $(NEW_1-OLD_1)/OLD_1<(NEW_2-OLD_2)/OLD_1<(NEW_2-OLD_2)/OLD_2$; (the last inequality holds, because $OLD_1>OLD_2$, and a larger number in the denominator is substituted by a smaller one). What we finally got is: $(NEW_1-OLD_1)/OLD_1<(NEW_2-OLD_2)/OLD_2$. This means that the rate of growth in the country 1 is lower than the rate of growth in country 2. In other words, "beta" convergence holds.

15.7 Did the original Lisbon Strategy (adopted in 2000) pay sufficient attention to sustainability?

Not explicitly. It aimed at "making Europe the best", but without admitting that everything should be sustainable. At the Gothenburg summit in 2001, the Swedish Presidency insisted that the sustainability constraint is mentioned explicitly.

15.8 Transport policy is a very sensitive area of the EU activities. What sort of measures could be envisaged in order to mitigate its environmental pressure?

During the COVID-19 pandemics our mobility was constrained, but we treated this as an exceptional, temporary thing. "Normally" we would not like to see our mobility to be constrained. Some years ago the European Commission endorsed a document which stated that "constraining mobility was not an option". This is something environmentalists oppose, since our mobility exerts enormous pressure on nature. Now we see that certain activities (of

course, not everything) can be carried out remotely (online), and perhaps a continued growth of the transport infrastructure is not inevitable. Yet this was unconceivable earlier. But even if transport is assumed to develop continuously, then its pressure on the environment can be mitigated somewhat. Measures envisaged by the Lisbon Strategy were to produce more efficient vehicles. As I argued earlier – because of the "rebound effect" – this was not sufficient to make sure that the pressure goes down, but 20 years ago, when "constraining mobility was not an option", this seemed to be the most important measure to mitigate the transport pressure.

15.9 What was the rationale of "freeing" the Lisbon Strategy of its environmental objectives?

Some politicians thought that "growth and employment" – i.e. what many people care for – are compromised by environmental protection. Hence, if "growth and employment" were considered the most important deliverables, everything else should be given a lower priority.

15.10 The revised Lisbon Strategy reduced its environmental agenda to seeking synergies between environmental protection and economic growth. Which of the earlier objectives did lose their priority?

All environmental objectives that did not translate into "growth and employment" immediately were considered of secondary importance. For instance if increased environmental quality did not translate into jobs, then it was considered not "synergistic". Likewise enhanced biodiversity did not seem to offer more jobs. Transport was considered crucial for economic development. Thus mitigating its environmental pressure was envisaged as something dangerous from the point of view of economic growth.

15.11 Is *Best Available Technology* (BAT) a solution to environmental disruption?

No. Because of the "rebound effect", improving a product or a process efficiency does not imply improved environmental quality, since the product or the process may become so much more attractive that the overall environmental impact can be detrimental. In addition, designating the *Best Available Technology* slows down technical progress. Instead of seeking better solutions, engineers are preoccupied with implementing the technology which won officially (among bureaucrats). In addition, if new installations have to apply BAT (usually they have to), then such new projects are postponed or cancelled which translates into emission higher than possible (because old installations do not have to comply with the same strict standards).

15.12 Why is the "sector-by-sector" negotiation strategy ineffective for policy integration?

By definition, if negotiations are carried out on a sector-by-sector basis, then no sector is allowed to raise questions regarding some other field. For instance, agricultural specialists are supposed to look for solutions how to apply fertilisers or pesticides, irrespective of what environmental specialists agree to from the point of view of biodiversity or eutrophication. Whereas policy integration calls for simultaneous analyses of fertiliser and pesticide application, and biodiversity and eutrophication questions. What was negotiated in the environmental sector could worsen the predicament of the agricultural sector, or *vice versa*.

15.13 Why does the second-hand car import compromise road safety and air quality?

Some of imported "second-hand cars" are in fact car wrecks (after accidents, floods, etc.). Sometimes they are sold as "running" cars (if the buyer is not aware of their history), and sometimes they are brought as a waste (disguised as old cars). In the latter case they simply have to be disposed of somewhere. In the former case they are driven by new owners which are not aware of the fact that their emission can be excessive, that their brakes are not reliable, and so on.

15.14 Why is making rivers navigable difficult to reconcile with environmental protection?

Making rivers navigable requires that they are straightened and deepened, their banks are strengthened with concrete, and the water flow is stabilised (which calls for building retention reservoirs, dams etc.). All these activities are disastrous for river ecosystems.