

SAM 27 2015

ISSN: 0804-6824

November 2015

Discussion paper

The Public Economics of Climate Change

BY
Agnar Sandmo

This series consists of papers with limited circulation, intended to stimulate discussion.

The Public Economics of Climate Change

Agnar Sandmo*

Norwegian School of Economics (NHH) and Centre for Applied Research at NHH (SNF)

*An earlier version of this paper formed the basis for a public lecture at Sciences Po, Paris, on 21 May, 2015. The lecture was one of a series on the theme of “Economists facing climate change”, organized by Sciences Po, École Polytechnique and Columbia Global Centers Europe. I am indebted to Claude Henry for inviting me to give the lecture, to my discussant, Martin Wolf, and to Tony Atkinson for helpful comments on a previous version of the paper.

Abstract

This paper considers the challenges to the field of public economics that arise from the issue of global warming. It outlines the argument for viewing the global climate as a public good and describes the problems that emerge when one tries to apply the insights of public goods theory to global public goods such as global warming. Special topics considered include the free rider problem in an international context and the extent to which private preferences should be taken into account in policy formation. The paper also includes a discussion of cost sharing in global climate policy and the design of policy when instruments for redistribution are imperfect. Green taxes are powerful tools for regulating emissions, and these are discussed both in a national and international context with emphasis on the proposal for a global CO₂ tax. Finally there is a discussion of the several dimensions of distributional justice that arise in the context of climate policy.

JEL classification: D60, H23, Q54.

1. Introduction

Outsiders to economics might well be puzzled by the term “public economics”: Is not all of economics concerned with issues of public policy? If you take a look at recent issues of leading academic journals in economics you will quickly discover that the answer is no, since many of the articles published are concerned with issues that have little or only indirect connection with policy issues. Nevertheless, it is indeed true that concerns with economic policy are prominent in many sub-fields of economics. Thus, experts in international economics study the effects of free trade versus protection, labour economists investigate the effects of minimum wages on employment and macroeconomists are concerned with the role of fiscal and monetary policy for economic stabilization. These are obviously issues that are highly relevant for public policy, but they do not form part of public economics as conventionally defined. At least since the 1970s it has become common to define the field in more narrow terms as being concerned with the analysis of public expenditure and taxation, and this is the definition that I will adopt for the purpose of the present discussion.¹

The analysis of public expenditure is concerned with the public provision of goods and services in areas like political and administrative infrastructure, education, health, communications and social protection and studies the effects that the provision of these goods have on social outcomes like labour force participation, the structure of industry and the distribution of income. It is also concerned with normative issues like how one ought to evaluate public projects in these areas from the point of view of social profitability or social welfare; the practical application of this analysis comes in the form of cost-benefit

¹ Prior to the 1970s it was common to refer to the area as “public finance”, and this term is still in use. The alternative of “public economics” may be a Franco-Norwegian innovation, since it was independently introduced by Serge-Christophe Kolm (1963) and Leif Johansen (1965). The case for using the more recent term is that it emphasizes that the field is concerned with a broader set of issues than the purely financial aspects of budget policy.

evaluation of public projects. On the tax side, public economists study the effects of taxes on the market incentives of consumers and firms that in turn lead to changes in the demand and supply of consumption goods and factors of production like capital and labour. They also aim to derive guidelines for the design of taxes and tax systems, trying to elucidate the difficult problems that arise in combining desirable effects on the distribution of income with adverse effects on economic incentives and social efficiency. Thus, the field of public economics has both a positive or descriptive side and a normative side. It lies in the nature of the case that, since the economist can make no claim to possessing moral authority, the normative analysis must be contingent on the adoption of certain value judgements: If a particular set of value judgements is accepted, certain conclusions about desirable economic policies follow.

It goes almost without saying that the threat of global warming is an issue that is of the highest relevance for research and teaching in economics. Taking up this challenge, public economics should be able to make a contribution to the formation of public policy in this area by studying how it can be met by expenditure and tax policy. But the application of the theories of public economics to the issue of global warming requires attention to some problems that have until recently received relatively little interest in the academic literature. The main challenge is to adjust the tools that have been used to study problems related to the nation state to the issues that arise when policies have to be considered with a view to their effects on the global economy. This adjustment is not without its difficulties, but it is also full of interesting challenges to the economic theorist, especially because the issue of global warming is of such overriding importance for the future of human society.

2. Some earlier views on climate and the economy

I cannot recall from my own beginning studies in economics more than fifty years ago that I ever heard the word “climate” mentioned – except possibly in the context of “a harsher economic climate” which usually referred to the development of inflation and unemployment statistics. To the extent that climate or weather (nobody was much concerned with the distinction) was discussed at all by academic economists it was to serve as an example of a variable that was exogenous to the economic system, meaning that it was independent of economic decisions and behaviour. As it was formulated by Jan de Graaff in his treatise on the theory of welfare economics

“... the weather is clearly an exogenous or non-economic variable, affecting individual choices but unaffected by them.” (Graaff 1957, p. 6.)

This view is echoed in the statement of the Nobel Prize winning economist Lawrence Klein in his textbook of econometrics:

“Rainfall affects the economy but is not affected by the economy.” (Klein 1962, p. 16.)

Today our most serious concern is exactly with the chain of causation that Graaff and Klein and most other economists thought could be neglected by economists.

Nevertheless, in spite of this early-modern view of the economy-climate connection, in some of the older literature of economics we do find signs of awareness of the effects of economic activity on the physical environment². A very early example is that of the Marquis de Condorcet who in a book published in 1776 discussed how some kinds of economic activity

² The early history of environmental economics is described in Sandmo (2015b).

could generate air pollution, causing illnesses in neighbouring homes. He went on to argue that such effects would justify public interference with property rights on the basis of a concern with the welfare of society as a whole. The interference that he mentions is that of forbidding the harmful activity altogether; he does not consider more subtle policy instruments like taxes or regulations which probably were not realistic tools of public policy at his time³.

A major step forward in the analysis of this type of issue was made by Arthur C. Pigou (1912, 1920) who in important respects built on the earlier work of Alfred Marshall (1890). In the perfectly functioning market economy, social and private benefits coincide, and so do social and private costs; under these conditions the allocation of resources in the market economy will be socially efficient. But in the real economy there are many important cases where these conditions will not be satisfied. In Pigou's analysis the concept of *externalities* is used to describe and analyse the cases where social and private benefits or costs do not coincide, so that the market system, even under otherwise perfect conditions, fails to achieve an efficient allocation of resources. Air pollution from factories causes negative externalities and calls for taxes on the polluting firms in order to give them incentives to cut back on the scale of their operation or adopt cleaner technologies of production. Pigou also mentions cases of positive externalities where the social benefits of some activities exceed the private benefits to the individuals or firms that undertake them. One such case is of special interest in the present context and concerns

³ The book by Emma Rothschild (2001) has done much to bring the contributions of Condorcet to the attention of modern economists.

“... resources devoted to afforestation, since the beneficial effect on climate often extends beyond the borders of the estates owned by the person responsible for the forest.” (Pigou 1920; 1952, p. 184.)

This example recalls the current debate about afforestation, particularly the restoration and preservation of the rain forest, as an instrument of global climate policy. Some years later Pigou’s argument was repeated in an important article by Meade (1952) who – prophetically as it turned out – referred to examples of this kind as “atmospheric externalities”. In spite of the suggestive name, however, Meade as well as Pigou was concerned with the local, not global climate. An awareness of the global dimension of this problem has emerged only in our own time.

3. The theory of public goods

A notion that is of fundamental importance for the economic analysis of climate issues is that of a public good. The idea that there are some goods whose provision generates net benefits to society as a whole, although it would not be profitable for a single agent to engage in them, goes back as least as far as Adam Smith (1776). He argued that one of the duties of the state consisted in

“erecting and maintaining certain public works and certain public institutions which it can never be for the interest of any individual, or small number of individuals, to erect and maintain; because the profit would never repay the expence to any individual or small number of individuals, though it may frequently do much more than repay it to a great society.” (Smith 1776; 1976, pp. 687-688.)

However, the first analytical formulation of a theory of public goods is due to Paul Samuelson (1954), whose work has been extremely influential in this area. It is worth setting out the elements of this theory as a background to the economic analysis of the global climate.

The starting point of the analysis is the distinction between private and public goods. Private goods are what we usually think of as economic goods: goods and services that are consumed individually. For these goods it must be true that total consumption in society is the sum of individual quantities consumed. Public goods are characterized by the feature that once they are provided, nobody can be excluded from consuming them; one can draw no meaningful distinction between total and individual consumption. The standard example in the literature has been national defence. Person A's defence is his compatriot B's defence; once defence has been provided for A, B cannot be excluded from benefitting from it. It is easy to see that this feature of public goods captures the insight of Adam Smith and other earlier writers: Leaving the provision of public goods to private enterprise runs up against the difficulty that individuals do not have incentives to reveal their true preferences for the good. Even if the provision of the public good would be beneficial for society as a whole, the market mechanism would not be successful in the attempt to generate such an outcome. Thus, there is a strong case for public provision and government action.

A central question in public economics concerns how much resources should be devoted to the production of public goods. Obviously, this question raises concerns both about efficiency and justice and cannot be answered by economic analysis alone. To begin with, let us focus our attention on the issue of efficiency, leaving the question of justice aside. For private goods, an efficient use of resources is obtained when the marginal consumer benefit

as measured by the price that the consumer pays, is equal to the marginal cost of production. In the case of public goods, a similar condition holds, but the consumer benefit must now be measured by the *sum* of the individual benefits which should accordingly, in an efficient allocation of resources to public goods, be equal to the marginal cost. This condition is often referred to as the Samuelson condition after its originator. Regarding marginal cost, a condition that is mostly implicit in the original Samuelson (1954) analysis is that when there are multiple producers of the public good, the marginal cost of production should be the same among all producers. This condition ensures that the total cost of producing the public good is minimized.

The Samuelson condition has often been misinterpreted to mean that there exists a uniquely optimal supply of the public good: if a reliable method could be found to ascertain the true willingness to pay of all citizens in society, the required sum could be computed and one could then proceed to find the right balance between benefits and costs. But this line of reasoning is in fact based on a simplified understanding of the theory as a whole. For the Samuelson condition to be valid the rest of the economy must also function in a way that satisfies the conditions for social efficiency; e.g. private markets must be assumed to be perfectly competitive. I shall ignore the complications that arise when this is not the case and instead focus on another assumption that is a central importance for the analysis of the climate issue. This is the assumption that the problem of achieving a just distribution of resources and welfare between individuals – i.e. the issue of economic justice – can be solved independently of the provision of public goods. But this requires a tax system with a degree of perfection that is plainly unrealistic. In a more realistic setting the optimal provision of public goods must also take into account its redistributive effects. The implication of this is that the social benefit of a public good can no longer be computed

simply as the sum of individual benefits; it must be modified to become a *weighted sum* where the weights attached to individual benefits reflects the distributional preferences of society.

Where do these weights come from? In the Samuelson formulation they are derived from the analytical device of a social welfare function which is an increasing function of individual utility functions, meaning that there is a positive association between individual and social welfare. The implication is not that there exists a higher being that actually maximizes social welfare; instead, the function should be considered as a means of capturing what we mean when we try to think about economic policy as being designed with a view towards promoting the common good – “the publick interest”, as Adam Smith called it.

To illustrate the implications of this modification of the Samuelson condition, assume that the preferences for the public good in question are strong among the high income groups in society and rather weak among people at the other end of the income scale. Then the optimum amount provided will depend on the degree in which the social welfare function trades off the benefits of the poor against those of the rich. An egalitarian social welfare function would give more weight to the benefits received by the poor and therefore recommend less public goods supply than one which reflected a more neutral view of the benefits accruing to the rich and the poor.

This discussion of the Samuelson model may seem very abstract and far removed from actual policy concerns. However, the theory has found practical application in the field of cost-benefit analysis, where applied economists study the social profitability of public projects over a wide range of public sector activities. For any given project proposal, the analysis considers whether or not the project should be carried out on the basis of a

comparison between the project's benefits and costs. If benefits exceed costs the project should be implemented; if the reverse inequality holds it should be rejected. The principles underlying the practice of cost-benefit analysis is the same as in the pure theory of public goods.

So far nothing has been said about the nature of the government that is supposed to provide the public good. In the original Samuelson discussion and in most treatments of the theory since then it has been assumed that the government is that of the nation state⁴. But this is not a strictly necessary assumption, for there is scope for flexibility regarding the community of individuals or consumers for whom the good in question is assumed to be a public good. While there has long been an extensive literature on local public goods, the application of the basic theoretical framework to the study of *global* public goods is of more recent origin. At least at a purely formal level, one could argue that the application to goods that are public with respect to the whole world population can be achieved by simply interpreting the number of consumers as being equal to the number of individuals in the world. Although this insight is a useful starting point, there are also adjustments that need to be made before the theory becomes a useful tool of analysis for global issues (Sandmo 2003). This is particularly the case when we take the global climate as a public good.

4. The global climate as a public good

Climate change, in particular global warming and the challenge that it poses for public policy, is a topic that has received enormous attention in recent years, both from policy makers and from researchers in the natural and social sciences.⁵ Within economics the contribution to

⁴ The use of the example of national defence to illustrate the nature of a public good underlines the nation state frame of reference.

⁵ A more formal theoretical discussion of the points discussed here can be found in Sandmo (2011).

the debate which has received the most attention is the Stern Review (2007) which states that

“[r]educing the risks of climate change is the most important example of the provision of a global public good. ... It is also in many ways the ‘purest’ example of a public good in that emissions of greenhouse gases ... from any one country have the same effect on the atmosphere as those from any other.” (Stern 2007, p. 510.)

If we take our point of departure from the theoretical framework of Samuelson, the argument that the prevention of global warming satisfies the definition of a public good is perhaps not quite as obvious as suggested by the quotation. Although the global temperature in the sense of some average for the different regions of the world is expected to increase, the degree of increase is predicted to differ between regions and also to go together with other changes in the climate that will show considerable regional variation; e.g., some areas are likely to become drier, while others will experience increases in their average rainfall. However, since all these changes have a common cause in the greenhouse effect, they can all be seen as consequences of the rise in the global temperature. It is this argument that justifies the view of global warming as “a public bad” and its prevention as a public good. It should also be kept in mind that in an integrated world economy the possibly positive effects of global warming on the climate of a single country easily become dwarfed by the indirect effects that it will experience via the negative effects on production and living conditions in most of the other countries of the world.

If we are to think in terms of the optimal provision of public goods, we need to consider the objectives of global climate policy. At least as a benchmark, it is useful to formulate this as a social welfare function for the global economy, containing as its arguments the utility levels

of all individuals in the world. This formulation obviously raises the issue of who is supposed to maximize such a function. Clearly, it cannot lay claim to being a realistic description of actual decision-making in today's world. We do not have a world government, and even if we had, it is extremely unlikely that its objectives and decisions could be analysed in such a simple and stylized manner. Nevertheless, the formulation is useful as a starting point for the discussion of global policy when its objective is recognized to be the promotion of the welfare of the world as a whole.

How is the public good of global warming prevention produced? Clearly, there is no well-defined production relationship – a function relating inputs to outputs - as we can imagine there to be in the more conventional cases of public goods like national defence or transportation infrastructure. Instead, we assume that the public good, in this case the quality of the climate, is generated by two sets of factors. The first is investment in abatement facilities that contribute positively to the quality of the climate like projects aimed at the production of cleaner energy, both in the private and public sectors. The other set of factors are the emissions caused by the production and consumption of particular private goods or by particular factors of production. This perspective serves to anchor climate policy firmly in the tradition of public economics. On the one hand it provides a role for public expenditure in the analysis of public spending on abatement. On the other hand it emphasizes the importance of public policies to influence private decisions both with regard to abatement and the composition of consumption and production in the private sector. These policies will mainly, although not exclusively, take the form of taxes and subsidies.

Here I shall think of abatement mainly in terms of public expenditure on measures designed to prevent global warming, while emissions of greenhouse gases that tend to increase global

warming are generated by a very large number of consumers and firms (both in the private and public sectors of the economy) who make decisions about consumption and production that lead to emission of climate gases. Obviously, this does not involve any conscious decisions to cause climate change. Individual actions generate atmospheric or public good externalities that have global warming as the result. In general, public good externalities are present when private agents impose costs on society in the form of lower quality of public goods and agents are not charged for these costs. A public goods externality can be seen as an example of the type of environmental externality first discussed by Pigou (1920).

With this global perspective on the Samuelson model we are now ready to draw conclusions about a globally optimal climate policy. First, expenditure on abatement should be carried to the point where the sum of marginal benefits equals the marginal cost of production of abatement facilities; the Samuelson condition should hold, with the weighted sum of benefits referring to all individuals in the global economy. Second, markets for private goods should be efficient in the sense that prices should capture all social costs and benefits. In the presence of externalities, this requires public policies in the form of taxes, subsidies or regulations that aim to modify private incentives.

It is not difficult to see that these conditions do not describe the world as we know it, neither with regard to the nation state nor the world as a whole. The purpose of welfare economics and normative public economics is to show how public policies can move us further towards a more efficient and just society. This should also be the goal when this framework of analysis is applied to global climate policy, but this application raises some further issues that need to be discussed before we turn to the more practical aspects of climate policy.

5. Assessing the global benefits: Free riding and consumer sovereignty

The benefits that enter into the condition for optimal use of resources on abatement should according to the standard theory of public goods be derived from the individual consumers' preferences; in technical terms, they should be based on consumers' utility functions. The individual's benefit on the margin should reflect his or her answer to the question: "How much income would you be willing to give up in order to achieve a certain slowdown of global warming?"

One sees immediately that it may be problematic to elicit a truthful and realistic answer to this question. The aspect of the problem that has received most attention in the public economics literature is referred to as *the free rider problem*. If the individual being asked believes that his answer will be reflected in what he will actually be required to pay, he will have an incentive to understate his true preferences⁶. He may truly be willing to pay 500 euros but may instead report a willingness to pay of only 100 or 10 or even 0. This will be the case if he thinks that since he is only one of many millions - or even billions - of prospective contributors, he can rely on the willingness to pay of all the others to finance public expenditure on abatement. In this way, he may reason, he gets his improvement in the climate, but at no cost to himself. But if everybody thinks in the same way, the reported willingness to pay will fall far short of the true benefits, and the result may be that the public good will be seriously underprovided. The same problem arises with public good externalities: Each one of us may realize that choosing collective rather than private transportation makes a contribution to prevent global warming. But because our own

⁶ If, on the other hand, the individual perceives that there is no connection between his stated preference and what he has to pay for the public good, he will have an incentive to overstate his true preferences. Thus, the incentive to misrepresent one's true preferences does not necessarily have a bias towards underprovision of the public good.

contribution is so small and the impact of the total emissions of all the others is so dominant, we nevertheless refrain from making an adjustment of our habits that imposes an individual cost on ourselves. From our own individual point of view, the best action may seem to be to let other people bear the cost of the required change in behaviour and still reap the benefits of a better environment.

The free rider problem is important for understanding public goods problems when there are a great number of beneficiaries, but the number does not have to be very large before the free rider problem arises; some may have witnessed it even in the context of the nuclear family. Now consider the fact that the United Nations has 193 member countries and you realize immediately that the free rider problem may be crucial for the possibility of establishing an international climate agreement that contributes to the limitation of global warming. Each country has an incentive to underreport its benefits from the agreement or refusing to join it, hoping that the remaining countries will reach an agreement from which this country too will benefit. There is no doubt that this is a fundamental problem in the public economics of climate change, and a good deal of research has already been done to study how it can be overcome. Thus, a recent article by Nordhaus (2015) suggests a way out that consist in the formation of what he calls a “climate club”. This is a coalition of countries that agree to undertake emission reductions while at the same time penalizing non-participants by means of tariffs on their exports to the coalition countries. In principle, the disadvantage of this construction is that the barriers to trade between participating and non-participating countries may create global inefficiencies in production and consumption patterns. However, Nordhaus presents simulation results that indicate that the trade costs are of minor significance relative to the benefits from the climate club.

Overcoming the free rider problem is of crucial importance for providing the global public good of a better climate and accordingly for progress in climate policy. But regarding the assessment of benefits there is also another problem that needs our attention. Even if we were to succeed in eliciting individuals' true preferences – true in the sense that they are reported honestly by the individuals themselves – would we like to base decisions concerning investment in abatement on their own assessment of these benefits? The standard economic answer to this question is yes. This is based on the view that social welfare should respect individual preferences. The good of society should be based on individuals' own view of what is good for them or, as it is often called, the principle of *consumer sovereignty*. This is a view that has considerable appeal both on economic and ethical grounds. But is it clear that it should also be adopted when making decisions about the prevention of global warming?

The issue of global warming is not an easy one to comprehend. It requires the understanding of complex scientific arguments, judging the likelihood of various possible scenarios of climate development and the ability to visualize effects on the natural and human environment that stretch very far into the future. Although I believe that the attention that is currently being given to questions regarding the climate in the public media must gradually lead to a more enlightened view of the issues involved, it probably remains true that many people are not very well informed about climate issues. In particular, they may have difficulties with assessing the probabilities of the possible outcomes that could follow from the pursuit of alternative policies. One may therefore be led to argue that since individuals cannot be relied upon to know what is best for them, governments are justified

in making choices that override consumer preferences when making decisions about climate related public projects⁷.

One problem with the principle of consumer sovereignty in the present context is that even if preferences are reported honestly, they will reflect not only individuals' tastes in the more specific sense but also their probabilities of the different outcomes that might follow from the adoption of public policies – in other words the quality of the information that they possess. Should one respect not only people's preferences but also the information on which they are based? If public decision makers believe that peoples' information is distorted, e.g. because of the self-interested activities of lobby groups, the ideal procedure in a democratic society would surely be not to override the preferences but provide information that will enable people to form more enlightened opinions about public projects in the climate area.

There are those who feel that there is too little time for such elaborate democratic procedures; the issue of global warming is so pressing that different political principles must be adopted. Indeed, it has been claimed that the problem of global warming demonstrates not only the flaws of the market economy but of democracy as well. Personally, I have no difficulty in seeing that there are some serious challenges here, but on the other hand I find it difficult to accept that the abandonment of the liberal society is the answer to these challenges⁸. Our historical experience with the performance of dictatorial regimes in regard

⁷ The history of economists' thinking about this issue is described by Banzhaf (2011).

⁸ When in 995 Olav Trygvason became king of Norway, he set out to convert the people to the Christian faith. To achieve this goal he used terror and violence, quite contrary to the Christian ethics that he had presumably made his own when he adopted the new religion. A possible explanation for his conduct was that he believed like many of his contemporaries that the year 1000 would see the arrival of Doomsday, so that he had little time to convert people and ensure their salvation by peaceful means. Should we condone his behavior? (In the end the year 1000 did not see the arrival of Doomsday; however, it saw the violent death of King Olav Trygvason. But that is another story.)

to the environment is not such that we should easily entrust them with the future of the planet.

So far we have focused attention on public goods of the abatement type. But very many other goods that are provided by the government, whether they are pure public goods or of the mixed private-public type, have consequences for the environment and frequently for the climate. Examples are not hard to find. The building of transportation infrastructure like airports or roads generates traffic that leads to emission of climate gases and contributes to global warming. Public projects that involve energy consumption in the form of coal and oil are major contributors to greenhouse gas emissions; think of airports, highways or military installations. When evaluating such projects in order to decide on whether they should be carried out and on what scale, the environmental effects should be included in the overall analysis of costs and benefits. To some extent of course this is currently being done. But it also tends to be the case that environmental and climate effects of public projects are the last items to be included in the calculations and they often come under the heading of “additional considerations”. One may regard this as yet another reflection of the free rider problem. Although each individual projects in the national economy may have only minor effects on the global climate, the systematic neglect of these effects can together result in a very significant negative effect on the climate. This practice therefore needs to be altered if the challenge of climate change is to be taken seriously. To the extent that incomplete cost-benefit analyses lead to the acceptance of projects with detrimental effects on the climate, we need to revise the common view that global warming is solely due to market failure. Government failure must also take a significant share of the responsibility.

6. Sharing the costs

The determination of a rule for sharing the cost of a public good amounts to the choice of a tax system that allocates the cost burden between citizens. In the public economics literature two alternative principles for tax design have been widely discussed. The first, called the benefit principle of taxation, recommends that taxes be distributed in such a way that citizens pay according to the benefits that they receive from public goods. The second, commonly referred to as the principle of ability to pay, would instead allocate the tax burden among citizens on the basis of their economic resources – their income for short. The appeal of the benefit principle is that it is fair that you pay for what you get. The attractive feature of the principle of ability to pay is that the people who bear more of the tax burden are those who can best afford it. Thus, although each of the two principles has its attractions, I will argue that it is the second of the two which has the best claim on our support⁹.

If we care about justice it follows almost directly that our judgements about the distribution of income and standards of living among individuals must have a bias in favour of equality. If we live in a society with substantial disparities between rich and poor, we would accordingly like the tax system to make a contribution towards making society more equal. But the benefit principle does not do that. Instead, by making people pay taxes to the government in accordance with the benefit that they get from it, it is roughly neutral when seen in an overall perspective on the distributive effects of the public budget. The ability-to-pay principle, on the other hand, does contribute in the direction of more equality. In fact, it is this principle that underlies the Samuelson optimality conditions and which implies that the

⁹ For further discussion of the two principles and their intellectual roots see Sandmo (2015a).

condition for optimal public goods supply is separate from (although interlinked with) the condition for the optimal distribution of income.

In the real world, however, things are not as simple as they are depicted in the model of the ideal economy. When we study the problem of combining an efficient use of resources with that of reaching a just distribution of income, we frequently find that the policy instruments that we can use to move closer to one of these goals have a negative effect on the other. A good illustration of this point is provided by the progressive income tax. On the one hand, the progressive income tax makes the rich pay proportionately more than the poor and so contributes to more equality. On the other hand, by reducing the rewards to labour and saving, it distorts people's incentives to productive effort and accordingly imposes an efficiency loss on society. More inequality therefore comes at the cost of less efficiency: The more equally we wish to divide the social pie, the more it shrinks. This is what economists refer to as the equity-efficiency tradeoff; a term coined by Arthur Okun (1975). However, it should be emphasized that there is not *necessarily* a conflict between equity and efficiency. In a realistic picture of actual market economies with e.g. monopolistic competition, environmental externalities and imperfect information, the goals of efficiency and equality might well be complementary rather than competing. In addition, there is considerable evidence that in societies with a modest degree of inequality of income and welfare it is easier to obtain acceptance for the beneficial effects of the market mechanism.

In any case, how far one wants to go in the direction of equality is not simply a question that can be solved by pure economic analysis. It also requires value judgements regarding the importance that we attach to equality as such.

7. Cost sharing in global climate policy

To understand the challenges that arise in sharing the cost of global climate policy we have to consider all aspects of the theoretical arguments that we have been through so far. Abatement should be carried to the point where the additional benefit of further abatement is just equal to its marginal cost. Moreover, for the efficient allocation of abatement investments among countries the requirement is that the marginal cost of abatement should be the same among all countries in the world – rich and poor alike.

The argument that the heaviest investment in abatement – and the largest cutbacks of emissions - should take place in the countries where the cost of these measures is lowest finds support in the theory of public goods and its emphasis on production efficiency. But once again we need to keep in mind that the requirement of production efficiency presupposes that the conditions for an optimal distribution of income are satisfied. If one wants to argue that the distribution of the costs of global climate policy should be distributed among rich and poor countries solely on the basis of efficiency considerations, one should also be willing to accept a system of transfers that would ease the burden on the poor countries and preferably contribute to further income equalization. This is in line with the recommendation of the Stern Review (2007, p. 364); see also the discussion in Sandmo (2003).

If such transfers are not in place, the argument for production efficiency is not equally compelling. In fact, instead of transferring income to poor countries, the rich parties to a global climate agreement could allow poor countries to use less resources on abatement than efficiency considerations would call for. Once again, we face the efficiency-equality tradeoff, this time in a global context. On the basis of a broad welfare judgement, it could be worth using the resources devoted to abatement less efficiently than strictly necessary if this

were to lead to a global redistribution of income that were biased in favour of the world's poorest.

Even with this modification of the principles of a globally efficient climate policy, it is not clear that this approach to fairness and efficiency is one that people in general would regard as the most relevant. A few examples may illustrate this point.

In 1991 Lawrence Summers, then chief economist of the World Bank, circulated a memorandum subsequently published in the *Economist* that aroused strong reactions. The gist of his argument was that pollution was likely to be much less costly and a clean environment to be much less valued in poor countries, so that there was a good efficiency case for encouraging the migration of polluting industries from the industrialized to the developing world. Although the underlying assumption was that both rich and poor countries stood to gain by the proposal, many people reacted to what they perceived as the unacceptable cynicism of suggesting that rich countries should bribe the poor to take over their environmental problems.

A similar discussion arose in my own country Norway regarding the government's policy to fulfil its international obligations to fight global warming. The government's position was that the best way for Norway was not to cut domestic emissions but rather to provide money to subsidize the preservation of the Brazilian rain forest. This was not only a better use of Norwegians' tax money but also in line with the principle of global production efficiency. The case for this policy was particularly well argued by the then (2005-2013) prime minister, Jens Stoltenberg, himself a trained economist. But environmental organizations as well as many others were extremely critical of it. They argued that by exploiting its position as one of the richest countries in the world Norway could unload the

real burden of climate policy on the poorest countries. Also, by its unwillingness to take costly cutbacks at home, Norway would set a bad example to the rest of the world. The arguments remind us that the welfarist approach with its roots in utilitarian philosophy has its limitations and that we may need to draw on other philosophical approaches to capture relevant notions of justice. For example, by adopting a Kantian¹⁰ rather than a utilitarian perspective on this issue, we might conclude that Norway should carry out its emission cuts at home in order to set an example that it would wish the other countries of the world to follow. I do not myself find this point of view entirely persuasive, although there is probably a case for using it to modify the conventional economist's view. In any case, a reasonable conclusion to draw is that we should be open to alternative sets of value judgements and be willing to engage in a dialogue with those who subscribe to them.

8. Taxation and private incentives

Up to this point our discussion of public economics in relation to the climate has focused on public expenditure and the provision of public goods. This is of particular importance in the context of abatement and the cost-benefit analysis of public projects that have implications for the state of the environment. But the revenue side of the public budget is also of the highest importance, for taxes affect the incentives of producers and consumers and can therefore be exploited to steer their market choices in a more environmental friendly direction by reducing emissions. The important idea of "green taxes" originated with Pigou (1920), and are therefore often referred to as Pigouvian taxes. To understand this idea we must first consider the effects of ordinary taxes on commodities and factors of production.

¹⁰ Immanuel Kant's categorical imperative can be stated as follows: "Act only according to that maxim whereby you can, at the same time, will that it should become a universal law." This principle was formulated in his book *Grundlegung zur Methaphysik der Sitten* (translated as *Groundwork of the Metaphysics of Morals*), 1785.

In a competitive economy, the price system conveys information to consumers about the costs of production and to producers about consumer preferences. The market price that balances demand and supply therefore leads – on the assumption that markets are competitive - to an efficient adjustment between consumers' willingness to pay and firms' costs of production. When a tax is introduced in such a market it disturbs this balance and leads to an efficiency loss for the economy as a whole. But although taxes cause harm to the economy in the form of efficiency losses they are obviously necessary to finance the public sector. The challenge for tax policy is how to design the tax system so that it can fulfil its functions with a minimum of harm to society.

However, in the case of goods and services that have harmful effects on the environment – negative public goods externalities - there is an initial maladjustment between benefits and costs that taxes can be used to rectify. By charging firms with a tax that reflects the additional cost that agents impose on society in the form of environmental degradation, taxation can make the economy function more not less efficiently. If the tax is set at the right level, firms will behave *as if* they took account of the environmental cost of their activities. This is a nice example of how market incentives can be designed in such a way that firms take account of broader social objectives although in fact they only do what is best from the point of view of their owners' private interests. Similarly, consumers who have weak incentives to take account of the effect of their consumption on the environment – or who are simply ignorant of it - can be confronted with this cost through a tax that corresponds to the cost that they would otherwise neglect¹¹. Although market failure lies at the root of

¹¹ In the environmental economics literature there may have been an overemphasis on the taxation and regulation of consumption, while in many cases it might be more effective to focus on the curtailment of production. For a forceful argument for this view see Sinn (2012).

many environmental problems, the market mechanism is also a powerful instrument for solving them.

Is it likely that the use of green taxes can reach such proportions that conventional taxes become superfluous? In other words, can one imagine that the public sector can be financed entirely by green taxes? I believe that the economics profession would be virtually unanimous in saying that the answer is no¹². Green taxes should form a significant part of an optimal tax system, but the design of the pattern of environmental taxes needs to be seen in conjunction with the rest of the tax system. How this should be done is a rather complicated issue in the theory of second best tax analysis; an early contribution to this theory is Sandmo (1975), while a more recent exposition is in Sandmo (2000).

A word may be in order regarding the assumption that in the absence of taxes firms and consumers neglect the effects of production and consumption decisions on the environment. This assumption reflects the realization that in regard to environmental effects each individual agent in the market economy is of very little quantitative importance, so that individuals are perfectly reasonable if they take the attitude that their own impact on the environment may be neglected. Since the climate impact is a global externality the assumption may be particularly easy to justify in this context. Nevertheless, we know that it is not exactly right. People do engage in trading energy quotas, and they sometimes travel by collective transport even when the use of a private car would be cheaper and more convenient. What drives them to do this are their moral incentives – the desire to do what is good for society. Nevertheless, it seems probable that these moral incentives are not strong enough to make an appreciable difference to climate gas emissions on a world scale so that

¹² In 2011, according to Eurostat, green taxes accounted for 6.35 per cent of tax revenue for the EU as a whole, and for no member country was the percentage higher than 10. Whether the calculations actually overestimate the environmental component of these taxes has been discussed by Bruvoll (2013).

policy makers will also have to rely on the creation of external incentives like taxes and subsidies¹³.

What should be the principles regarding the design of green taxes? The basic principle is that the tax should correspond to the cost that one's consumption or production imposes on the environment in the form of global warming. To compute this cost is obviously not an easy task and has to be based on scientific information about each type of emissions and its source. Another important consideration concerns the tax base, i.e. the choice of the unit on which the individual agent's tax payment should be levied. In the choice of the tax base, the guiding principle should be to levy the tax so as to affect the right margin of decision. A general purchase tax on all cars might have an effect on the number of cars in use and could therefore have some desirable effects on the emission of climate gases. But the disadvantage of such a tax is that it does not distinguish between small and big cars or between cars running on different types of fuel. A tax that is differentiated in this respect, particularly when combined with taxes on fuel, would not only encourage consumers to buy more environmental friendly cars but would also give car manufacturers incentives to develop models that would both be better from the environmental point of view and at the same time cheaper for the consumer to buy and use. Even better would be a tax that was levied directly on the amount of harmful emissions, but this might be too costly to monitor to be within the range of feasible alternatives. Clearly, there comes a point where the gains in the better targeting of the tax are outweighed by the increased administrative cost¹⁴.

¹³ In the theoretical literature moral and external incentives are sometimes referred to as intrinsic and extrinsic incentives; see e.g. Bénabou and Tirole (2003).

¹⁴ However, a CO₂ tax could be implemented by having vehicle taxes differentiated on the basis of emissions. For a discussion of this and empirical estimates of the effects in France, Germany and Sweden see Klier and Linn (2015).

Car use is an important source of emission of climate gases, and the design of taxes on car use is therefore an important topic in the public economics of the climate. But there are other sources of emissions that raise different and more complex issues. In principle, one should take account of the possibility that car owners in France might react so strongly to high taxes that they would take their cars – as well as their families, jobs and houses - with them and move to (say) Venezuela, but that is not a very realistic possibility to consider. When it comes to taxes on producers, however, the situation is different. A manufacturing plant in Norway or France that faces high taxes on emissions (and stiff regulations regarding environmental protection) could close its domestic operations and re-establish itself in a part of the world where taxes are lower and regulations more lenient. This might possibly lead to an improvement of the local environment in France or Norway, but for the emission of climate gases and global warming it would be without importance since emissions in one country have exactly the same effects on global warming as emissions in another. Indeed, if there is an effect on the global environment it is likely to be negative, since the relocation of polluting firms to countries with lower taxes and laxer regulations is likely to encourage the adoption of more emission intensive technologies. This example demonstrates that for the analysis of the public economics of the climate the international dimension is of essential importance. In order to throw more light on this I shall briefly discuss the issues that arise in the proposal for an international tax on CO₂ emissions.

9. An international CO₂ tax

A tax on the emission of carbon dioxide would be an important element in policies to prevent global warming¹⁵. Some countries have already implemented such taxes while others are lagging behind. One of the effects of such a tax that a national government needs to take into account is that firms that are engaged in CO₂-intensive activities might relocate their activities to foreign countries where CO₂ taxes are lower or non-existing. This international mobility will obviously be of some concern to the government. First of all, from a purely domestic view of tax policy, mobility means that the tax base is sensitive to the level of the tax, and this gives the government an incentive to keep the tax level low. Moreover, even if the domestic government is deeply concerned about the global climate, it will realize that for the firms that move abroad the tax effect on the global climate is zero since emissions generated abroad have exactly the same effect on global warming as those generated at home. At the same time, the loss to the domestic economy could be substantial in terms of loss of employment and revenue from other taxes on labour and capital. Domestic governments might therefore have a strong incentive not to impose such a tax or to keep it relatively low except possibly when the activities in question also generate other environmental externalities such as local pollution¹⁶. Since the incentives to impose the tax are weak from one domestic government's point of view, the same will hold for all governments. The result might very well be a tax level that would be much too low from the global environmental perspective.

The obvious solution to this dilemma is to have an international agreement on the introduction of a global CO₂ tax, one levied on emissions in all countries at the same rate.

¹⁵ A more detailed analysis both of the theory and practical experience with taxes and quotas can be found in Metcalf (2009). A discussion that ties the proposal for an international carbon tax with some rough estimates of its revenue potential for economic development is Sandmo (2005).

¹⁶ Automobile use is an interesting example of an activity that generates multiple externalities. For a discussion of the appropriate choice of policies to control these see Parry, Walls and Harrington (2007).

This would be neutral with respect to the international location of industries and it would also be globally efficient in that emissions would be cut most in the countries where it is cheapest to do so. This is because each polluting firm would compare the cost of cutting emissions with the tax that it could save by the reduction. If the cost is very high, it will be rational to pay the tax and refrain from emission cuts. If on the other hand the cost is low, it pays to cut emissions to save on tax payments. The predicted outcome is that any amount of cuts in global emissions would be obtained at a minimum of costs for the world as a whole.

The drawback of this proposal from the point of view of political acceptability is that while the benefits of reduced CO₂ emissions accrue to all nations of the world, the costs are borne locally. Here we encounter a major difference between national and global public economics. When a tax is imposed in a single country, the citizens have to adjust to this tax in accordance with their own interest, but paying the tax is not a voluntary decision¹⁷. But because there is no world government, a global CO₂ tax has to be approved by all sovereign countries of the world. If the desire is to establish a truly global tax it is easy to see that world-wide approval will be very difficult to achieve. Each national government will compare its own benefit from a slow-down of global warming with the cost that it has to bear, and in many cases this calculation is bound to conclude that the costs will outweigh the benefits. This will be the case if the tax will necessitate large domestic national adjustments and if the benefits are perceived to be modest. The latter could be the case either if the domestic government takes a narrow view of the consequences of climate change and fails to take account of the benefits to the world as a whole, or if the results of global warming for this

¹⁷ This argument abstracts from the obvious objections with regard to evasion and avoidance which are not my major concerns here.

particular country are seen as positive. Thus, the chances of a truly global CO₂ tax might seem to be remote.

There are two main ways out of this dilemma. The first is for some countries who clearly perceive the global benefits to take action on their own, either alone or together with like-minded countries, as in Nordhaus' proposal for a climate club that was discussed above (Nordhaus 2015). This could lead to climate agreements that would be of global significance although with less than total participation from individual countries. The other way is to combine the global tax with a system of international redistribution, so that income is transferred from the countries with high benefits but low costs to countries whose costs are high but benefits are low. In this way all countries could come to gain from the combination of the tax and the system of transfers, and one could ideally hope for a world-wide support of the scheme. Since it seems likely that such a system of transfers would flow from rich to poor countries, it would also form one element of a policy to modify the inequality in the world distribution of income.

From a more theoretical public economics perspective the underlying idea behind the latter scheme is that if the benefits exceed the costs for the world as a whole, there must exist a way of distributing the costs so that all countries gain. In the history of public economics, this idea goes back to the Swedish economist Knut Wicksell (1896). He suggested that any proposal for a public project ought to include a plan for the distribution of the tax burden needed to finance it. The project should be adopted only if the total benefits exceed the cost. But if this were the case, it should also be possible to distribute the taxes in such a way that everyone experienced a personal net gain from adoption of the project. From this conclusion he also derived the policy recommendation that projects should be adopted only

on the basis of unanimous agreement. This sounds like a very conservative attitude to public expenditure, but Wicksell in fact proposed it with a view to protecting the poorer classes of society from having to pay for public projects that gave them little or no benefit. Had he lived today, Wicksell would probably have supported the proposal to combine a global CO₂ tax with a scheme of international redistribution.

10. Environmental policy and distributive justice: Three dimensions

Any reasonably large-scale turnaround of economic policy will by necessity raise issues about its effects on the distribution of income and welfare between individuals and groups in society. The environmental reforms of public expenditure and tax policy are no exceptions to this. Indeed, it can be argued that these issues are of particular importance here, since climate policy can be expected to affect distribution along at least three dimensions. The first is the distribution of income between the current members of a given country. The second concerns the distribution between the different countries of the world whose average standard of living varies dramatically. The third dimension relates to the distribution of welfare between generations. While traditionally public economics has been mostly concerned with the first of these, a concern for the global climate must by necessity bring the other two dimensions to the forefront of our attention. The importance of the second dimension follows from the nature of the climate as a global public good, and that of the third from the long-run perspective that one needs to adopt when judging the benefits and costs of climate policy.

Regarding the first dimension, the main problems discussed in the literature have been on the one hand the effects on the distribution of income of alternative tax systems and on the other hand the distributive effects of public projects. The adoption of a more climate friendly

tax system is likely to involve higher taxes on such goods as energy and transportation, and on the expenditure side stricter standards regarding the climate effects of public projects in this area. It is hardly possible at a general level to draw conclusions as to whether such policy changes are likely to favour the rich or the poor. If on the tax side we assume that the adoption of a greener tax system takes place in a setting of constant overall tax revenue, the effects on distribution depends on which taxes are going to be reduced to offset the increased revenue from environmental taxes. The most important general point that should be made is that it is always possible to design the reform such that the distributional profile of the new tax system is at least roughly the same as the old. This conclusion holds true also when we extend the analysis to take account of the distributive profile of the public sector's budget as a whole. Adverse distributional effects of public climate projects can – at least in a developed economy with access to a large range of policy tools - be neutralized by appropriate adjustments in other parts of the budget, either on the expenditure or the tax side. Parry (2015) discusses this issue in more detail and concludes on the basis of analysis of data for a number of advanced countries that "... while distributional concerns are potentially important both for fairness and the politics of reform, they should not hold up establishing a robust price on CO₂ emissions." He emphasizes that the distributional impact of carbon taxes depends on the whole package of taxes and public expenditure of which it forms a part.

Things are more difficult when it comes to the second dimension of the design of public climate policy, simply because of the range of policy tools that are available in global public economics is so much more limited than what is the case for the nation state. We have already touched on the problems that arise in the discussion of a global CO₂ tax above. The design of a globally efficient climate policy might easily come to involve elements that would

impose heavier burdens on the poor than on the rich countries. In order to counteract this one needs to develop a complementary set of policy tools regarding international distribution that can neutralize the possible regressive effects of international climate policy.

The third dimension of climate policy concerns the intergenerational effects. This has been widely discussed in the literature, particularly in the wake of the *Stern Review* (Stern 2007) and its recommendations of adopting a rate of discount for climate policy evaluation of 0.1 per cent; see also the discussion in Stern (2010). This recommendation is in sharp contrast to economists' more standard view of the social rate of discount as lying in the range of three to seven per cent. The justification for recommending a very low discount rate for environmental projects is that these typically involve a high cost in the present with benefits extending far into the future. With a high discount rate future benefits are given a low weight compared to the cost; the lower the discount rate, the more importance is accorded to the benefits that only materialize in the distant future, thus increasing the profitability of environmental friendly investments. This recommendation has given rise to some controversy, but a full discussion of the issues involved would take us too far afield to be undertaken here. The important point in the present context is that the climate costs and benefits both of tax reforms and public investment projects need to be considered in a very long-run perspective, meaning not only decades but even centuries. Adopting discount rates in the standard range may, if seriously applied to environmental projects, have dramatic negative effects on the standard of living of future generations; see the discussion in Stern (2010).¹⁸

¹⁸ There is also a discussion in the literature on whether the discount rate should be constant (exponential discounting) or variable. A case of variable discounting that has received much attention is that of hyperbolic discounting, whereby the discount rate declines over time. This is claimed to be more in line with observed

The distributional effects of public tax and expenditure policy with regard to the climate must be considered on the background of the distributive impact of climate change itself. As Stern and others have pointed out, climate change itself is deeply inequitable with serious negative impact on the standard of living both for the poor nations of the world and for the poor in the rich nations. This has to be kept in mind when one discusses the distributive effects of green tax reforms and environmental regulations and the adoption of stricter climate standards for public projects.

11. Concluding remarks

The above discussion has been set in the conventional framework of public economics which is concerned with the effects of public policy as they are related to government budgets. Climate change raises several challenges for the design of policy. On the expenditure side, the view of the climate as a global public good leads to an emphasis on the need to include climate effects in the cost benefit analysis of public projects. On the tax side, there is a strong case for moving in the direction of a “greener” tax system that encourages the adoption of a more climate friendly pattern of consumption and a corresponding reallocation of the resources of production. Any major reform of expenditure and tax policy is bound to have a distributional impact, and environmental reforms may – although they need not – cause adverse distributive effects. If so, one needs to think about how compensating changes can be made in other parts of the public budget.

To a large extent, the incorporation of the climate perspective can be accommodated within the standard framework of public economics. But taking account of climate change also

behavior and experimental evidence, but from a normative point of view it has the drawback of leading to time-inconsistent decisions.

forces us to move beyond the conventional framework in a number of ways. Some of these I have already discussed; others should at least be briefly mentioned.

The main step beyond the conventional framework comes from the global nature of climate change and the consequent need to study public goods and taxes in a world-wide perspective where there is no well-defined government and where the feasible range of policy instruments is narrower than in the nation state. Other extensions of the standard framework involve a critical look at the assumption of consumer sovereignty and the pressing need to take a very long view of public policy by adopting a lower rate of discount than usually applied to public projects.

An important topic in the economics of public policy is market regulation which also plays an important part in environmental economics, being important for the control of emissions and hazardous waste. Although economists are fond of emphasizing the advantages of taxes over regulations, regulations also have a role to play in the control of emissions. When regulation takes the form of tradable emission quotas one achieves a system where quota prices have many features in common with environmental taxes with similar efficiency properties. The reason that I have not discussed these instruments of policy is simply that they are on the borderline of public economics as conventionally defined, and within my limited space I have obviously not been able to discuss everything¹⁹. Another set of issues that falls outside my framework are those related to population growth and population policy which can also be influenced by public expenditure and taxation. This is of major importance for the analysis of global climate change although it has been largely neglected in the economics literature of recent years. There can be no doubt that population growth is

¹⁹ For further discussion of markets for pollution allowances and references to the literature see Goulder (2013).

another issue that will be of central interest to the public economist who devotes himself to analyse the issue of global warming.

References

- Banzhaf, H. Spencer (2011), "Consumer sovereignty in the history of environmental economics." *History of Political Economy* 43 (2), 339-345.
- Bénabou, Roland and Jean Tirole (2003), "Intrinsic and extrinsic motivation" *Review of Economic Studies* 70 (3), 489-520.
- Bruvoll, Annegrete (2013), "The misinterpretation of Pigouvian taxes." *Journal of Environmental Protection* 4, 154-160.
- Condorcet, Nicolas de (1847-1849), *Oevres*. Edited by A. Condorcet O'Connor and M. F. Arago. Paris: Firmin-Didot.
- Goulder, Lawrence H. (2013), "Markets for pollution allowances: What are the (new) lessons?" *Journal of Economic Perspectives* 27 (1), 87-102.
- Graaff, J. de V., 1957. *Theoretical Welfare Economics*. Cambridge: Cambridge University Press.
- Johansen, Leif (1965), *Public Economics*. Amsterdam: North-Holland. Translated from *Offentlig økonomikk*. Oslo: Universitetsforlaget, 1965. (Preliminary edition published 1962-64.)
- Kant, Immanuel (1785), *Grundlegung zur Methaphysik der Sitten*. English translation as *Groundwork for the Metaphysics of Morals*, various editions.
- Klein, Lawrence R. (1962), *An Introduction to Econometrics*. Englewood Cliffs, N. Y. : Prentice-Hall.

Klier, Thomas and Joshua Linn (2015), "Using taxes to reduce carbon dioxide emissions rates of new passenger vehicles: Evidence from France, Germany, and Sweden." *American Economic Journal: Economic Policy* 7 (1), 212-242.

Kolm, Serge-Christophe (1963), *The Foundations of Public Economics*. Paris: IFP.

Marshall, Alfred (1890), *Principles of Economics*. London: Macmillan. 8th Edition 1920.

Meade, James E. (1952), "External economies and diseconomies in a competitive situation." *Economic Journal* 62 (March), 54-67.

Metcalf, Gilbert E. (2009), "Market-based policy options to control U.S. greenhouse gas emissions." *Journal of Economic Perspectives* 23 (2), 5-27.

Mill, John Stuart (1848), *Principles of Political Economy. Collected Works of John Stuart Mill*, Vols. 2-3. Toronto: University of Toronto Press, 1965.

Nordhaus, William (2014), "The ethics of efficient markets and commons tragedies." *Journal of Economic Literature* 52 (4), 1135-1141.

Nordhaus, William (2015), "Climate clubs: Overcoming free-riding in international climate policy." *American Economic Review* 105 (4), 1339-1370.

Okun, Arthur (1975), *Equality and Efficiency. The Big Tradeoff*. Washington, D.C.: Brookings Institution.

Parry, Ian (2015), "Carbon tax burdens on low-income households: A reason for delaying climate policy?" CESifo Working Paper no. 5482.

Parry, Ian W. H., Margaret Walls and Winston Harrington (2007), Automobile externalities and policies." *Journal of Economic Literature* 45 (June), 373-399.

Pigou, Arthur C. (1912), *Wealth and Welfare*. London: Macmillan.

Pigou, Arthur C. (1920), *The Economics of Welfare*. 4th Edition, 1932. Reprinted with eight new appendices, 1952. London: Macmillan.

Rothschild, Emma (2001), *Economic Sentiments: Adam Smith, Condorcet, and the Enlightenment*. Cambridge, Mass.: Harvard University Press.

Samuelson, Paul A. (1954), "The pure theory of public expenditure." *Review of Economics and Statistics* 36 (4), 387-389.

Sandmo, Agnar (1975), "Optimal taxation in the presence of externalities." *Swedish Journal of Economics* (later *Scandinavian Journal of Economics*) 77 (1), 86-98.

Sandmo, Agnar (2000), *The Public Economics of the Environment*. Oxford: Oxford University Press.

Sandmo, Agnar (2003), "International aspects of public goods provision." I. Kaul et. al. (eds.), *Providing Global Public Goods: Managing Globalization*. Oxford: Oxford University Press, 112-130.

Sandmo, Agnar (2005), "Environmental taxation and revenue for development." A. B. Atkinson (ed.), *New Sources of Development Finance*. Oxford: Oxford University Press, 33-57.

Sandmo, Agnar (2011), "Atmospheric externalities and environmental taxation." *Energy Economics* 33, S4-S12.

Sandmo, Agnar (2015a), "The principal problem in political economy: Income distribution in the history of economic thought." A. B. Atkinson and F. Bourguignon (eds.), *Handbook of Income Distribution, Vol 2A*. Amsterdam: North-Holland, 3-65.

Sandmo, Agnar (2015b), "The early history of environmental economics." *Review of Environmental Economics and Policy* 9 (1), 43-63.

Sinn, Hans-Werner (2012), *The Green Paradox: A Supply-Side Approach to Global Warming*. Cambridge, Mass.: MIT Press.

Smith, Adam (1776), *An Inquiry into the Nature and Causes of the Wealth of Nations*. Glasgow Bicentenary Edition, R. H. Campbell and A. S. Skinner (eds.). Oxford: Oxford University Press, 1976.

Stern, Nicholas (2007), *The Economics of Climate Change. The Stern Review*. Cambridge: Cambridge University Press.

Stern, Nicholas (2010), "Imperfections in the economics of public policy, imperfections in markets, and climate change." *Journal of the European Economic Association* 8 (2-3), 253-288.

Wicksell, Knut (1896), *Finanztheoretische Untersuchungen*. Translated in part as "A new principle of just taxation." Richard A. Musgrave and Alan T. Peacock (eds.), *Classics in the Theory of Public Finance*. London: Macmillan, 1958.



**Norges
Handelshøyskole**

Norwegian School of Economics

NHH
Helleveien 30
NO-5045 Bergen
Norway

Tlf/Tel: +47 55 95 90 00
Faks/Fax: +47 55 95 91 00
nhh.postmottak@nhh.no
www.nhh.no