Ecological Economics and Global Change

Aspects of Research

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Foreword

Ecological economics claims to integrate natural sciences and economics. This is not a merely interdisciplinary task. It is an approach without analogy in the history of science. Therefore, any research strategy following standard approaches and arguments runs the risk of failure. Simple straightforward analysis and empirical work without a reassessment of the underlying paradigms seem to be inadequate.

At this stage priority should be given to methodological questions and to a critical look at prevailing assumptions and approaches. This is the precondition to avoid premature conclusions about the outstanding problem. What is the subject of ecology? What is the primary concern of economics? How can the interface between ecology and economics be described? Is there a relationship between the two different sciences which constitutes a new research field?

The following pages raise some of these basic questions and reflect on major misleading assumptions research in ecological economics unwittingly relies on. An outlook is given as to the aspects on which research in this field should now primarily concentrate. It has to be stressed here that this publication addresses first of all natural scientists and politicians, though economists, too, might find some new aspects apart from traditional economic reasoning.

Acknowledgements

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Gerhard Maier-Rigaud *Bonn, September 1991*

The difficulty lies, not in the new ideas, but in escaping from the old ones, which ramify, for those brought up as most of us have been, into every corner of our minds.

(J.M. Keynes)

I. Some Aspects of Research and Scientific Knowledge

1. Introduction

The enormous and accelerating increase of knowledge in natural sciences has produced a generally optimistic attitude within the scientific community. This optimism is justified in many respects. But the urgent environmental problem and the growing signs of global change are striking evidences that science is not able to prevent us from disastrous trends. The same is true in social sciences. The limited insights of economics especially are evident. For more than 15 years economists have not been able to present, for example, efficient remedies against unemployment. Millions of people in the OECD area are forced to be in a sort of idle motion.

The starting point of any research, therefore, should be a creative scepticism concerning ecological economics and scientific approaches and findings in general. This does not necessarily mean to challenge the sciences but to deter us from oversimplified approaches and a kind of scientific superstition. Such an attitude should also dominate our approach to ecological economics.

Rather than outlining a more or less complete array of research fields this paper intends to stress the deficits of the ongoing research, its approaches and paradigms. Furthermore, it keeps in mind that it is often only a short step from carefully formulated findings to a political world of mere catchwords. Often, good and sound results of research turn into wrong political conclusions. At the same time there are important scientific findings which get no chance to reach the political agenda. As an example, the discussion on the greenhouse effect goes back to the last century. About 100 years ago it was already evident that CO_2 has an impact on the climate.[1] This means we also have to take into account a kind of socio-political ignorance or, at least, a limited capacity of perception.

1 Svante Arrhenius (1896), Über den Einfluß des atmosphärischen Kohlesäuregehalts auf die Temperatur der Erdoberfläche (On the Influence of Carbon Dioxide in the Atmosphere on the Temperature of the Earth), Stockholm (Royal Swedish Science Academy). Arrhenius is even talking about "the old greenhouse-theory" (page 74).

2. On the Hypothesis of Knowledge

– *Objective Knowledge?*

In spite of the currently dominating empirical approaches in all sciences, basic methodological questions should not be neglected. Therefore it seems useful to remind of a fundamental theses related to the growth of scientific knowledge: Science does not lead to objective knowledge but only to better explanations. These explanations are hypotheses. In the normal course of events such hypotheses are leading to other problems, especially when political or individual action is based on it. This is what Karl Popper pointed out in many of his publications. Science starts with problems and science progresses from problems to problems - that is to problems of ever-increasing depth.

Seen in this way scientific progress is an endless task, an interaction between solving problems and the emergence of new problems. The radical consequence of this is the acknowledgement of the fact that any research can only lead to preliminary results. Therefore we should not think that, for instance, the problem of global change could be solved now and forever by engaging a certain manpower during a certain time in this field of research.

– *A Hazardous Experiment*

Another aspect worth mentioning is the crucial element of trial and error in scientific progress. "The method of learning by trial and error - of learning from our mistakes - seems to be fundamentally the same whether it is practised by lower or by higher animals, by chimpanzees or by men of science."[2] Consequently fallacies seem to be essential for progress. This well-established approach is now questioned in certain cases. Global warming, the depletion of the stratospheric ozone layer and the destruction of tropical forests are part of the ongoing non-scientific hazardous "experiments" we can do only once. Resulting errors may leave us no chance for a second or third trial. This means that uncertainty together with irreversibility play a very decisive role with respect to global change. A strategy of waiting for deeper

2 Karl R. Popper (1963), The Growth of Scientific Knowledge: Theories and Problems, in: Conjectures and Refutations, London (Routledge & Kegan Paul) (Chapter 10)

scientific insights, the mere observation of the global experiment, is not sufficient to cope with global change. Our real task is to prevent the world from environmental desaster. But how can prevention or precaution in a world of preliminary knowledge be defined?

– *Changing Paradigms*

The next point to draw attention to is the concept of paradigms. Referring to the important book by Thomas S. Kuhn on "The Structure of Scientific Revolution" (published almost thirty years ago)[3] we should keep in mind that "normal science" works with well-settled basic ideas called paradigms. These paradigms are defended rather than questioned. Scientists seek to justify their theories rather than to falsify them. Therefore, we have to reckon with the possibility that higher funding of research ends up in stabilizing the same traditional paradigms and theories which have caused current and may cause future problems.

In social sciences and in economics, the perception of the relativity of paradigms seems to be more developed than in natural sciences.[4] There are two reasons: First of all, paradigms change more often because they are not based on experiments or direct observation but on interpretations of observations which can rarely be proved empirically. Secondly, the subject of research itself is changing in time. In contrast, natural scientists usually do not have the chance to experience a period of changing paradigms in their lifetime, wheras economists during the last twenty years, for example, have been able to observe more than one change of paradigm.[5]

Thirdly, the results of economic research depend very much on the point of view. Rising wages, for example, are evaluated differently by employees, entrepreneurs, a central bank or a minister of finance etc. As the history of economic analysis shows, paradigms can not easily be separated from manyfold vested interests. Sometimes they are nothing but an expression of ideological views, though to prove this is

3 Thomas S. Kuhn (1962), The Structure of Scientific Revolution, (1st ed. University Press of Chicago)

4 This is at least the impression of an economist. For a discussion of this point of view first of all a definition of the term "paradigm" has to be agreed upon.

5 E.g. the change of the world monetary system from "Bretton Woods" to a system of flexible exchange rates and back again to the European Monetary System, for example; the change from demand to supply side policy; the change from interest rates orientated monetary policy to the monetary volume orientated "monetarism".

no easy task in economics. Consequently, research and policy recommendations in ecological economics, too, might be permanently jeopardized by a mixture of theoretical assumptions and vested interests. This problem is likely to be even more complicated in the inter- and transdisciplinary research conducted in the field of global change.

3. A Framework for Competition

As we all know, there are many research fields in which only a few people are engaged. This is evident particularly on a national level, whether we regard problems of sophisticated technologies, problems of genetic engineering or socio-economic problems. In all these cases there is an unknown risk of opinion leadership and monopolization of research. But in research just as in an economy monopolistic structures should be avoided. In this respect research funding agencies bear an evident responsibility.

The creation of an institutional framework activating discussion and competition within the scientific community seems to be the best possible guarantee for good scientific results. It would be no waste of money if studies were conducted on the organisation of research in ecological economics and on the enforcement of scientific competition.

The process of scientific discovery does not work like say, a Coca Cola vending machine, where you have just to insert the coins. Research funding functions more like a one-armed bandit where you may sometimes have a stroke of luck, but most of the time the final result has to be regarded as a waste of money. The message drawn from this example is simple: Spend more money on how to raise questions. To think about learning how to ask questions is often more important than to get answers, especially during a first tentative period. In ecological economics we are starting from scratch, in spite of about twenty years of research . This is the time to re-think paradigms and not the time to seek impatiently for so-called practical results. What we should have done yesterday, and for which urgent actions are needed today, is evident anyway.

II. The State of the Art

1. Perception by Sciences

Imagine a world in which people began to suffer of yet unknown diseases and in which continents were afflicted by drought and inundation, a world in which allergies abound, huge forests began to die and dead seals were swept onto the beaches. Imagine further that we were confronted with such a world and endowed only with the knowledge we had some two hundred years ago. How would we explain these incidents?

We could simply say that all these anomalies are exceptional but nevertheless natural catastrophes. We might say, for example, that forests already died some hundred years ago. Though droughts, bad harvests and inundations were new experiences for the period we are living in, we might reassure ourselves that such events are rare but still normal. After all, we would say, epidemics already occurred in former ages. Nobody would call the calamities an environmental problem.

As an environmental problem, we identify events or developments in nature which have manmade causes. But such diagnoses require a certain knowledge of interactions which we normally can not draw from direct experience. The precondition for this is scientific discovery, in other words, our idea of normality as forged by sciences23. Therefore, however concrete environmental problems of today may seem, they are as such identified only by scientific perception. Diagnoses **and** solutions are completely dependent upon the state of science, particularly upon prevailing theories in ecology and economics.

But how reliable are the findings of science? Can it ever be possible to define the carrying capacities of the earth? And how can we think of an adequate definition of sustainability? Is there any chance to attain sustainability with our preliminary theories? In this context it seems worth to recall the ongoing discussion about the tolerable concentration of greenhouse gases in the atmosphere.

In principle, there are two extreme and hypothetical positions to distinguish. The first assumes that the natural system is endowed with a perfect adjustment capacity. In this case, no restrictions for the economic system would exist and conseqently there would be no envi-

ronmental problem. The second position is just the other way round. If we regard the economic system as perfectly flexible, we can stop all polluting interventions in nature without the fear of any repercussions on the macro-economic side.

Neither of these two hypotheses reflects our present state of knowledge. We assume that both the natural and the economic system have limited adjustment capacities. But we don't know and will never know the exact range of adjustment capacities. Viewed from this perspective, environmental policy seems bound to rely on trial and error.

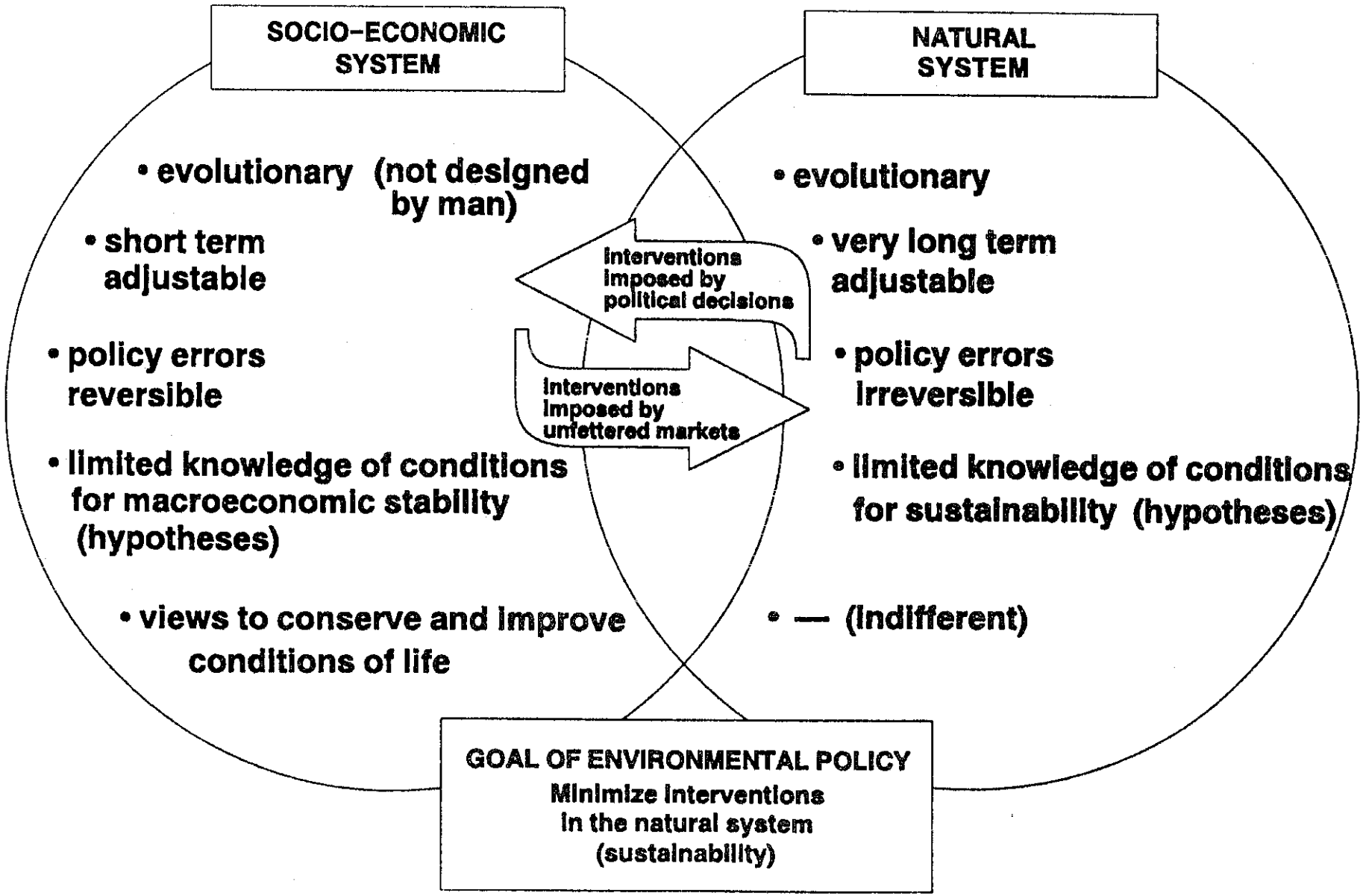
But such a strategy can only be justified if errors are reversible. And this is often not the case in ecological systems. Therefore, from a scientific point of view, **only a strategy of minimizing interferences with nature counts as a cautious one.** This is the only strategy which gives a chance to come closer to the idea of sustainability. All other strategies, built upon definitions of environmentally harmless pollution levels, are a sort of scientific superstition or at least a strategy taking unknown risks.[6] But, as it is, environmental policy follows just this strategy.

If the environmental problem is seen in a strictly scientific way, the whole burden of adjustment is assigned to the economy and, finally, to society alone. The scheme in FIGURE 1 outlines how the environmental problem can be conceived at a first stage. It compares the properties of the socio-economic and the natural system, with special regard to their relevance for the need of interventions into both systems.

6 There seems to be a growing awareness of the fallacy behind such an attitude: "When confronted with risks which could be menacing, cumulative, and irreversible, uncertainty argues strongly in favour of prudent action and against complacency." (E. Arrhenius/ T. Waltz (1989), *The Greenhouse Effect: Implications for Economic* Development, World Bank Paper, quoted by Michael Grubb, The Greenhouse Effect: Negotiating Targets, Royal Institute of International Affairs, London, p. 8)

FIGURE 1

The Environmental Problem



2. Challenge of Economics

Our deliberations lead directly to a profound challenge for economics. Is the economy capable to cope with ecological constraints? Is a sustainable market based economy possible? Such questions bring us to the center of the pervasive conflict hypothesis between ecological and economic ends[7]. Do we really have to decide between a situation of ecological disaster and economic prosperity on the one hand or a situation of economic crises and sustainability on the other hand? Does this mean that we have reached an apocalyptic end of the progress which mankind has concentrated on? And how could ecological economics prevent the showdown?

From the very beginning of the environmental discussion economists have accepted the scientific challenge of the emerging problem. An immense amount of literature and several new journals specializing in environmental or ecological economics prove this.[8] FIGURE 2 gives an impression of the different approaches developed in environmental economics.

In spite of these manyfold (and at the same time confusing) efforts, there is a strong feeling that many theoretical problems are still not solved. Above all, a reconciliation between economic and ecological ends is still lacking. Globally this might be due to the fact that economists have started to integrate the environment in the analytical scheme of economics. But in doing so, they omit raising some more fundamental questions concerning the character and dimension of the environmental problem in respect to traditional paradigms. A short flashback may help to provide some light at the end of the tunnel.

7 Gerhard Maier-Rigaud, The Background to the Conflict between Economic and Ecological Ends, in: Ecological Economics (forthcoming). See also appendix: "Examination of a Conflict".

8 In the announcement of the International Conference on Human Ecology in Göteborg (June 1991) an interesting difference between **environmental** and **ecological economics** is made: "The limits posed by the global ecosystem on what activities are possible in a sustainable society, are traditionally neglected in economic analysis and economic theory. The existence of environmental economics as a special branch of economics does not change this fact. Since ecology is essential to economics, a new discipline, ecological economics, is now emerging, based on the knowledge of the conditions set by the global ecosystem." Whatever the importance of this differentiation, in this paper is not concerned with semantic questions; the two terms are regarded as synonyms.

FIGURE 2

The Environmental Problem as a Subject of Economics

Environment defined as		related to	Problem diagnosis
overall economic target like full employment, price stability		macroeconomic theory	depending on theory: antinomie or harmonie with the targets employment, stability of price level, external equilibrium
good	private	property rights theory	insufficient differentiation of property rights (policy failure)
		behavioural approach	insufficient individual consciousness of problems; possible approach: eco-pedagogics, environmental ethics, moral suasion
	public (meritorious)	theory of public goods	no markets possible (market failure); possible approach: shortage of the good "environment" via command and control,charges, taxes, quantitative restrictions (tradeable permits) etc.
production factors		production theory, allocation-theory, environmental economics (in the narrower sence)	negative external effects on the production of private goods lead to allocative distortions; approach: internalisation according to the "polluter pays principle"

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3. Paradigms and Patterns

– *The Price Problem*

Economics is traditionally oriented to market processes. Starting from a set of given preferences, it is asked how resources such as labour and capital are allocated in order to maximize the supply of goods demanded. The integration of the environment into this context was a rather easy task. At a first stage, the environment was taken as a resource or **production factor** which had become scarce. Its allocation and exploitation was subordinated to the same rules as had been discovered for traditional resources. The only problem was that no market and thus no prices exist for the resource "environment". This problem became the primary concern of environmental economists.

Economists have elaborated a broad range of concepts to solve the price setting problem. The most common approach here is the "polluter-pays-principle", which is closely related to what is called "internalisation of external costs". Environmental economists think that if all costs were internalized at the polluters', the resulting allocation would be optimal[9]. But this approach does not lead to market prices, because market prices do not primarily reflect costs, but the relationship between supply and demand. Internalisation is only an instrument to come closer to what is meant by "market prices", it does not by itself solve the problem of pricing environmental goods.

For an analogy to market prices it is necessary to reveal the preferences of individuals for environmental quality. This is done by sophisticated investigations on the willingness to pay. But why should we assume that individuals are able to conceive, for example, sustainable economic structures? The core of this kind of problem is not new; John Stuart Mill, to name but one, discussed it already with respect to other public goods, such as education. He concluded: "The uncultivated cannot be competent judges of cultivation."[10] To transpose this to the ecological problem at hand: The individuals brought up in a world of

9 Allocation theory investigates how the production factor environment has to be used to achieve an optimal output of traditional goods and services. This task has to be solved even assuming that all individuals are absolutely indifferent to environmental quality. Therefore, internalization is not necessarily equivalent to an implementation of environmental policy.

10 J. S. Mill (1987, 1st ed 1848), Principles of Political Economy, Fairfield NJ, p. 953

unsustainability cannot be competent judges of sustainability. It has to be noticed that this important problem demands careful and in depth deliberations, yet the intention here is but to raise the question at all.

A passing glance at these research acitivities in general inspires various doubts; it might even be that most of the research done in this field is wasted. Which idea does make us believe that it is possible to find prices for the environment by an artificial simulation of market processes? It has to be accepted that economics as well as other sciences are mere tools unable to bring about values. **No science can take the value judgement off our hands.**[11]

– *Emergence of New Preferences*

The focus on market goods and market processes has forged the whole apparatus of economics. This has become the source of another important fallacy. All well-defined notions such as national product, productivity, inflation and growth are adjusted to a world where markets and private goods are dominant and changes in individual preferences negligeable. In such a world a correlation between an increase of the national product and an increase in welfare is self-evident or probable. But the shift of our preferences to the **common good environment** brings confusion into the traditional concepts and makes the old terms in many respects obsolete. However, most economists are not aware yet of the inadequacy of traditional terms to tackle the environmental problem. This is the source of an important misunderstanding.[12]

Economic and scientific progress promotes a strong tendency to exploit nature and to jeopardize ecological stability. The goal must be to stop this exploitation. And there is no reason not to integrate this goal into the whole scope of preferences and economic ends. Only

11 See chapter V "Costs and Benefits of Global Change"

12 See chapter III "Macroeconomics and Environment"

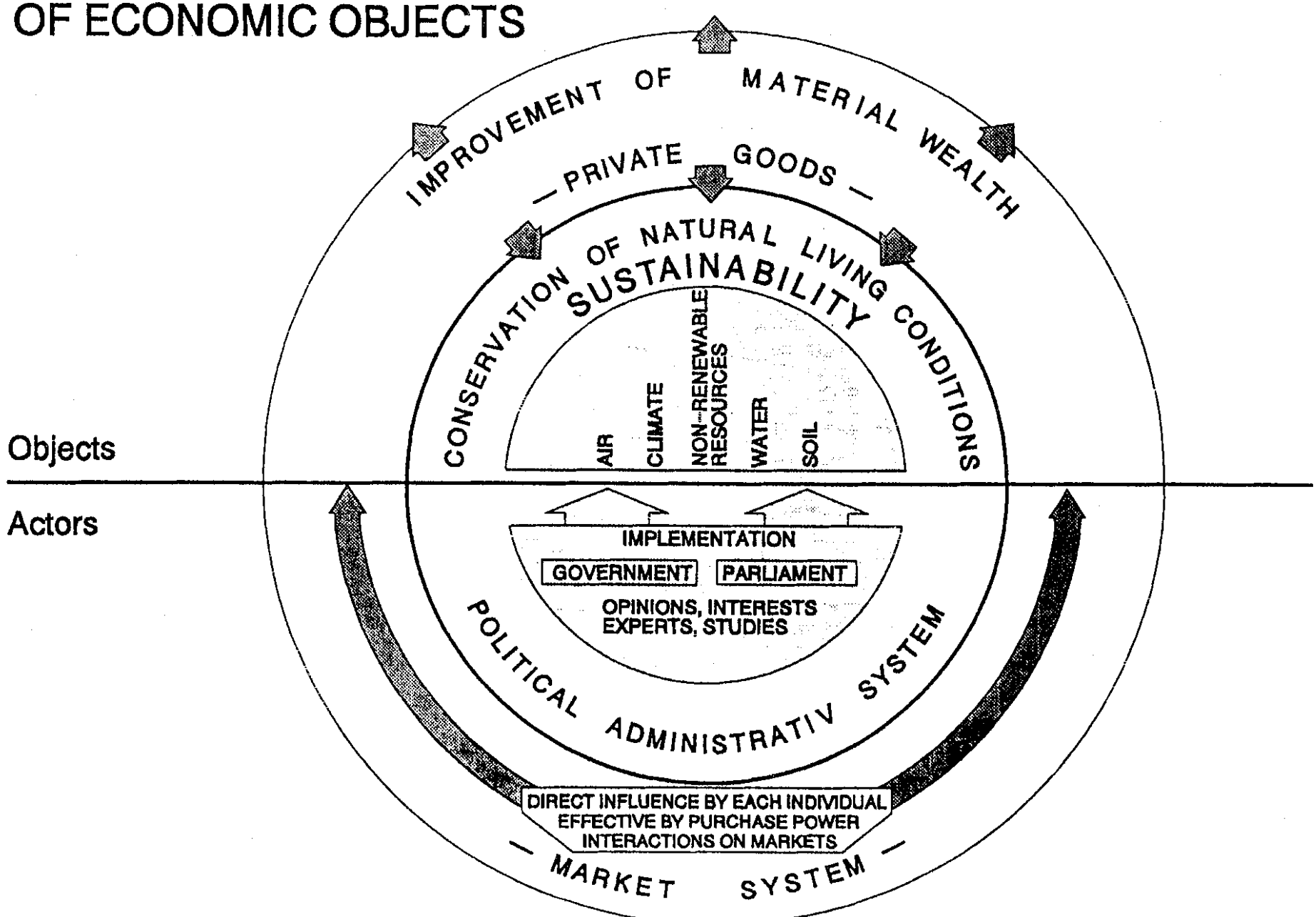
misguided economists can construct a conflict between man's efforts to save the natural conditions of life and to improve material wealth. Both are intrinsic to economic interests. **From the outset the protection of nature is of primary economic concern.**[13].

This insight leads to the conclusion that a change in our economic treatment of natural resources and global stability has to come about. But who can initiate such a change? The improvement of material wealth in traditional terms is an area where market forces and individual decisions and activities have a direct impact. However, the conservation of the natural life supporting system requires a different approach. This task does not underly the direct influence of the individual, but can only be tackled by political decisions, as is true for any public good. Here the individual can claim an indirect influence only, e.g. by voting or via interest groups and lobbies. **The management of our environment can only be assigned to the political administrative system.** This is visualized in FIGURE 3.

13 The Brundtland Report (1987), Our Common Future, Oxford New York , p.53, states: "Sustainability requires views of human needs and well-being that incorporate such non-economic variables as education and health enjoyed for their own sake, clean air and water, and the protection of natural beauty." It has to be noted that this is quite different from saying: Human needs and well-being comprise sustainability.

POLICY ASSIGNMENT OF ECONOMIC OBJECTS

FIGURE 3



– *A New Dimension*

The third paradigm to be mentioned here concerns the still prevailing idea of an unlimited progress. Inspite of the vision of the "spaceship earth", formulated long ago by the economist Boulding, the challenge of the environmental problem is mostly regarded simply as a further restriction to the ongoing progress. Environmental policy is placed on the same level as social policy or any other restriction imposed on the market system. This leads many scholars to consider it generally possible to safeguard the traditional patterns of behaviour, welfare, consumption and so on. At least on the political level one might get the impression that the environmental problem can be solved by limited adjustments of the production processes accompanied by some technological effort.

In recent times we notice a promising and necessary change of attitude against this optimistic view. The emergence of notions such as "sustainability" and "global change" as well as discussions on the carrying capacity of the earth seem to be valuable signals. The time has come that environmental economists are increasingly aware of the fact that until now they have only discussed "how to arrange the deckchairs on the Titanic". Now they are looking into how to make the system sustainable.

The following chapters mainly deal with the different aspects of the asserted conflict. The reasons for the assumption of a conflict are identified, and it will be demonstrated that the conflict hypothesis is nothing but the outcome of superficial reflections in economics.

III. Macroeconomics and Environment

1. What is Macroeconomics?

One of the most important obstacles hindering the implementation of drastic environmental measures is the fear of repercussions on the overall performance of our economies. This fear is largely caused by the prevailing assumptions of economists. Before discussing this problem it seems necessary to outline what is meant by macroeconomics. This can be done by looking at the questions macroeconomics deals with.

From barter economies...

In former times, say in the Middle Ages or during the Roman Empire, the division of labour was very limited. Almost 100 % of the population worked in agriculture, occupied with self-supporting activities. Only a few craftsmen were engaged in economic relationships outside their villages or towns. Therefore, it is possible to describe these economies like great families where everybody was well-informed about the interests, intentions and objectives of the other. In terms of economics there was a perfect transparency and flow of information between the individual economic actors.

... to the information problem ...

This situation changed in the 18th and 19th century. The characteristics of modern economies emerged, i.e. the division of labour and large markets. The exchange of goods and services no longer occured among people who knew each other. Trade became an impersonalized act based only on price information. Industries started to produce for unknown consumers. Furthermore, the process of buying became independent from the process of selling. The barter economy changed totally to a money-based economy with a highly-developed division of labour. The barter process "goods against goods" split into two independent processes: Goods were changed for money and money was changed for goods. As a result money became not only an instrument to facilitate trade, but it became the means of storing wealth.

... on anonymous markets.

This role of money, the division of labour and the emergence of anonymous markets were the starting points of macroeconomic problems and of macroeconomics. The subject of macroeconomics is focused on the information problem of anonymous markets. Economic crises, business cycles, longlasting unemployment and inflation are the outcome of information inherent to the coordination process itself or superimposed by false economic policies.

A good example of a macroeconomic problem and, at the same time, of the difference between microeconomics and macroeconomics was given by Joan Robinson. She wrote in her famous book published in 1937:[14]

> *"It is said that if wages were reduced costs would fall, and therefore entrepreneurs would find it profitable to produce more goods. But money incomes fall as much as costs, and money demand is reduced correspondingly. Any one entrepreneur, by cutting the wage rate which he pays, can increase his profits, but if they all cut wages together none of them is any better off. Any one man in the crowd can get a better view of the procession by standing on a chair, but if they all get up on chairs no one's view is improved."*

If the subject of macroeconomics is seen in this way, there is no room for the discussion of changes in relative prices, preferences or ecological degradation. These problems are not related to the problem of coordination between millions of economic actors in an economy and the information given by prices. But this view is not the mainstream one. There are many examples past and present assuming an interdependence between overall economic problems and the change of individual prices.

This thought of mainstream economics is of utmost political relevance. As this view has become the greatest obstacle for environmental policy and firm political action to prevent global change, we have to look for the sources of this idea. **Where do the theoretical roots of the belief in the existence of a conflict between macroeconomic stability and microeconomic changes lie?**

14 Joan Robinson (1960, 1st ed. 1937), Introduction to the Theory of Employment, London (Macmillan), p. 40/41

2. Theoretical Roots of the Pitfall

Ever since the days of Adam Smith, many economists have failed to tackle the notion of wealth in an appropriate manner, a failure which has now become an obstacle to even minor progress in environmental quality. Three aspects of this error are distinguishable: the laisser-faire paradigm, the income concept confusion, and the national accounting error.

– *The Laisser-faire Paradigm*

When Bernard de Mandeville published his fable of the bees in the early 18th century, the turning point to laisser-faire was marked. The assertion that private vices bring about public benefits kindled the interest of political philosophers as to how a free market economy works.

Later on, from Ricardo to Lord Keynes and Professor von Hayek, economists focused on the mechanisms of market systems. They tried to find out how such a complex system allocates resources, creates growth and distributes wealth. They defined wealth and income according to their scientific interests and limited their analysis to private goods and markets mainly.

In the context of their major concern, government intervention into markets seemed mostly to create distortions. But only a superficial public and some less critical economists have interpreted this result as generally valid. The best economists have always rejected this conclusion. Even Adam Smith was well aware of the necessity for governmental intervention, such as the need for public investment into infrastructure. And John Stuart Mill wrote in his Principles, as if he wanted to remind that **laisser-faire is justified in many respects, but that it is absurd to block with laisser-faire arguments activities which are today called environmental policy:**

> *"But is there nothing recognized as property except what has been produced? Is there not the earth itself, its forests and waters, and all other natural riches, above and below the surface? These are the inheritance of human race, and there must be regulations for the common enjoyment of it. What rights, and under what conditions,*

a person shall be allowed to exercise over any portion of this common inheritance cannot be left undecided. No function of government is less optional than the regulation of these things, or more completely involved in the idea of civilized society."[15]

– *Income Concept Confusion*

The heading of this paragraph refers to a problem in the history of economic analysis which Schumpeter called a "dusty piece out of a museum". He treated this issue only because

> *"it affords an excellent example of the manner in which the discussion of meaningful ideas may lose sight of their meanings and slip off into futility. But it could serve one purpose only, namely, to display the word-mindedness of economists and their inability to tell a real problem from a spurious one".*[16]

The story began well before Adam Smith defined income as net revenue which people could spend "without encroaching upon their capital".[17] In modern terms, this would be expressed as something like the production potential. Some fifty years later, Friedrich List, as well as other economists, treated this definition of the Smithsonian School with irony: "He who raises pigs is a productive member of society, but he who educates people is an unproductive member of society."[18]

But even during Smith's lifetime, Italian economists like Ferdinando Galiani used definitions of production and income which are still valid today. "They declared all labor resulting in the production of useful and desired things to be productive, without insisting that these things take

15 John Stuart Mill (1987, 1st ed. 1848), Principles of Political Economy, Fairfield NJ, p.797

16 Joseph A. Schumpeter (1976, 1st ed. 1954), History of Economic Analysis, London (Oxford University Press), p. 631

17 Schumpeter (1976, 1st ed. 1954), p. 628

18 Friedrich List (1925, 1st ed. 1840), Das nationale System der Politischen Ökonomie, Chapter 12 ,Stuttgart/ Berlin, p. 128

on material form; and they identified national income as the value of the annual production of all such comprehensively conceived useful and desired things."[19]

There is no reason to ignore this state of the art and, for example, call the production of environmental quality an unproductive activity.[20]

– *The National Accounting Error*

The last sequence in this story deals with our national accounting systems. When economists started to construct these systems in the 1930s and 40s, the old controversy on the income concept was still undecided in mainstream economics. The statisticians therefore set up an empirical rule. They distinguished between final products and intermediate products. If a product is sold by one business unit to another for resale, and if its cost is incorporated in the price of the final product, it is called an intermediate product. A good example affords the catalytic converter in an automobile. This aggregate makes cars more expensive. But the higher price has nothing to do with inflation. It reflects only the equivalent of an additional good, namely cleaner air.

However, environmental quality is not an intermediate product, it is a public good and, therefore, not available for sale. Its costs are - as the polluter-pays-principle claims - incorporated in the prices for conventional goods. This has an unfortunate effect on macroeconomic aggregates.

19 P. Studenski (1958), The Income of Nations, Theory, Measurements, and Analysis: Past and Present, A Study in Applied Economics and Statistics, New York (University Press), p. 16

20 The historical roots of the income concept are outlined in: Heiner Flassbeck/Gerhard Maier-Rigaud (1982), Umwelt und Wirtschaft. Zur Diskriminierung des Umweltschutzes in *der ökonomischen Analyse (Environment and Economy. On the Discrimination* of Environment in the Economic Analysis), Tübingen (Mohr/Siebeck).

Environmental policy diminishes the gross national product, lowers the rate of productivity and increases prices of final products. Therefore, in macroeconomic models the impact of environmental policy appears as disastrous: it looks like more inflation, more unemployment, less productivity and less growth. But all these effects only occur in the artificial world of national accounting systems, they are the outcome of measuring the wrong aggregates.[21]

The firm conclusion of these deliberations is the following: conflicts between ecology and economy are highly abstract and a consequence of inaccurate constructions of economists since the days of Adam Smith.[22] Nevertheless, these creations have an enormous political influence. "According to official economic policy, unemployment can only be reduced by a growth in production, and conservation of the environment is at the expense of employment. By repeating this statement practically every day in the news media, the public has become convinced that a political choice has to be made between employment and saving the environment." [23]

There are politicians who hesitate for such "economic reasons" to establish ambitious CO_2 emission ceilings, to increase energy prices,

21 Mainstream economists, as well as the statisticians who establish so-called satellite-accounts in order to measure the environmental costs of economic activities and to correct the GNP concept, are not aware of this. See, e.g., the OECD-publications:
- The macro-economic impact of environmental expenditure, Paris 1985
- Issue Papers on the Int. Conference "Environment and Economics", Paris 1984
This error has to be distinguished from the numerous attempts to evaluate the economic damages of pollution and to provide socially and economically adequate measures in the face of environmental and natural resource degradation.

22 To overcome definitely macroeconomic irritations stemming from accounting systems it is necessary to discuss the conflict hypothesis within general economics, too. The precondition for more employment (output) is more money in real terms. This condition also applies whenever more labor is dedicated to protect the environment. Therefore, environmental policy is not able either to produce unemployment nor to increase employment by itself. There is thus no difference between environmental policy and any other policy affecting the structure of demand. Positive impacts on employment depend solely from upward shifts in the overall budget restriction (real money supply). This extra money may come from the central bank or - as Keynes pointed out - from "the monetary management of the trade unions". However our preferences change (also concerning private or public goods), there are no repercussions on the level of economic activity to fear or to hope for. This is demonstrated in a simple model presented in: G. Maier-Rigaud (1988), Umweltpolitik in der offenen Gesellschaft, Opladen (Westdeutscher Verlag)

23 Roefie Hueting, The Brundtland Report: A Matter of Conflicting Goals, Commentary in: Ecological Economics, 2 (1990), p. 112/113.

to conduct a firm strategy of waste reduction or to change transport policy. In doing so they think to show a sense of responsibility. But in fact they are merely victims of modern economists.

3. Unilateral Strategies and International Competition

In current debates on the problem of international competitiveness environmental policy plays an important role. Unilateral strategies of "greening the economy" are postponed in order to avoid aggravations of trade balance deficits. This fear leads to delaying tactics until there are agreements on the international level. A look at the state of the world and at the tremendous differences among countries brings home that international commitments, their implementation and verification, are difficult to attain.

Here again the main obstacle lies in economics. Mainstream theory as well as microeconomic evidence make us assume an inevitable trade-off between the costs of a green strategy and international competitiveness. In other words, it seems that economic instabilitiy is the price to pay for an environmental protection which exceeds the environmental investments of the trade partners.

Without going into details on the complex question of balance of payments one important aspect should be briefly mentioned. There is one simple rule to safeguard international competitiveness: national inflation is to keep close to the inflation rate of countries with important trade relations. The inflation rate is determined mainly by the nominal wage rate, the productivity rate and the exchange rate. As the latter two rates are endogenous or hard to influence in the short term for many reasons, international competitiveness is assigned to wage policy. Wages are the most important strategic factor for changes in national cost levels and inflation rates.

All differences among nations with an influence on production costs have to be ruled out by wage adjustments. This refers to disadvantages due to climate situations and any other natural conditions as well as to different taxation systems and different structures in the demand for private and public goods. Normally we are not aware of most of these differences because the whole economy has adapted to them, or because the quantitative effects are small and other aspects like exchange rates are dominating.

Obviously, unilateral strategies for a better environment will increase costs for traditional goods. This is the normal result of the polluter pays principle which enforces the good "environment" to be financed by higher prices for tradeable goods. But these prices are not competitive on international markets. Therefore, the costs for the environment have to be compensated by the reduction of other costs - and this means in general by a slowdown in the growth rate of wages.[24]

As people in developed countries have higher preferences for a better environment, **national policies should not hesitate to implement unilateral strategies.** They should try to set an example to the world, proving that unilateral strategies to improve the environment, if based on sound economic analysis, do not necessarily lead to a loss of international competitiveness. To withdraw false economic constraints from environmental policy seems to be a major precondition to bring forward political action on a national and international level.

24 cf. Gerhard Maier-Rigaud (1988), Umweltpolitik in der offenen Gesellschaft (Environmental Policy in the Open Society), Opladen (Westdeutscher Verlag), Chapter B. IV. "Macroeconomics and Environmental Protection")
The usual arguments for unilateral action are a) assertions that there are beneficial (energy) conservation strategies which are undiscovered by "free markets", b) the idea that unilateral strategies will help to develop relevant technologies offering good market opportunities in the future when other countries seek to reduce emissions. Argument a) neglects the so-called transaction costs. Argument b) neglects the relevant transitional period. For the whole range of standard arguments see e.g. Michael Grubb(1989), p. 51-52

IV. Microeconomic Adjustments

1. Data Changes, Equilibrium and Private Interests

Assuming that macroeconomic theory gives the right answers on how to keep the overall economic activity on a full employment level under the condition of price stability, and assuming furthermore that economic policy follows the doctor's order and therefore is successful. What happens in such an "economic wonderland" on the microeconomic level? To deal with this problem economists have boiled it down to the question: How does the economic system cope with an exogenous change of one data? It has been demonstrated that such a change - which can always be expressed in price changes - will trigger off manyfold adjustment processes leading to a new equilibrium situation. However trivial this result may look, it is the basic insight which proves that a market economy can not in the long run stay in a disequilibrium situation.

All that occurs under a regime of given macroeconomic conditions are temporary adjustments on a microeconomic level. But the overall stability of market systems is not endangered. This applies to minor data changes as well as to important changes like oil prices etc. This finding of utmost political importance is just the same as the one already stressed when discussing the macroeconomic side.

Nevertheless two problems have to be admitted: First of all, there is the problem of time to consider. Because adjustments need time, there might be a long transitional period during which social problems arise. The change of demand and supply to a new structure is accompanied by job losses and the creation of yet unforseeable new jobs. Policy has therefore often a tendency to lengthen the adjustment process or to alleviate it e.g. by giving subsidies. In many cases such a tendency might be justified. But whenever the data changes are caused by a change of preferences a basic problem emerges: the economic structure and the related interests are given a higher priority than the preferences of consumers. **The whole economic arrangement, justified by individual and common preferences only, turns out to have become an economic end in itself.**

This same attitude is observed vis à vis the common preference for global stability and environmental quality. In this case the false priority should be evident. How is it possible to sacrifice or jeopardize the stability of the natural system for the ordinary interests of some economic actors to save their current market positions?

Secondly, there is a risk of false macroeconomic policy reactions to data changes. This happened, for example, after the first oil price crisis in 1973/74 when trade unions tried to defend the purchasing power. The consequence was a home-made inflation,restrictive monetary policy and a sharp rise of unemployment. Thus, the unavoidable adjustment process was aggravated.

2. The Laisser-Faire Strategy to Global Change

With these crucial aspects of microeconomic adjustment processes in mind, now it is time for a closer look at problems of global environmental change. Even without too much stress on pessimistic projections, the tendency might be agreed upon that global change will most likely express itself in changes of climate, decreasing fertility of soils, sea-level rises, degradations of water quality and many other tremendous and unforeseen changes in the course of, say, the next fifty years.

From a pure economic perspective all these changes will bring about decreases and increases in the prices of goods, assets and all forms of wealth. This change of the price structure itself will initiate various individual strategies to prevent losses. Individuals all over the world will try to escape from worsening situations. Therefore they will change the structure of their expenditure. The same applies to public budgets. Defensive expenditures will increase. This means more money will be spend to keep away disastrous developments, either by simply building dikes, by looking for new technological solutions in many areas or by migration to other places. The overall shift of purchasing power will influence all relative income and market positions. World trade flow will change. We have to envisage breakdowns of firms and markets as well as the emergence of new possibilities and new markets. There will be no island untouched by these changes.

The adaptation to these lasting changes in environmental conditions is not costless. We are permanently losing a portion of the traditionally defined wealth as a consequence of the laisser-faire strategy. One

look at how this adaptation would happen in reality proves that - given a limited capacity of manpower, and given a rate of productivity - it is unavoidable that an (increasing?!) percentage of these resources must be dedicated to otherwise unnecessary activities. This means, for example, that a higher share of people are engaged in the production of agricultural goods, more people are engaged in dike buildings, more in the health services, in the discovery of new trade possibilities, in the water supply utilities, in migration efforts, technological preventions etc.

All these activities will decrease relatively or even absolutely the production of traditional goods. This is the price of global change. To put it in the vocabulary of economics: the terms of trade with nature are worsening. The laisser-faire-strategy to global degradation means a strategy of mere reaction or defense which produces in itself the need for ever more adaptation.

3. The Strategy of Sustainability

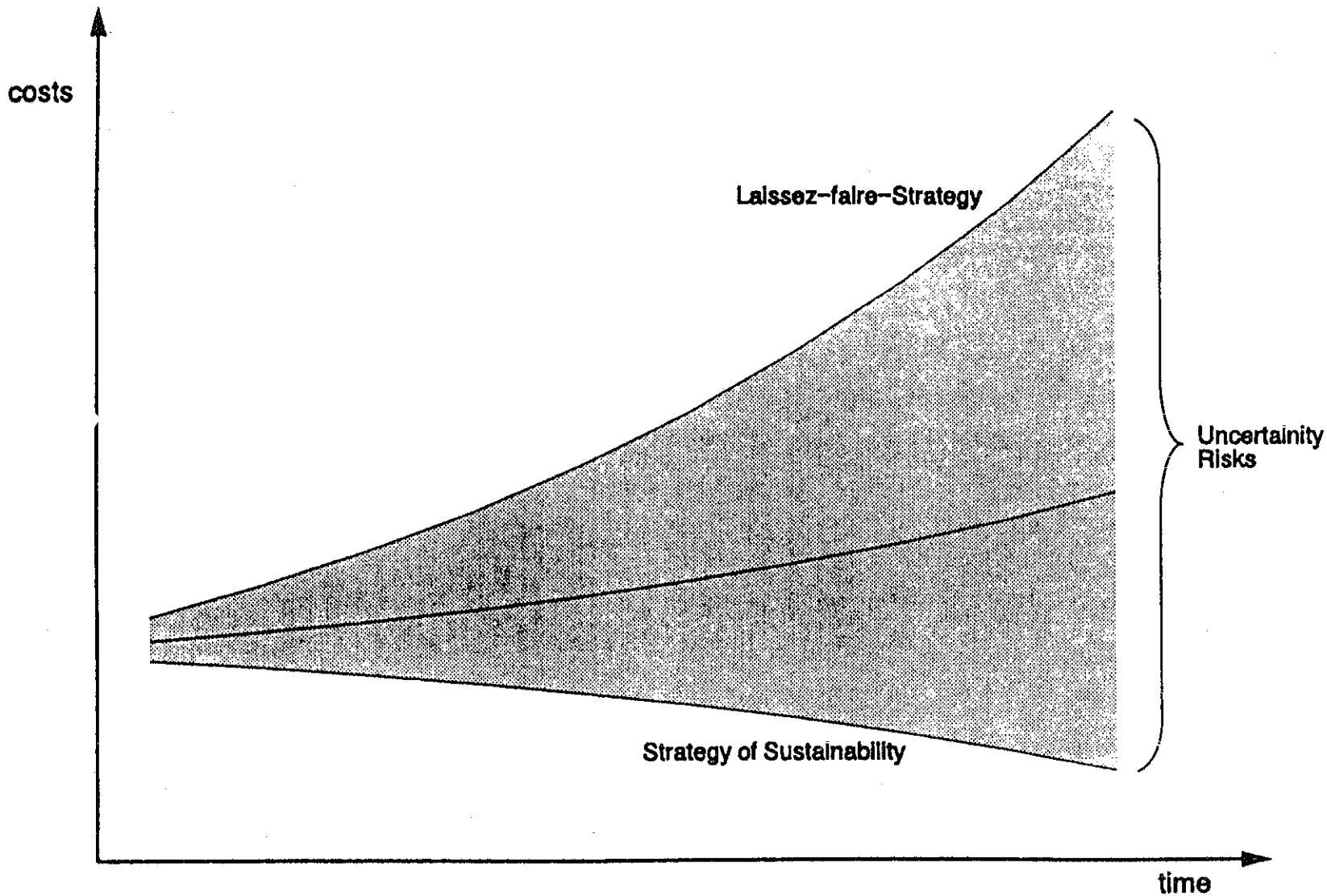
But there is another option. Global change can be stopped if a "Strategy of Sustainability" (SOS) is pursued. This strategy will also change prices as well as individual income and market positions. It will absorb a lot of manpower, capital and other resources which are not available for any other production. But the resources are used in a very different way. Instead of building dikes etc., economic efforts are dedicated to a cutback of CO_2 emissions and other climate gases, to avoiding production of waste and to enforcing environmental policy measures in general. It is to be acknowledged that this strategy, too, will encroach upon wealth in the traditional sense.

Considering the two opposite strategies, the question emerges how to design the best one. As the future is not our's to see, we can only give some crude patterns and assumptions about the possible costs and benefits of the two strategies.

First, from a macroeconomic point of view, the laisser-faire strategy to global change and the strategy for sustainability are equal. In both cases it is possible to keep the economy on a full employment level and to prevent inflationary processes.

ADJUSTMENT COSTS

FIGURE 4



Second, from a microeconomic adjustment point of view, both strategies are equal, too. Individual actors are in both cases confronted with price changes. And in both cases they try to adapt themselves in order to optimize their benefits, income etc. In both cases there will be losers and winners in the course of adjustment processes.

Third, when comparing the two strategies it is important to keep in mind the fact that we are familiar with current climate and that the world is well adapted to this climate in all respects. Therefore, if we manage to prevent greenhouse warming, no further adaptation measures are to be expected. This is not the case with the laisser-faire strategy. We cannot foresee the climate change in detail, nor forecast the amplitudes of temperatures and the frequency of storms, nor describe the impacts on different regions of the world. All cost guesses are very crude and in no way reliable. Thus, any attempts to compare the costs of both options are based on very different degrees of uncertainty.

Fourth, the most decisive argument lies in long-term considerations. The laisser-faire approach is linked with a permanent degradation of nature and a lasting change of climate. The underlying idea of most discussions, that we have only to face a one-time and limited change, is wrong. Laisser-faire provokes a non-ending adaptation process. In contrast to this, SOS is the only chance to cope definitively with the problem mankind is confronted with on the spaceship earth.

Consequently, a correct assessment of the costs of both strategies can not be made; it has no basis as long as neither the ecological nor the economical effects of ecological changes are predictable. All attempts of adjustment-cost analyses have to be read with great care.

However, since the laisser-faire strategy does not tackle the underlying problem, but only reacts, "repairing" the resulting damage, whereas the strategy of sustainability (SOS) prevents damage (and thus repair-costs); it can be assumed that the adjustment-costs of SOS would be less, and this advantage would become increasingly pronounced, particularly in the long run. How much more expensive the laisser-faire approach would turn out can not be forecasted (FIGURE 4). And even if the laisser-faire strategy may seem to be less cost-intensive than SOS, according to highly hypothetical assumptions, politicians, in coming to decisions, have to keep in mind that economic valuation can not reflect the whole complexity of this world. Regarding

the diverse phenomena of global change, economic aspects could even be regarded as minor.

4. Losers and Winners?

Whatever current and future findings of natural sciences on global change might bring about, a linear impact all over the world is not to be expected. The different regions of the world will be affected differently. The potential winners are therefore likely to be susceptible to egotistical positions whereas the potential losers will claim worldwide solidarity. Starting from these opposite attitudes it will be very difficult to achieve international commitments by mere diplomacy. To overcome this dead end, it seems useful to learn from economics.

Confronted with global change, nations are likely to be in the same position as individual economic actors on a market. They are bent on maximizing their gains. But in contrast to the famous "invisible hand" described by Adam Smith, there are likely scenarios where individual actions are not leading to the benefit of the economy as a whole. Such cases are theoretically demonstrated by Knut Wicksell and John Maynard Keynes. In this context we have to recall the illustrative example given by Joan Robinson.[25] An individual strategy to improve the situation may turn out to worsen the situation for all individuals. In order to prevent such a situation economists claim an economic policy action.

The problem of global change has the same logics of decision. If nations seek to realize individual advantages by a laisser-faire strategy they will produce a worsening of the global situation. Within such a situation the assumed winners will still be better off than the assumed losers. But this is only a relative perspective telling nothing about the situation in absolute terms. To put it more directly: What sense lies in the assertion that the last passenger on the Titanic who died by drowning is better off than the first one?

The lesson to draw from these deliberations is evident. The community of nations should avoid the "perception trap" emerging from the prevailing idea that there might be losers and winners. In economics, it has become common wisdom that there is a need to prevent people from actions which are individually rational but have repercussions

25 see Chapter III of this paper

finally undermining the same individual goals. The same holds for the interaction of nations.

Furthermore another important aspect has to be taken into account: the presumed conflict between the North and the South. Here again we may learn from economics. The North is more conscious of environmental problems. This roots mainly in the North's material wealth: basic needs are only in the background of preferences, as they have been satisfied for decades. This gave room to open up society to ecological problems, and let ecological questions climb the scale of preferences. In contrast, the South still has other priorities. Preferences are orientated to the fulfillment of basic needs. Therefore, it is evident and should be understandable to the North that global change can not be the first concern of the South. Seen this way, it is up to the North to achieve the satisfaction of its preferences by paying the South for, let's say, the maintenance of the tropical forests, not only because the South could not afford to do so otherwise, but also because payments such as these are nothing but the price for the fulfillment of the Norths own (ecological) interests. Therefore, such a transfer would conform to the rules of the market system.[26]

Global changes are the result of microeconomic decisions in an environmentally unregulated world. The same is true with respect to microeconomic reactions to emerging data changes. No specific policy measures are needed in the laisser-faire case. In contrast to this a strategy of sustainability depends on policy action. And, as we all know, there are manyfold vested interests directed against an intervention for sustainability. These interests, on the one hand, are caused by the above mentioned false macroeconomic perception that such an intervention would lead to overall economic problems. On the other hand, these interests are the expression of a general tendency of all actors to safeguard their current conditions, their market shares, their individual working places, their patterns of behaviour etc. In the laisser-faire case these interests are regarded as a sort of natural outcome of economic activity. They are not questioned but judged as

26 This economical and theoretical reason for the responsibility of the North does not, of course, free the South of its own responsibility to maintain its environmental resources.

the driving force of economic development. In general, "interventions" governed by private interests are praised but interventions of a policy in order to keep the world sustainable are debated, questioned and even judged as a source of economic distortion.

It is the task of ecological economists to make this discrimination of the common good evident. After more than two centuries of economic development dominated by private interests, it is high time to redirect the economy toward a sustainable future.[27]

27 cf. Herman E. Daly, John B. Cobb, Jr. (1989), For the Common Good. Redirecting the Economy toward Community, the Environment, and a Sustainable Future, Boston (Beacon Press)

V. Costs and Benefits of Global Change

1. An Optimum Level of Pollution?

When talking about different strategies for coping with global change it is self-evident costs and benefits are compared. The background of this procedure is the idea of an optimum. This approach is well established in economics and in our daily private decisions as well. How to spend a given amount of money in order to draw a maximum benefit out of it? In economics the whole problem is treated with the so-called marginal analysis. The condition for an optimal solution is fulfilled when the benefits of an additional monetary unit spent is equal across all kinds of expenditures. In other words: marginal benefits must be equal to marginal costs or prices. A given budget should therefore be restructured up to the point where this condition holds. This is the basic idea of any cost-benefit analysis.

The same method is applied with regard to global change. Take for example the carbon dioxide problem. All efforts to reduce CO_2 emissions and all damages of CO_2 can be expressed in an otherwise possible supply of other goods, say opportunity costs. It is evident that as the marginal emission reduction costs increase global stability will be higher, too. But, at the same time, the marginal emission damage costs will decrease. The same logic applies to the tendency to more global change. Marginal emission damage costs will increase and marginal emission reduction costs will decrease.

The economic conclusion of this simple deliberation is that an optimum for the degree of global stability or global change exists. It is defined as the identity of marginal damage costs and marginal emission reduction costs. This means that more global stability (left from the optimum) constitutes a waste of money and resources as well as less global stability (right from the optimum). From this point of view, the problem of cost-benefit analysis is only how to gather all relevant information about the two cost-curves. Therefore, the problem of information, of value assessments, of assumptions about risks and technological developments turn out to be the key problems of cost-benefit analysis.

2. Assuming Uncertainty Away

Cost-benefit analysis has proved to be a useful tool in many cases. It helped to clarify the often difficult structure of decision scenarios and to find optimal solutions. Even if we think of the fact that some arguments can not be transformed into monetary values, the results of cost-benefit analysis are assumed as an approximation. **But to assess the costs and benefits of a by-pass, a tunnel or a sewage purification plant is fundamentally different from cost-benefit analysis of global change.** In this case it may even be judged as a very misguiding tool to discover an optimal strategy.

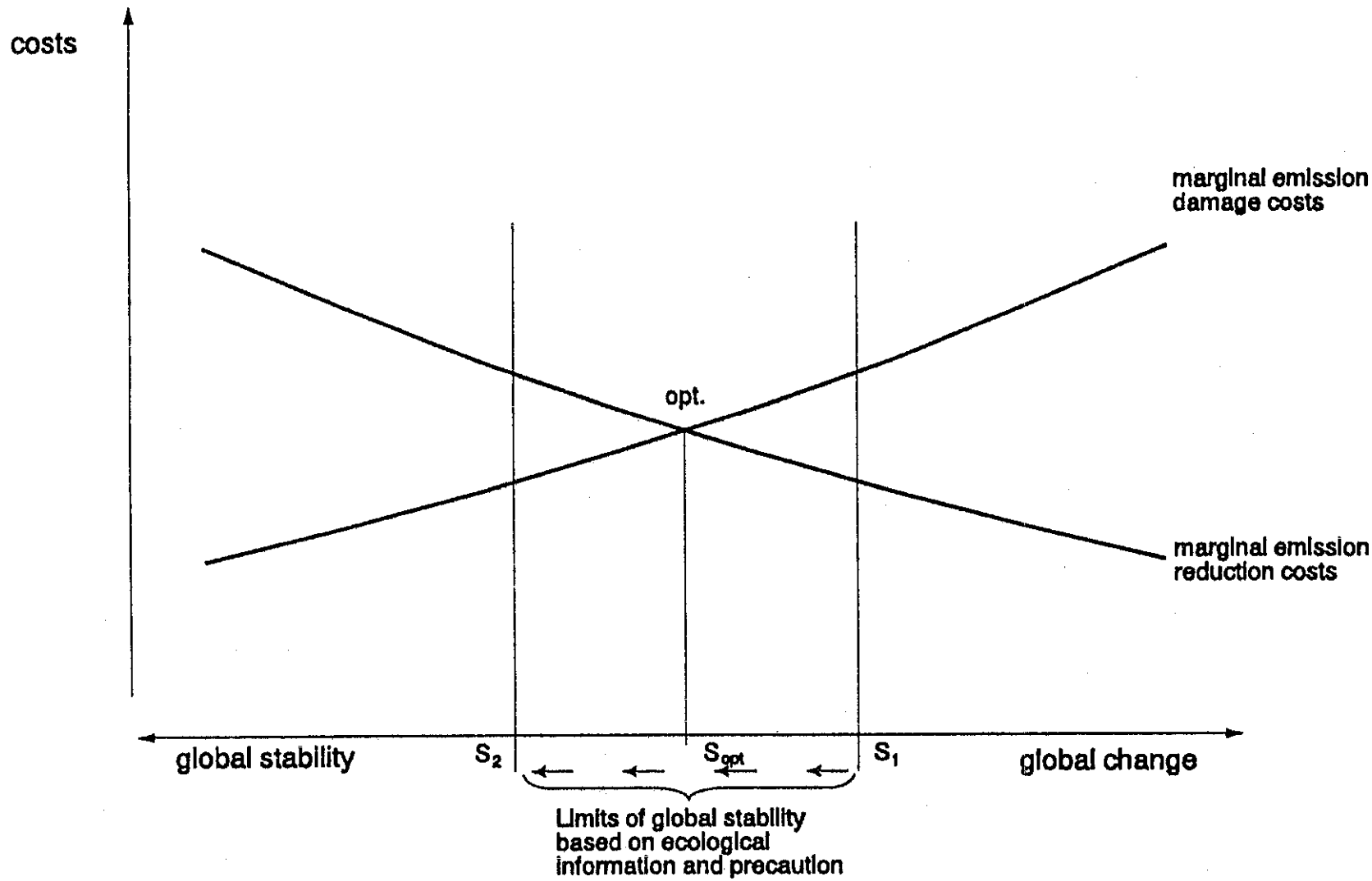
The most crucial element of global change is the **pervasive uncertainty** which forges all aspects of this problem. And uncertainty is a very uncomfortable situation for all scientists. Therefore, they try to transform it into certainty and knowledge. Scientists who stress the uncertainty of their findings or the limits of their knowledge are often regarded as wise people. But in the real world there is no demand for such wisdom. Let us think of Socrate who finally did not succeed in saying: "I know that I know nothing".

Economists as well as other scientists are more or less aware of the tragic end of Socrate. Therefore, Socrate became not a tarnished example. Whenever uncertainty can not be replaced by "solid" findings, it is banned to explicit and implicit sets of conditions and assumptions. This means simply assuming uncertainty away. In economics this fact is expressed by the use of the famous ceteris paribus formula, which states that all other conditions are assumed as constant. Therefore, all findings are only valuable in a well-defined artificial world. The same is true for the results of any cost-benefit analysis dealing with complex systems.

As carbon dioxide emissions are regarded as the major cause of global change they are the obvious choice as an example of the unavoidable limits of cost-benefit analysis. One of the scientific findings accepted today is the relation between the volume of CO_2 in the atmosphere and the change of the climate. Apart from this there is no consensus within the scientific community concerning the amount of CO_2 reduction which is required in order to prevent climate change. Reduction rates between 20% to 80 % in the next 20 years are debated. Furthermore, it is admitted that predictions of regional and continental climate changes are currently not possible. And also the ocean-

OPTIMAL GLOBAL CHANGE

FIGURE 5



coupled climate models are not able to predict regional changes of general weather situations, for instance, the frequency of storms. We have to keep in mind that this uncertainty is the starting point of cost-benefit assessments, and it marks at the same time their limitation.

The definite limits of cost-benefit analysis and of any economic argument are set out by the findings of natural sciences. If science states that a degree of global change S1 (in FIGURE 5) could be tolerated, then economic aspects are decisive. But if further findings show the need for more stability, for example up to point S2, any economic deliberations loose their relevance as long as that point of stability, S2, is not reached.[28]

Nevertheless, based on well-defined scenarios, cost-benefit analysis of climate change could at least serve for demonstration purposes, and it could give an idea about economic repercussions. But analysts should not presume to define optimal targets for a climate policy.

3. On the Wrong Message of Prices

During a first stage of assessments economists will use actual prices whenever this seems to be helpful. Market prices are taken as a sound basis for monetary evaluations. But what are the determinants of prices and to what extent could current prices be relevant for long term solutions?[29]

In 1920 Arthur Cecil Pigou's voluminous book on "Economics of Welfare" was published. In this book he stressed the fact that there is a difference between private and social costs. The production costs reflected in the prices of many goods do not include the so-called external costs which comprise, for instance, the damages caused by air pollution and noise. The realization and clarification of this problem was Pigou's important achievement; it marks the starting point of what we now call environmental or ecological economics.

28 This sort of limit was first outlined by David Pearce (1976), The Limits of Cost-Benefit Analysis as a Guide to Environmental Policy, in: Kyklos, Vol. 29, p. 97 - 112

29 For a critical view of economic valuation methods see e.g. John G.U. Adams (1990), Unsustainable Economics, in: International Environmental Affairs. A Journal for Research and Policy, Vol. 2, No.1, p.14 -21

This is to admit that **market prices in general are wrong from a more comprehensive economic point of view.** But many economists treat this fact as a rather technical question. Negligently, they disregard the fundamental character of the problem, namely that current market prices are on the whole the economic mirror of the ongoing global change. Current prices are not only the economic expression of unsustainability but pervasive signals to all economic actors, influencing their decisions. To take these prices as a basis for the assessment of social costs is misguiding. We should not believe it is possible to fundamentally change the direction of economic development if we draw the decisive criteria from the past.

Besides prices, technologies play an important role in cost-benefit analysis. Therefore we have to ask which factors determine, for example, the CO_2 reduction technology. Our currently available technology is the result of a development mainly spurred by private interests. From the outset technological solutions were dedicated to the improvement of the individual circumstances of life. This meant and still means not only the amelioration of working conditions or the improvement of the productivity of labour, but also includes the tools for the exploitation of natural gifts. Therefore, what we call the best available technology to reduce pollution is actually not more than a by-product of the historical evolution of technology.

If, for instance, in the end of the last century, a decision had to be made on the production of cars after careful cost-benefit analysis, alternatives like stage-coaches and related costs like blacksmiths' wages would have been taken into account. In 1991, however, these opportunity costs have long since become obsolete, for car-industry has undergone a breath-taking development which created its own dynamic. Today stage-coaches are at best nostalgic objects in a largely engine-powered economy, and the craft of blacksmiths has almost completely vanished. In the end, a new preference has ousted the old one which initially had set the standard. This example may elucidate the myopic and static bias inherent to cost-benefit analysis.

4. The Political Argument

The general conclusion of these deliberations is simple to understand. There is no way to find out firm criteria for political decisions. **To**

sum up actual costs and benefits is a very misguiding approach to identify optimal developments for the future. The same is true for the willingness-to-pay analysis which is applied to reveal preferences for public goods. We should acknowledge that our current preferences are the "incidental" result of manyfold historical circumstances and to a large degree simply acquired. Thus, regarding such approaches, the main problem is to overcome one idea prevailing in our minds: the idea that knowledge about the future can be based on past and present.

All these difficulties might be neglectable in the cost-benefit analyses of small projects, but can hardly be ignored with respect to global change. And still, inspite of the weakness or inadequacy of cost-benefit analysis there are many economists working on this subject. Especially, the problems of projections into the future and intergenerational equity have become an important research field for economists.[30] This is rather astonishing, since most of these experts are well aware of the scientific hazard involved. In discussions with these people outside academic plenary sessions, in a more informal environment, their arguments melt down to merely political ones. This line of arguments runs as follows:

30 The method of discounting was originally developed for microeconomic decisions on alternative long-term investments. It is like the cost-benefit analysis based on the assumption of other things being equal. This becomes evident in connection with the famous article by Harold Hotelling, The Economics of Exhaustible Resources, in: Journal of Political Economy, Vol. 39, 1931. Currently we have to observe a hopeful growing criticism of this approach in respect to environmental problems. See for instance David Pearce et al. (1989), Blueprint for a Green Economy, London, p. 138: "Note that what is being argued generally is that if we cannot substantiate the case for positive discounting, the presumption must be that a zero discount rate is, initially anyway, the more appropriate choice." Other authors are even claiming negative discount rates. See Friedhelm R. Drepper/ Bengt A. Mansson, On the Role of Unpredictability in Environmental Economics, paper given at the international conference on Economics of the Environment, Center for Economic Research, Tilburg University, Netherlands, September 1990.

To convince politicians, in order to trigger off firm political action, it is necessary to present hard figures. Only the transformation of environmental damages and risks into economic terms and figures can impress politicians as well as the man in the street. Any other, scientifically more justified approach will not be able to change the narrow-minded ideas of economic hard-liners. All talks about risks and uncertainties have proved to be useless compared to any questionable figure brought up to the political agenda. Therefore, some say, fooling the people would be the best strategy to bring about ecologically efficient political actions.[31]

But, of course, the argument that figures have to be presented because politicians want figures to be presented is not a scientific argument, but merely a matter of fact. This fact, moreover, was brought about by economists themselves, that is by their traditional emphasis on markets, prices and the measuring rod of money which has historically provoked the general tendency to express values in monetary terms. Therefore, values are often reduced to their monetary fraction, while value aspects which can not be expressed in monetary terms have been ignored. It is the task of economists to expose this bias. The demand of politicians for figures has to be treated as what it is, as a reflection of well-established economic methods. To defend these methods with their own effects on the political arena is nothing but a tautology.

31 The epilogue to a survey concerning external effects, written by Edward J. Mishan, runs as follows: "Many of the considerations brought forward in the last section do not, I recognize, lend themselves easily to analytic elegance. But with respect to environmental spillover - the most urgent economic problem of our fragile civilization - they are more pertinent than those arising from traditional allocative analysis. It is not, of course, hard to understand the somewhat exaggerated weight attached by economists to the allocative aspects of an economic problem as distinct, say, from those connected with equity. For the former aspects lend themselves nicely to formal theorizing and, with patience and a little finesse, impressive measures of social losses and gains can be foisted on credulous civil servants and a gullible public. Yet the priority given to allocative aspects in real economic problems cannot, I think, be justified; certainly not by recourse to welfare economics. The more 'affluent' a society becomes, the less important is allocative merit narrowly conceived. And in any society in the throes of accelerating technological change (one in which, of necessity, pertinent knowledge of the human, social, and ecological consequences of what we are doing is generally slight and partly erroneous) complacency on the part of any economist, guided in his professional decisions by considerations alone of allocative merit or economic growth potential, is both to be envied and deplored." (E. J. Mishan, The Postwar Literature on Externalities: An Interpretative Essay, in: The Journal of Economic Literature, 9/1971, p. 26)

VI. Economic Instruments

1. "Greening" the Red Tape?

Despite the deficiencies of centrally planned economies, which have just now become particularly evident, planned economy-type models are still applied in the context of environmental policy. There is a sort of two-tier system of regulation: The supply and demand for private goods is generally subject to the market system. Supplies of the public asset "environmental quality", however, are administered by law, regulation and administrative provisions, which frequently refer directly to each specific source of emission. This policy is not capable of pushing developments towards a sustainable management of resources. Indeed, instead it provokes widespread opposition to the transformation that is needed.

The command-and-control policy means to transpose directly administrative procedures into traditional environmental policy. In accordance with that policy, individually assigned emission standards, based on politically defined "best available technology", and subsequent directives determine the environmental policy landscape. The notion prevails that the use of the environment as a production factor, e.g. to accommodate for the disposal of certain harmful by-products, can be properly managed by a list of environmental regulations. But this is about as realistic as the concept of a planned economy. A purely regulatory management of resources leads only to a direct restriction of economic activities, and merely shifts the allocation of environmental resources to several economic actors. It does not positively adjust the economy to the fact that natural resources are limited, nor does it try to cope with this shortage by means of an imaginative, decentralized and dynamic search for new solutions.

The idea behind the command-and-control policy is that emissions should be avoided as far as technically possible. According to the advocates of that policy, it is simply not possible to limit emissions further. That, however, is not true. The "best available technology" is not the product of a research into what is technically possible. It is chosen according to micro-economic calculations and largely influenced by plant operators themselves. Economic and short-term political considerations have a considerable impact here: The operational costs

of limiting emissions have to be 'reasonable' in relation to the economic situation of the polluter, and are not seen from an overall perspective. In short: The best available abatement technology is the result of a bargaining process.

Usually, in environmental policy processes, the thus resulting "best technology" standards are the basis on which environmental quality targets are defined. As a result, the instrument to avoid emissions also determines its target, the emission reduction levels. This circular linking of objective and instrument guarantees from the outset that the objective will be achieved. Such a policy protects itself against implicit criticism. Objectives in such a system can fail to be met only if the predefined technology for emission abatement is not generally implemented. Criticism is thus limited to shortcomings in implementation.

It should be emphasized that the criticism of the command-and-control policy by environmental economists relates principally to its cost-efficiency. Since the marginal costs of emission reductions differ from case to case, they are not cost-efficient. Economically, to demand the same emission standards from all polluters means to demand comparatively excessive expenditure of some, whereas on the other hand potential emission abatement which are comparatively low in costs for others are not exploited.

But the most significant and fundamental criticism of command and control questions this policy's capability to develop the economic structure towards sustainability. Even where command and control cautiously tries to give incentives to such progress, it just concentrates on techniques added to the traditional production process. Only the producers of end-of-pipe technology have an economic interest in new appliances; because the demand for their technology will increase by policy measures. But a wide-ranging search for new technical solutions to the problem in its entirety, covering all activities from input factors to production and recycling, is not induced. However, such a type of incentive is vital if forms of sustainable resource management are to be found.

2. Obstacles

Given the complex nature of the ecological system on the one hand and of the market economy process on the other, it would be a mistake to look for an ideal instrument of environmental policy. **An effective**

range of environmental policy instruments will therefore always have to form a complex whole, and should at the same time be receptive for new approaches. In some cases, this might certainly include compulsory obligations or prohibitions. Standards, too, can be ecologically advantageous in form of temporary measures. Thus it should be considered with care that it depends on the case at hand which mix of instruments would be most adequate.

Over the past 10 or 15 years the debate on instruments for the protection of the environment has made no headway for the following four main reasons:

1) Inaccurate perception of the problems

The scale and nature of the ecological challenge were not understood or underestimated. In the early days of environmental policy the general view was that ecological problems could be regulated on the same basis as road traffic, i.e. by laying down rules of conduct and by setting technical standards. Consequently, environmental policy has been placed exclusively in the hands of administrators and technical experts who have so far been successful in maintaining their dominant position which, of course, favours command and control strategies.

2) Negligence of environmental economists

Economists have, from the outset, viewed the question of instruments too rigidly. Their starting point has been (and in many cases remains) the problem of how a particular environmental policy objective can be achieved most favourably in cost terms[32]. As a result of that and of the fact that the economists frequently placed limits on themselves by requiring that instruments should "conform with market principles", the discussion was narrowed down to models of dubious practical use, at least in the eyes of those to whom they were addressed, principally the administrators and practitians.

32 Thus, for example, the advantages of flexible instruments for US clean air policy are viewed exclusively in terms of cost savings. R. Hahn writes: "Because marketable permit approaches have been shown to have a demonstrable effect on cost savings without sacrificing environmental policy, this instrument can be expected to receive more widespread use. (R. Hahn, "Economic Prescriptions For Environmental Problems: How the Patient Followed the Doctor's Orders", in Journal of Economic Perspectives (1989), Vol 3, No 2, p. 112. Cf. also R. Hahn and G. Hester, "The Market for Bads" in Regulations (1987), No 3/4. Unfortunately the figures in dollars quoted there are not very conclusive because there is no reference to overall investment costs.

3) Static models

Above all, however, economists have yet failed to establish an environmental economic theory in analogy to the theory of economic development. It has not been sufficiently realized that environmental policy means to enforce a new preference against traditional structures and vested interests. This can only be achieved by ousting old structures rigorously from the market. Therefore, environmental politicians who heed the views and concerns of existing firms can not but fail in their task.

4) Good instruments; but little incentive

In recent years an ideological or party-political dispute about adequate instruments has erupted. The fact that "victory" for one side or the other does not in itself mean progress in environmental policy may well be lost out of sight. What really matters, after all, is that the appropriate environmental policy objectives pursued by appropriately strong incentives. A decision about the kind of instrument to be chosen in itself does not guarantee success. The best conceivable economic instrument is of no use if the incentive it offers is too weak and does not bring about the relevant decisions of the private sector. Therefore, whatever instrument is chosen (taxes, tradeable permits, refund systems, etc.) , its effectiveness depends on its economic stringency.

3. Administrative Perfectionism Versus Efficiency

The advocates of the inherited command-and-control policy hold that flexible economic instruments present considerable disadvantages. Their most significant objection probably can be subsumed under the heading "hot-spot problem", i.e. the concentration of various pollutants at one site. But this argument is not valid in all circumstances:

It is in practice impossible for economic instruments like taxes on inputs or emissions to produce the same results as a policy directed to each source of pollutants. If their impact did not differ there would be no need to argue about a choice of instruments for the protection of the environment. A policy of standards has evidently other structural effects with respect to emissions and inputs than a uniform rate of taxation. In certain cases, the substitution of individual standards by taxes might even cause a deterioration in the quality of the local envi-

ronment. Vice versa, a shift from economic instruments to a command-and-control policy would have comparable effects.

But if existing standards and emission regulations are substituted in problem areas by eco-taxes, local deteriorations can be avoided without any significant impairment of the dynamic efficiency of the new instrument. Seen from a dynamic point of view, the objections of those who favour command and control policies rapidly lose significance. The processes of adjustment render them obsolete because of the generell improvements triggered by economic incentives.

When considering the choice of instruments of environmental policy, it must be kept in mind that administrative regulation can not be effec-tive once the issue ceases to be one of administratively perfecting the implementation of familiar approaches but of discovering new solutions. In this respect, administrative regulations, which are largely static, can not provide an alternative to economic instruments. Nor is there any point in demanding the same perfection of detail from economic instruments as from the command and control policy. The tendency to perfectionate economic instruments appears to be one of the main obstacles to their use. As a result of such requirements, those instruments no longer provide the same impetus, but become complicated and involve excessive bureaucracy, so that, in the final analysis, they even appear subordinate to administrative regulations.

4. The Case of Carbon Dioxide

Current national and international discussions on the issue of CO_2 provide a good example for problems to cope with in ecological economics and illustrate some aspects already mentioned in this paper. Typical, for instance, is the way the problem itself is identified among natural scientists. At the outset, a great variety of findings and opinions about the influence of CO_2 on climate changes characterizes the issue. That uncertainty gives room for more or less personal proposals which depend on individual scientific backgrounds and risk aversions. Pre-scientific convictions compete with assumptions. **But, nevertheless, the least risky guideline for action seems to be the consistent reduction of CO_2-emissions from now on.** As a first working hypothesis this is sufficient. There is actually no need to decide **now** whether we should stop the adaptation process at 30 % or 60 % below current emission volumes.

– *No Impact on Growth Rates*

Such a working hypothesis conflicts with the idea of a "no regret" policy. "No regret" in this context means to go forward in short steps only which have to be well considered. The ultimate aim is to avoid paying too much in terms of growth rates and the supply of traditional goods. The main interest is to safeguard the conventional welfare pattern as long as possible. In an Orwellian sense, this notion of "no regret" policy is to be judged as a sort of "newspeak". From the ecological point of view, i.e. taking into account that climate change is irreversible, a "no regret" policy can only mean to bring down CO_2 emissions. **There are no signs that such a policy might be regretted by future generations, while a "no regret"policy as discussed today will most likely be.** And the price we have to pay now will not be regarded as a waste anyway.

Current discussions on the overall economic impacts of a cut-back in carbon dioxide emissions mainly stress three aspects:

First of all the estimated costs are simply presented in terms of world GNP (output). This is an appropriate way to illustrate a cost dimension which can hardly be comprehended when perceived in absolute terms and figures.

But besides this statistical relation there is secondly a tendency among economists to subtract these costs from the GNP. For example, if the costs are estimated to be at a range of 1% of GNP, it is argued that growth rates would be diminished by one percentage point. It has to be realized, however, that this purely mathematical operation implies important theoretical judgements. Indeed, it reveals the pervasive idea of a trade-off between economic growth and emission reductions. If this is simply a way of saying that resources used for emission reduction are not available for the production of other goods, this can not be questioned. However, the general interpretation of the term "trade-off" in this context seems to be a different one, and emphasizes more the impacts of diminished economic growth rates. But such an interpretation of the trade-off depends completely on the definition of GNP. If climate stability is regarded as a good and consistently as part of the GNP, expenditures for the reduction of CO_2 are included in the GNP concept and no impacts on growth rates could be identified. (This is shown by curve I in FIGURE 6)

Thirdly, it has to be noted that the term trade-off is indeed interpreted as a conflict with growth. And this leads straight to the conclusion that a stringent carbon dioxide policy can only mean "to plunge the world into depression"[33] This statement proves that economists actually believe in a such a kind of trade-off, although it only roots in their own definitions. Real economic problems can never be produced by a merely theoretical phenomenon, made up by conventional definitions of aggregates. In other words, the level of economic activity does not depend on semantic agreements between economists.

A short glance at a historic example may serve as illustration. If economists in the middle of the last century, for example, had build up a system of national accounts, and had listed up all final products which the GNP comprised. Obviously, GNP would not have included motor vehicles. Thus, the production of cars some decades later would have been regarded as having a disastrous impact on growth rates. Consistently, economists would have talked about the depressive effects of the production of the "non-good" automobile. Of course, this is a far-fetched example. But, still, the current reasoning on depressions caused by a stringent CO_2 policy is solely based on the same error.

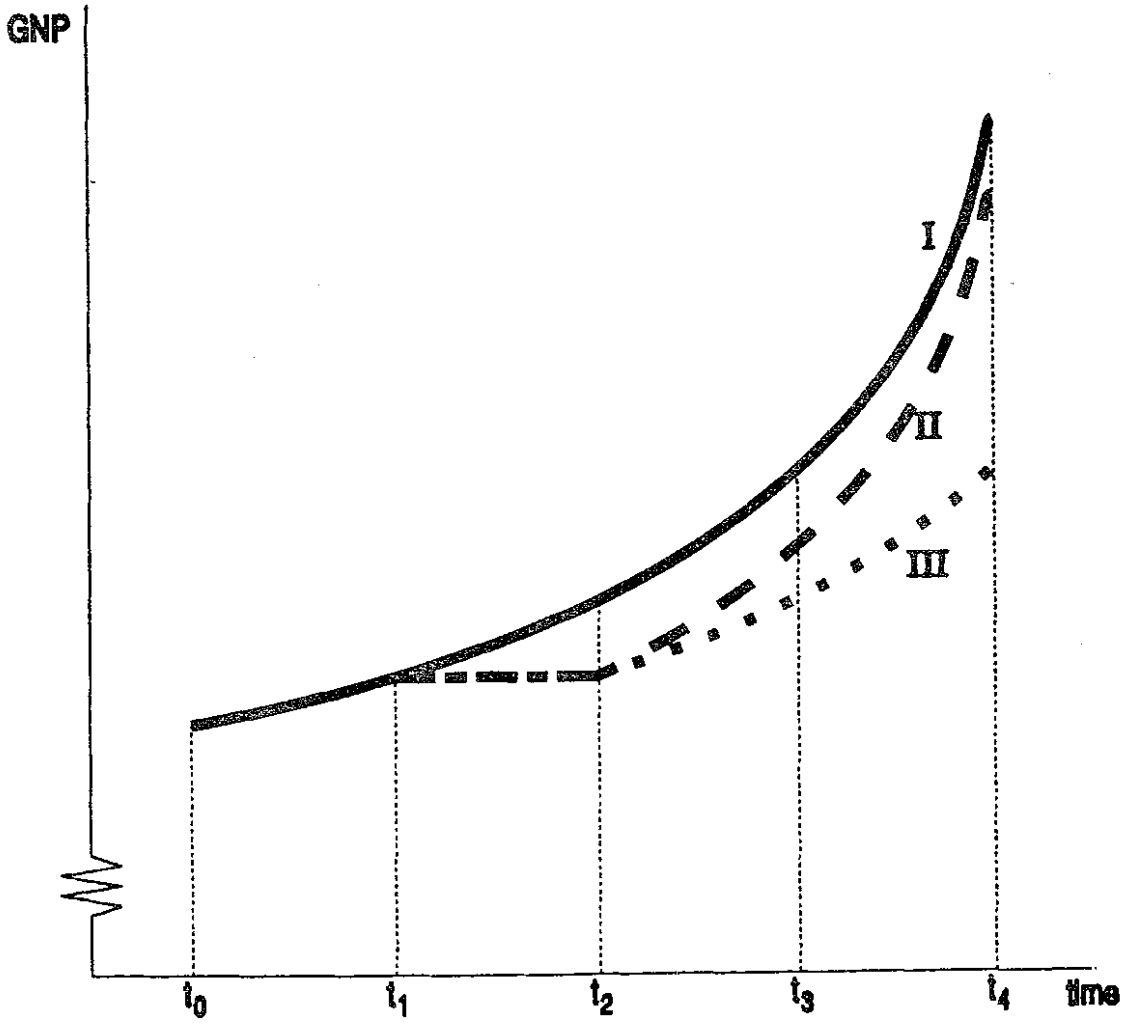
But even if the conventional understanding of GNP is accepted, the impacts of climate stability expenditures are not as grave as often expected. A permanent expenditure equivalent to an amount of, say, 2% of the current world output is nothing more than a postponement of the realization of income levels which would otherwise have been attained a certain period of time earlier. Hence, an effect is felt only during a first period, and only once. Apart from the initial shift down of the GNP, the growth rates remain the same (curve II in FIGURE 6). The idea that we have to face permanently lower growth rates turns out to be a mathematical error. Only permanently increasing expenditures have permanent negative impacts on conventionally measured growth rates. Curve III in FIGURE 6 shows an example for this.

Finally it has to be stressed that measured growth rates become only zero if annual increases of the overall production potential are wholly dedicated to the reduction of CO_2 emissions. But even then the result would be an economy which is stationary according to conventionally measured GNP, but not a world confronted with depression.

33 William D. Nordhaus, *Greenhouse Economics - Count before you leap, in: The Economist*, July 7 1990, p. 22.

FIGURE 6

Climate Stability Expenditures and GNP



I: GNP comprising Climate Stability
⚠ Measured GNP in the case of zero Climate Stability Expenditures

II: Conventionally measured GNP in the case of constant annual Climate Stability Expenditures

III: Conventionally measured GNP in the case of constant annual rates for Climate Stability Expenditures

– *Technological Reduction Potential*

The targets of environmental policy are often determined by existing technological solutions. The same approach is used in order to get an idea of the CO_2 reduction potential[34]. In the context of global warming the fallacy of such target finding is evident. The degree up to which CO_2 emissions are compatible with climate stability depends in no way on the technological potential we happen to know today. Technological arguments have to be looked at during a first stage of implementation, of course, but they can not determine our environmental targets. They are misguiding criteria when dealing with ecological goals.

Another aspect of this approach should be criticized. The technological orientation provokes a case by case policy, a policy looking at industries, sectors and even individual firms. But it is not the existing process of energy consumption which is to be reviewed. Instead, here again a strategy of defending conventional welfare patterns and behaviour can be observed; any CO_2 reduction strategy is accepted as long as these patterns are not endangered. But it is a socio-economic mistake to exclude unknown future adaptations of these patterns from the outset by a chosen policy.

– *Permanent Intervention*

A further misconception which is often neglected to be questioned roots in the idea that environmental policy is a temporary task. Many seem to consider the task as fulfilled when the "best available" energy efficient technology was implemented. This is the result of static thinking and ignores the pervasive dynamism of market economies and their permanent tendency to discover less expensive solutions. Therefore, if ecological restrictions or economic incentives are withdrawn from the economy it will gradually fall back into former patterns. Any decision on environmental policy instruments thus should keep in mind the **need for permanent "intervention"**. Viewed this way bureaucratic instruments must lead to widespread disastrous effects. This is particularly true regarding CO_2 emission reductions, because here such a policy is bound to intervene in all economic sectors.

34 German Bundestag, Enquete-Commission "Preventive Measures to Protect the Earth's Atmosphere", Studyprogramme and Third Report "Protecting the Earth", October 1990.

But the long term perspective should also be considered in the design of instruments like taxes, levies or tradeable permits. Here a problem arises because of the enormous revenues to be expected from efficient tax rates or permit prices imposed on fossil energy resources (depending on their carbon contents). In general, special (parafiscal) funds or temporary expenditure programmes funded by the additional revenues imply a permanent administrative intervention which does not only collect the revenues but also re-allocates the considerable sums, e.g. as individual subsidies. Even if the loss of parliamentary control over part of all tax revenues is neglected, such a system would impair the budgetary discipline and would lead to more bureaucracy. Additional permanent revenues arising from climate policy should rather be integrated in the normal budgets from the outset. By that a **change of the taxation structure could be envisaged according to fiscal principles, political goals and social concerns.**

– *Tradeable Permits*

The continuing international discussion on climate policy is likely to focus on quantitative national carbon dioxide emission targets. Such a national approach, however, leads to at least three problems:

First of all, great differences in the implementation of the national targets are to be expected. The application of various instruments - command and control measures, economic incentives, or subsidies for energy efficient investments - provokes manyfold distortions, not only on energy markets, but in international trade in general. National targets tend to favour protectionism.

Secondly, national targets limit from the outset globally efficient adjustment strategies. Existing (though mostly incalculable) reduction potentials can not be used in an economic manner. The dynamic search for globally efficient solutions is restricted to national markets, with the result that climate stability is achieved at higher costs as on open markets.

Thirdly, each national target has to be set within rather modest bounds, both concerning reduction volume and time scale. Past experience shows that the imponderables of business cycles, dynamic economic developments and technological progress prevent any reliable forecast of fossil energy consumption - so how should it be possible

keep to the agreed reduction levels even if a nation plans to, particularly if the effects of chosen instruments are not assessable?

These fundamental problems have lead to investigations into more flexible, international solutions, and to a discussion of a tradeable permit system which could eradicate some of the drawbacks of national targets: Member states of a climate convention would be allowed to trade their reduction commitments.[35]

However, such an arrangement may turn out rather inefficient. It operates on three different levels: In a first step, the global reduction target is divided into national targets. Secondly, nations act as intermediaries on a new "market", while on a third level the microeconomic adjustment processes take place which in the end account for the realization of emission reductions.

An alternative arrangement is conceivable to harness the tradeable permit concept for the international carbon dioxide problem. In analogy to the use of tradeable permits on a national level, the idea would be to set a global limit to the supply of fossil energy resources (this corresponds to a global CO_2-reduction target). Tradeable supply rights would then be issued for the agreed supply volumes; their price would be determined on an international market. As a result, all prices for fossil energy resources reflect the additionally implemented scarcity.

The main advantage of this approach is the circumvention of national complications: The global climate policy target is straigth passed on to the individual actors who are engaged in steps leading to emission reductions; national targets need neither be set nor controlled. Such an approach would thus help to achieve a political consensus, but, obviously, a number of important social, economic and practical problems had to be solved by a well-designed arrangement.[36].

35 cf. M. Grubb (1989), The Greenhouse Effect: Negotiating Targets, The Royal Institute of International Affairs, London.

36 The author of this paper has presented a concrete model for a "Carbon-Dioxide Policy by Tradeable Permits" to the German Ministry for Environment, published by the Umweltbundesamt, Kohlendioxid-Politik mit handelbaren Emissionsrechten, in: UBA-Texte 20/91, Berlin, 1991.
A further UBA-study by the same author, concerning the international dimension of carbon-dioxide policies, has just been finalized: "World Climate and World Market - Against the National Approach in the International Climate Debate".

VII. Research Priorities

Any list of wishes for further research and the corresponding search for funding is itself based on theories, speculations and even on prejudices. The following proposals evidently root in the experience of the author, i.e. almost twenty years of work in a federal administration, his theoretical background and his own work on environmental economics. Apart from this there are two general criteria for a consensus: Research should deal with clearly identified problems and with clearly identified obstacles, those which a sound and effective environmental policy is confronted with.

1. Liberation from Macroeconomic Constraints

High priority should be given to the question whether environmental policy has any impacts on macroeconomic goals such as full employment and the stability of the price level. The political relevance of this question is evident. It is sufficient to recall the arguments put forward in several international conferences concerning CO_2 reduction strategies last year.[37] The problem entails an important theoretical error of mainstream economics. Indepth studies, therefore, should question their theoretical background. But it must be emphasized that clarifica-

37 **IPCC, Policymakers Summary of WG5 III, June 1990**:"The information available to make sound policy analysis is inadequate because of (...) c) uncertainty with respect to the costs, effects on economic growth, and other economic and social implications of specific response options or groups of options." (S. 12)
Council of Economic Advisors, Annual Report to the President, Washington D.C. 1990:"There is no reason to believe that an attempt to reduce energy use significantly would be substantially less economically disruptive today (than in the oil-shock period 1973-1986, GMR)" (p. 214). And, p.215: "The impact of carbon dioxide stabilization policies can also be considered in terms of growth-rate impacts. A recent estimate based on energy output balance relationships suggests that global carbon dioxide stabilization could cut world economic growth in half, even after accounting for substitution toward cleaner energy."
Michael J. Boskin, Chairman, President's Council of Economic Advisors, Address to the White House Conference on Science and Economics Research related to Global Change, Washington D.C., April 17th 1990, p. 4:"Available studies suggest that it would cost at least 1 percent of annual US GNP, or perhaps several times that amount, to meet widely-discussed CO_2 reduction targets, and that economic growth could slow significantly."
Bergen Ministerial Declaration on Sustainable Development in the ECE Region, 16 May 1990, Chapter III, Pt. 14:"We assume a major responsibility (...) to recognize the need to stabilize, while ensuring stable development of the world ecomy".

tion can not be found by further empirical work or in more sophisticated econometric models. **The precondition of a way out of the dilemma is a profound discussion and the identification of the decisive mile stones in the history of economic analysis.** Therefore it is necessary to bring together macroeconomists, economists specialised in the history of economic thought, sociologists, experts of national accounting systems and environmental economists.

With due respect to the high importance of the problem a three steps procedure is proposed:

1) Organisation of a one week seminar held, for example, in a lonesome Scottish castle with very bad traffic conditions. The number of participants should be limited to about 30 well selected scientists representing mainstream as well as divergent points of view and approaches. The result of this seminar should be published and at the same time serve as a background paper for an international conference to be held one year later.
2) This international conference should bring together about 300 scientists from all continents. Well before this conference each participant should hand in a paper closely related to the outstanding problem. The publication of a conference document should be envisaged.
3) As a third step a discussion with politicians and administrators should be organized. Participants from the political side should be representatives of organisations like the OECD, IEA, IMF, World Bank, EC, GATT, UNEP etc. This conference should encourage a direct transfer of research findings to the political decision process.

The result of such a procedure would at least be a critical review of the prevailing idea that the price for maintaining our future might be an economic slowdown, employment problems and inflationary tendencies. But, as likely, the result could be a definite liberation of environmental policy from superimposed false restrictions. Thus these three steps could push forward the discussion of global change from an artificial economic discourse to real questions.

2. Lessons from the Past to Cope with the Future

The second important issue in environmental economics concerns economic development. From the beginning of economics this has been a rather neglected phenomenon. This can first of all be explained by the fact that economic development became an important factor only in the middle of the last century, when the industrial revolution spread. Secondly, it has to be admitted that economic development is too complex to be expressed in models, too complex also to be observed in order to draw conclusions about inherent mechanisms. Thus it is methodologically understandable that economists started with research on the less complicated "stationary economy". The classical model is a static one where preferences and technologies do not change. This fundamental abstraction from the real world was well adapted to the dominant scientific interest which mainly focused on ways to achieve an optimal allocation of resources in the market system. Only Marx and later on Schumpeter have, besides some other less known economists, tried to discover the driving forces behind economic development.

This deficit in economics was not grave. Development occurred independently from our theories. Any special political action was not needed. Economic development or growth was considered as being the natural outcome of individual interests and some general conditions in favour of these interests. **But now, in view of global change and global threats emerging from unfettered markets, economic development should become a central issue.** As we want to change the economic development towards sustainability, we must have a better insight into development processes. Yet, although this is a rather evident precondition, this issue cannot be found in the topical litera- ture.

In order to demonstrate the political relevance of a theory of economic development it might be useful to give some brief remarks on an essential part of Schumpeter's theory published in 1911.[38] In order to explain how and why an economy turns from a stationary state to development, Schumpeter has identified the so-called dynamic entrepreneur. Endowed with fresh money he has the purchasing power to attract production factors from other firms and to realize new combina-

38 Joseph A. Schumpeter (1934, 1st German ed. 1911), The Theory of Economic Development, Harvard University Press, Cambridge, Mass.

tions, such as new products, new forms of production and so on. Thus he enforces a process of "creative destruction", leading to higher levels of material wealth. Why is this explanation so important to environmental policy?

First of all, we may learn that in this theory consumers play only a reactive role. Schumpeter has even written about the fact that consumers are conditioned by the entrepreneurs. This signifies that environmentalists should not count too much on the effects of an awareness of ecological problems or of ecological education, for example. In the process towards sustainability, consumers' behaviour does not play a decisive role.

Secondly, we realize that these entrepreneurs act regardless of existing market shares, of individual jobs and of existing structures in general. Because they intervene in this way in the market process, they make the capitalist machine work towards new frontiers. Comparing this driving force behind economic development with the way environmental policy is conducted, it is quite evident that policy has no chance to change the direction of this development. Therefore, to be successful, environmental policy must learn from Schumpeter and act like a dynamic entrepreneur, i.e. without consideration for the economic interests of other actors, in order to trigger off a process of creative destruction concerning unsustainable economic structures.

Thirdly, learning from Schumpeter means also to improve our understanding of the fact that environmental policy is in no respect a transitional task but an endless one. Sustainability cannot be described like a new stationary state. It is an infinite process of trial and error in order to discover ever new forms of living and new welfare patterns.

The problem raised in the last paragraph can hardly be expressed in a single question. It is a sketchy idea of a whole research programme under the heading of economic development. At the beginning of such a programme it seems essential to start from scratch, i.e. first of all to confront economics with the idea of such a programme itself. After the realization of its general validity and necessity, it is possible to start with more detailed research. For some examples see the following list of projects:

—What can we learn of Schumpeter's theory of economic development for our conception of a theory of sustainable development?
—What are the interactions between macro- and microeconomics in the light of a theory of development?
—Where do the theoretical roots of those vested interests which are directed against a strategy of sustainability lie?

Additionally to these more theoretical studies, mainly intended to overcome the misguiding fascination of static economics there is a need for historical case studies in order to make us aware of the powerful driving forces behind economic and social development in the past:

—Case studies on the historical change of consumer preferences
—Case studies on the enforcement of public goods in the past (e.g. social insurances) and identification of obstacles and historical conditions
—Case studies on the adjustment capacities of a market economy (selected historical periods and data changes)
—Case studies on the economic and social conditions setting the course for fundamental technological changes in the past.

All in all, what is proposed here is patch-work aimed at giving a better picture of how evolution occurs in the socio-economic system. This research is based on the assumption that the understanding of developments in the past is essential to manage the future.

3. "Spaceship Earth-Approach"

Based on a sound view of economic and social developments a third area of research should focus on the common good environment and the common interest for global stability. Three main issues can be identified:

– *How to Manage the Free Rider Problem?*

Here research should focus on the common responsibility. The leading idea should be that, world-wide, more or less unfettered markets are pitilessly exploiting and destroying the natural conditions of life. Studies should contribute positively to a growing awareness of the need for supranational actions dealing with the problem of the limited capacity of this planet. The ecological, economic and social consequences of attempts to pursue a free rider position, i.e. an attitude of waiting for the action of others, should be exposed.

– *Environmental Aims and Economics*

Here **the leading idea should be that economics is a neutral analytical tool and thus not able to replace political value judgments.** Preferences of the world community must derive from thoughts and assessments outside the world of market values - a simple insight which should be emphasized. In fact, this means first of all to define the limits of cost-benefit analysis, any kind of willingness-to-pay approaches and methods of discounting the future. Finally, such studies could disentangle the prevailing mismatch in ecological economics between aims and instruments.

Furthermore, theoretical studies should be initiated in order to distinguish more carefully between the environment as a production factor and environment as a good. The result might be the insight that allocation theory is not the adequate tool to deal with preference changes regarding environmental quality.

Another very important point is the losers and winners approach. Studies should be carried out, not to identify the distribution of pure economic advantages and disadvantages, but to show the limits and pitfalls of this approach.

– *Creation of an Institutional Framework*

The establishment of a new "soft ware" of ecological economics is an important precondition. But at the same time the "hard ware" should be developed, i.e. the institutional arrangement. An information system to collect systematically all research findings and projects should be created. Furthermore, there is an urgent need for independent power-

ful institutions to cope with ecological economics on a scientific as well as on a political level. The competence of such an organisation could include the verification of international agreements. With regard to possible sanction facilities, one may also think of an international court for global change problems or the International Court of Justice. A first step could be a directory of relevant international institutions and their evaluation.

4. Institute for Advanced Speculative Knowledge (I-ASK)

Normally, what is called progress is the result of individual short term steps in reaction to current problems. We generally disregard long term consequences. This holds for individuals as well as for institutions like governments and administrations. This attitude might be compared with driving a car at a 100 kilometers per hour with a visual range of ten meters. But only for the last two decades there has been growing awareness of this myopia. An answer to this problem was the technology assessment analysis.

Since then many other attempts have been made to get an idea of the consequences of our decisions. One of those attempts has been the establishment of a "Congressional Clearing House on the Future" in 1976 by members of the US Congress. Another example is the Environmental Impact Assessment. Nevertheless, many examples demonstrate that the scientific community as well as political administrative systems do not have the capacities to cope, for instance, with "creeping catastrophes".[39]

Conventional approaches and methods are based on "normal sciences". They are thus limited in many respects and for the most part do not challenge their own methods and paradigms. In addition to these assessments and to the need for their implementation in the political decision process it seems, therefore, important to establish an institution which acts as a scientific conscience.

39 Carl Böhret (1990), Folgen. Entwurf für eine aktive Politik gegen schleichende Katastrophen (Consequences. Design for a Active Policy against Creeping Catastrophes), Opladen (Leske + Budrich)
Some of the main reasons for this deficiency are mentioned in Chapters I and II of this paper.

Such an institute for "Advanced Speculative Knowledge" should take over the role of a countervailing scientific power. Its task might be described by the following sketch:

—Identification of the quality of assumptions and "knowledge", especially of those relevant in global change assessments. In contrast to normal science the institute should try to falsify scientific findings and put an emphasis on risks and on the dependancy of findings on assumptions.

—Systematic search for "sleeping knowledge" as well as for scientific speculations outside the mainstream. Findings regarded as valuable should be put on the agenda of normal scientific research programmes.

—Application of methods to identify creeping catastrophes.

As a final remark, the interdependence of all four proposed research fields has to be stressed. They are - like all such proposals - based on more or less sketchy ideas about current and future problems, about the functioning of market and administrative systems as well as on processes of scientific discovery. In short, they are related to a pre-scientific picture of the future and insofar a research programme in itself.

Conclusion

The intention of this study was to give a critical view about current research, and its underlying assumptions in this new branch of science. Stress was laid on the unavoidable limitations of all knowledge concerning the eco-system as well as the economic system. Therefore, the aim of research should be primarily the prevention of any strategies in "global change policy" which are based on a kind of scientific superstition. The leading criteria for a sound and efficient strategy should be the insight that we do not, and will never, know enough about our ecological and economic environment. Thus, all our activities will have consequences we can not "predict". It is this perception of the world that scientists should first of all point out. The simple assertion of knowledge jeopardizes the global stability by assuming away this overwhelming uncertainty.

The paradigm of ecological economics lies in the idea of an interrelation between the natural system and the economy. This is true in the sense that both systems actually do influence each other. But it is wrong to conclude from this that there exists an optimal level of interventions into the natural system which could be identified by ecological economics. The eco-system earth depends in no respect on current prices, current economic preferences and currently available technologies. Therefore, conditions for global stability have to be regarded as existing beyond our economic world.

The prevailing claim for a reconciliation of ecology with economy envisages a kind of compromise. But such a compromise is the result of a superficial reflection of the problem. A reconciliation can only happen in our imagination. In reality, we must accept the fact that it is our proper and original interest to adjust the artefact of society to the natural limitations of the earth. There is no hope for a compromise with nature to alleviate these adjustment efforts.

The main task of ecological economics is to demonstrate how the society and its economic activities can be transformed to become sustainable. The research priorities suggested in this study investigate the most important preconditions required to trigger off a successful dynamic process towards sustainability - that is the removal of the obstacles to such a process, obstacles built up by the traditional thinking in market economics mainly.

Annex

Examination of a Conflict

Revised version of a Paper given at the International Conference "Economic Aspects of Environmental Creation and Protection", Kromeriz, CSFR, 26 - 28th March 1991, and at the Meeting of the International Group of Funding Agencies, Brighton, UK, 1st - 3rd May 1991

Abstract

This paper intends to give an interpretation of the term environmental problem. The starting point of which is to distinguish between the natural system on the one side and the socio-economic system on the other (I.1). This more introductory aspect will lead us to the question if there is actually a conflict between economy and ecology (I.2). This is to explicitly challenge a ubiquitous and rarely questioned argument.

In the second part I'll briefly discuss five possible explanations of the conflict hypothesis: Budget restrictions necessitate a choice between goods - whether they are private or public (II.1). The allegation of an antagonism between mankind and nature is regardless of the fact that the subsistence of human beings depends wholly on intact natural structures (II.2). The belief in deregulation has gone so far as to discredit political interventions even in fields where they are vital (II.3). Particular economic interests convey a sceptical attitude to environmental policy (II.4). Last but not least, national accounting systems operate on a basis regardless of the value of environmental goods annually produced in an economy (II.5.).

My thesis will be that none of these arguments can substantiate the idea of a conflict between economy and ecology.

I.1 The Environmental Problem

When talking about environmental policy we have in mind an idea about the nature of environmental problems. This idea is forged by two kinds of information. First of all there is the conventional way of becoming aware of a problem: namely by our five senses. This kind of information is less important today. Now the perception of environmental problems is mainly based on second-hand information circulated by media like newspapers and television programmes. The source of

these pieces of information are results of research - intended or incidental results. Therefore, what we identify as an environmental problem is a patchwork of direct experiences and second-hand information.

This approach has its merits. But nevertheless, an important aspect of the problem escapes. I call it the macro-view. Instead of forming a patchwork out of the manyfold case by case information we should complement our perception by focussing on a system approach. We are familiar with the idea that the planet and all people living on it are regarded as one system, the spaceship earth. But to make clear what is meant by the term environmental problem it seems useful to distinguish two sub-systems: the natural system and the socio-economic system.

This distinction leads directly to questions concerning the interface of the two systems and the interactions between them. On a very abstract level we may identify interventions of the socio-economic system into the natural system. And at the same time we may find social behaviour (e.g. environmental policy) motivated by the natural system.

Now, if the natural system had an unlimited capacity of assimilation there would be no need for environmental policy. And if the socio-economic system had a perfect adjustment capacity we could and would stop all interventions in nature without thinking about any repercussions. But neither of these hypotheses is regarded as reflecting reality. Actually we think that neither of the two systems is perfectly flexible. That's why we are talking of a problem. It boils down to the question how many interventions each system can sustain.

Obviously, this question is highly scientific or even philosophical. What do we really know about the conditions essential for the two systems we are living in and living from? All in all I think we must admit that we have only a very limited knowledge, in fact we have only preliminary knowledge, only hypotheses. This in mind, how can we decide upon the volume of interventions in each system?

I think there are two decisive criteria. First of all, compared with the time perspective of the socio-economic system the natural system must be regarded as non adjustable. It has to be accepted as it is. There is no room for compromises with nature. Secondly, we have to face the fact that many interventions in nature trigger off destabilising processes which are irreversible. If we take these two criteria for serio-

us and don't foolish ourselves by taking our knowledge for sure and comprehensive, there is only one strategy to be claimed by sciences, the strategy of a minimization of interventions in the natural system. All other strategies are, strictly speaking, based on mere presumptions.

As we know, current environmental policy is far from being guided by this result of our deliberations. In fact it is rather guided by the assumption that the best available technology to avoid interventions is just in accordance with what the natural system can sustain. It is guided by the assumption that current knowledge is sufficient to set up threshold values defining the volume of harmless interventions in the natural system. Furthermore, environmental policy assumes that there is a connection between current market prices and individual preferences on the one side and the carrying capacity of the natural system evolved in millions of years on the other.

I.2 The Conflict Paradigm

In addition to all these more or less absurd assumptions current environmental policy is influenced by the idea of a conflict with the economy. In fact the whole discussion about environmental policy is from the outset haunted by the conflict hypothesis. **This hypothesis is the brake-shoe on our way to sustainability**.

At the core of that conflict lies the assertion that environmental policy does have macroeconomic impacts. The usual way to qualify and quantify these impacts is to pursue the traces of environmental expenditures within our national accounting systems or within models built upon the same aggregates. This approach is the state of the art. An awful lot of researchers all over the world is engaged in empirical work in order to quantify impacts of environmental policy on aggregates like growth, income, productivity, price levels and especially on employment.

Rather than to discuss the outcome of these studies I'd like to draw your attention to the underlying assumption of this approach, namely that there **is** a problem and that there **must** be impacts. This should be quite evident, because if we did not see any relationship between environmental policy and the performance of an economy we would not try to quantify any impacts.

But why do we believe that environmental policy has an influence on macroeconomic goals at all? Who has done this important analysis

which proves that there **is** a conflict between economy and ecology? Where is this study published?

The answer is disappointing. Such a study does not exist. This means that environmental economics simply proceeds on an assumption which has never been discussed. Therefore, I think, it is high time to raise the question as to how the prevailing conflict hypothesis can be justified.

Let us have a look on possible interpretations which each might be regarded as a source of the conflict hypothesis. As far as I see we should distinguish at least 5 different lines of argument.

II.1 Budget Restrictions and the Problem of Choice

A first interpretation of the conflict hypothesis could be based on the simple fact that we are living in a world of scarcity. We have limited resources on the one side and a rather unlimited demand for goods and services on the other. Under such a condition it is evident that the more we spend on one good the less we can afford of at least one other.

On an individual level we are all familiar with this sort of restriction. We have a lot of wishes but only a limited income. Therefore we are bound to decide how to spend it. Normally we manage this situation without thinking too much about it. Only when there occurs a cut back of our income or when new preferences come to the fore we become aware of the fact that a choice has to be made.

Environmental quality is such a new preference. And as it can not be achieved without costs we have to pay for it. However, we can not pay for a unit of environmental quality as we pay for a pair of shoes. For a better environment we have to pay by higher prices of private goods or by higher direct taxes. But the way how we pay for a better environment can not disguise the fact that, in real terms, we always have to pay by renouncing other goods.

This also applies to the economy as a whole. The only price we have to pay for a better environment consists of the goods which could otherwise be produced. But can this be a sufficient reason for environmental economics to assume a fundamental and pervasive conflict between economy and ecology?

If the simple dilemma to choose between two goods is called a conflict, why do we not talk about conflicts between, say, economy and

better education, between economy and higher social security or between economy and national defense? To put it more generally, why do we not talk about a conflict between economy and public goods? In all these cases we are confronted with the same budget restriction and the problem of choice.

Therefore, it is hard to understand why of all public goods it is only environmental quality which is discriminated by the assertion of a conflict. Obviously there must be a different explanation for the assumption that a conflict exists only in the case of environmental policy.

II.2 The Misguiding Antagonism of Mankind versus Nature

A second interpretation of the conflict hypothesis may be based on the idea of a fundamental antagonism between nature and mankind. In this context, any economic activity is seen as an expression of an everlasting human struggle against limitations set by nature. The improvement of material wealth -increasing the supply of private goods- is considered to be the only object of economic activity.

In our market system the responsibility to achieve this objective is assigned to individual actors. Environmental policy, however, seems to prevent the achievement of this objective, it seems to be a direct threat to economic growth. But this interpretation is based on a profound fallacy in our definition of growth and wealth.

The whole perception changes when we become conscious again of the fact that mankind was from the outset interested in guaranteeing the basic needs of life; economic activities were initiated because of the will to survive. But, in the course of economic progress, this fundamental economic aim lost importance. It got out of sight. What we today identify with the term "economy" relates to a highly sophisticated set of products and services and an increase of wealth, effectuated by the market system, which is far from being essential for physical survival.

This sort of progress was so fast and comprehensive that on this planet we are now again confronted with the problem to secure the elementary conditions of life. This time, however, the economic task can not be fulfilled by individual action on markets, simply because the problem does not lie in a scarcity of private goods: The very public or common good "environment" is endangered. That is why sustainability

can only be assigned to the political administrative system whereas private goods are assigned to the market system.

But this policy assignment of objectives can not create a conflict with the economy. The conservation of the life supporting system remains an economic end -regardless of who is in charge and by which instruments the task is fulfilled. Otherwise we would have to assume a conflict between our own economic priorities. And this simply means to assume confusion. So let us turn to a third possible explanation.

II.3 Preferences Incompatible with the Market System?

At the time when environmental policy was put on the political agenda, market economies happened to be in a rather bad condition for the first time since the second world war. The dream of ever lasting prosperity and high growth rates had turned into a mood of scepticism and fears. Furthermore, publications like "The Limits to Growth" by the Club of Rome and the two oil-price crises contributed to that change of perception. Stark facts like recession, unemployment and inflation marked the economic situation. And above all, the traditional economic theories and instruments of economic policy obviously failed to improve the overall economic activity.

Economists suspected regulations of markets and interventions into markets to be the reason for the economic calamaties. The prevailing idea was and still is that the precondition of functioning market economies would be a small public sector and as little administrative regulations as possible. And since environmental policy is unavoidably based on direct and indirect interventions in the private sector it seemed only logical to construct a conflict between environmental policy and the market system. Environmental policy was identified as a source to economic problems. In other words: the maintainance of the natural conditions of life seemed to be incompatible with a market based economy.

This conflict hypothesis is absurd. Most astonishingly, the same fighters for laisser-faire who praise the market economy to be the best economic system to realize individual preferences have established an obstacle to the preferences for environmental quality.

They neglected that the supply of public goods, too, is based on individual preferences. This blindness, however, - I must stress - is not the result of these economists' individual value judgements, ideologi-

cal interests and prejudices. It is the result of the narrow focus on markets and private goods. In other words, it is simply the outcome of a sort of "déformation professionelle" which has become ideological.

The approach of these economists gives the market system a superiority to individual preferences. That which emerged as nothing but an institution for the realization of individual economic decisions becomes an end in itself and supersedes the aims which it originally was meant to achieve. In doing so, these economists even discriminate the market system since their approach leads to the conclusion that we have to decide between a functioning market system and the conservation of our life-supporting environment. Since this does not allow us a real choice we would have to abolish market economies in order to survive. But this confusing dilemma is only due to a superficial reflection.

What we need to understand is the plain fact that the market system is an instrument to our preferences and that instruments can not be given higher priority than human preferences. Our fourth interpretation deals with

II.4 Vested Interests and Structural Change

One further root of the conflict hypothesis might be found in the microeconomic perception of environmental policy. The argument runs as follows: Effective environmental policy measures change in various ways the conditions of economic activities. Economic actors are forced, by command and control measures as well as by economic incentives, to rearrange production processes, to diminish the input of natural resources, to adjust technical facilities, to modify products and to invest in end of pipe-technologies. These changes altogether will at the same time change relative prices and market shares and will redistribute profits among economic actors.

It is not surprising that all economic actors forced to change their business-as-usual behaviour are in a sort of natural opposition to environmental policy. They prefer unchanged economic conditions and dislike any adjustments. This conflict between the vested interests of polluters and the targets of environmental policy can not be denied. The question, therefore, is whether there are any special aspects involved which distinguish these adjustments from other adjustments in the normal course of structural changes in the economy.

According to Schumpeter, economic development can be described as a process triggered by dynamic entrepreneurs in an act of creative destruction. This is the way how a stationary economy turns into a developing one.

Important for our problem here is the fact that the economic conditions are changed by the actors themselves. It is them who cast off the business-as-usual behaviour and, under a regime of competition, make production processes obsolete, change the structure of supply, change market shares, destroy individual jobs and create new ones. They even create new preferences for new private goods. All these activities are well praised as the source of growth, progress and innovation. In this context nobody would talk of a conflict.

Seen from a purely economic standpoint there is a complete analogy between the activities of dynamic entrepreneurs and environmental policy. It also does nothing but to trigger off structural changes. There are only two differences.

First of all, the driving force behind the dynamic entrepreneur are private profits. The driving force behind environmental policy is the insight that unfettered profit-seeking is forced to exploit nature rigorously and to destroy the essential conditions for mankind to survive on this planet.

Secondly, many individual actors independent from each other are engaged in economic development. Environmental policy, however, is conducted by a monopolistic agent.

Obviously, these two differences can be very important in some cases and some contexts. But they can not constitute the conflict we look at, because they can not explain why one kind of structural change is considered as beneficial and the other as detrimental to the economy.

Instead of putting forward a superficial conflict thesis, environmental economist should learn from Schumpeter. They should push ahead the idea that environmental politicians are the dynamic entrepreneurs for the common good environment. Interventions into the market system from their part are in better accordance with individual preferences than the interventions of private entrepreneurs.

II.5 The National Accounting Pitfall

The last possible explanation for the construction of a conflict between environmental policy and economy leads us directly into the center of the confusion prevailing among modern economists, i.e. the national accounting systems. Here we are faced with the hard core of empirical evidence.

Overwhelming evidence seems to prove without chance of refutation that environmental policy has a disastrous impact on the economy as a whole. Empirical studies show that environmental policy diminishes growth rates, leads to drops in productivity rates and is a source of inflation. Starting from these statistical facts it seems consistent to conclude that environmental policy jeopardizes employment and international competitiveness.

To refute this assessment we must discuss the definition of income which is used in national accounting systems. This notion is a subject of controversy in economics since the days of Adam Smith. He and other classical economists defined income as the net revenue which people can spend without encroaching upon their capital. Income was defined and therefore calculated like the profit of a firm, i.e. total turnover minus all costs such as wages and depreciations. According to this definition only such activities were regarded as productive which contribute to the "net income" respectively the production potential, to use a modern term.

These definitions were well adjusted to the main scientific interest of classical economists, namely the "wealth of nations" as a function of market activities. But even during Smith's lifetime, Italian economists used other definitions. They declared all labor which results in the production of useful and desired things to be productive, without insisting that these things take on material form; and they identified national income as the value of the annual production of all such comprehensively conceived useful and desired things.

The problem of how to define income was still not solved when economists started to construct national accounting systems. Statisticians, therefore, set up an empirical rule. They distinguished between final products and intermediate products. If a product is sold by one business to another for resale, and if its cost is incorporated in the price of the final product, it is called an intermediate product.

As we know, environmental quality is a public good and, therefore, not available for sale. The costs for the production of environmental quality or -seen from another point of view- for the conservation of the environment are incorporated in the prices for conventional goods -at least in many cases and in complete accordance with the polluter pays principle. This simple fact has far reaching consequences under the empirical rule set out in the national accounting systems: The production of environmental quality does not contribute to the measured income and growth, but it absorbs resources which are not available for the production of any other goods. In other words, global stability is not regarded as a useful and desired thing.

Thus, an empirical rule of statisticians can be identified as a source of the conflict. If we become aware of this rule and the fallacies this definition provokes, we have to admit that there is no sign of a conflict left at all. Empirical evidence, so much stressed in economics, proves to be an evidently misguiding criterion. To overcome definitely the confusion about a trade-off between the economy and environmental policy is just now the most important task of environmental economists.

We are at the end of a fruitless search for a conflict which ramify into every corner of our minds. Thus, to reconcile economy and environment there is no need for theoretical and empirical studies and no need to talk about it in ceremonial speeches. The reconciliation starts and ends in our theories. This once conceived the very task is to change the structure of our economies in order to discover sustainable ways of economic activity.

List of References

John G.U. Adams (1990), Unsustainable Economics, in: International Environmental Affairs. A Journal for Research and Policy, Vol. 2, No.1

E. Arrhenius/ T. Waltz (1989), The Greenhouse Effect: Implications for Economic Development, World Bank Paper

Svante Arrhenius (1896), Über den Einfluß des atmosphärischen Kohlesäuregehalts auf die Temperatur der Erdoberfläche (On the Influence of Carbon Dioxide in the Atmosphere on the Temperature of the Earth), Stockholm (Royal Swedish Science Academy)

Carl Böhret (1990), Folgen. Entwurf für eine aktive Politik gegen schleichende Katastrophen (Consequences. Design for an Active Policy against Creeping Catastrophes), Opladen (Leske + Budrich)

Michael J. Boskin, Chairman, President's Council of Economic Advisors, Address to the White House Conference on Science and Economics Research related to Global Change, Washington D.C., April 17th 1990

Brundtland Report (1987), Our Common Future, Oxford/New York

John B. Cobb Jr., Herman E. Daly (1989), For the Common Good. Redirecting the Economy toward Community, the Environment, and a Sustainable Future, Boston (Beacon Press)

Council of Economic Advisors, Annual Report to the President, Washington 1990

Deutscher Bundestag, Enquete-Commission "Preventive Measures to Protect the Earth's Atmosphere", study-programme and Third Report "Protecting the Earth", October 1990.

Friedhelm R. Drepper/Bengt A. Mansson, On the Role of Unpredictability in Environmental Economics, paper given at the International Conference on Economics of the Environment, Center for Economic Research, Tilburg University, Netherlands, September 1990

Heiner Flassbeck /Gerhard Maier-Rigaud (1982), Umwelt und Wirtschaft. Zur Diskriminierung des Umweltschutzes in der ökonomischen Analyse (Environment and Economy. On the Discrimination of Environment in the Economic Analysis), Tübingen (Mohr/Siebeck)

M. Grubb (1989), The Greenhouse Effect: Negotiating Targets, The Royal Institute of International Affairs, London

R. Hahn, "Economic Prescriptions For Environmental Problems: How the Patient Followed the Doctor's Orders", in: Journal of Economic Perspectives (1989), Vol 3, No 2

R. Hahn, G. Hester, "The Market for Bads" in: Regulations (1987), No 3/4

Harold Hotelling , The Economics of Exhaustible Resources, Journal of Political Economy, Vol. 39, 1931

Roefie Hueting, The Brundtland Report: A Matter of Conflicting Goals, Commentary in: Ecological Economics, No. 2 (1990)

IPCC, Policymakers Summary of WG5 III, June 1990

Thomas S. Kuhn (1962), The Structure of Scientific Revolution, (1st ed. University Press of Chicago)

Friedrich List (1925, 1st ed. 1840), Das nationale System der Politischen Ökonomie, Chapter 12 (p.128 of the edition Stuttgart/ Berlin)

Gerhard Maier-Rigaud (1988), Umweltpolitik in der offenen Gesellschaft (Environmental Policy in the Open Society), Opladen (Westdeutscher Verlag)

— (Mai 1991), Kohlendioxid-Politik mit handelbaren Emissionsrechten (Carbon Dioxide Policy by means of Tradeable Emission Rights), in: Umweltbundesamt Texte 20/91, Berlin

— The Background to the Conflict between Economic and Ecological Ends, in: Ecological Economics, (forthcoming)

John Stuart Mill (1987, 1st ed. 1848), Principles of Political Economy, Fairfield NJ

Edward J. Mishan, The Postwar Literature on Externalities: An Interpretative Essay, in: The Journal of Economic Literature, 9/1971

William D. Nordhaus, Greenhouse Economics - Count before you leap, in: The Economist, July 7 1990

OECD, The macro-economic impact of environmental expenditure, Paris 1985

— Issue Papers on the International Conference, Environment and Economics, Paris 1984

David Pearce (1976), The Limits of Cost-Benefit Analysis as a Guide to Environmental Policy, in: Kyklos, Vol. 29

David Pearce et al.(1989), Blueprint for a Green Economy, London

Karl R. Popper (1963), The Growth of Scientific Knowledge: Theories and Problems, in: Conjectures and Refutations, London (Routledge & Kegan Paul)

Joan Robinson (1960, 1st ed. 1937), Introduction to the Theory of Employment, London (Macmillan)

Joseph .A. Schumpeter (1934), The Theory of Economic Development, Harvard University Press, Cambridge, Mass.

— (1976, 1st ed. 1954), History of Economic Analysis, Oxford University Press, London

P. Studenski (1958), The Income of Nations, Theory, Measurements, and Analysis: Past and Present, A Study in Applied Economics and Statistics, New York (University Press)