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The Greenhouse Effect, Property Rights and Developing Countries

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This article suggests a market-oriented solution for the main cause of the presently menacing greenhouse effect, the rise of the amount of carbon dioxide in the atmosphere. After a short introduction to the problem (part I), the proposed solution, based on the property rights approach, is presented (part II). Part III deals with the distributional and political aspects of the proposal. Finally, the main conclusions of the article are summarized (part IV).

I. The Greenhouse Effect[2]

The expression "greenhouse effect" denotes the capability of certain infrared-active gases, the "greenhouse gases", to "trap" heat in the atmosphere through letting pass solar radiation, on the one hand, but absorbing long-wave planetary radiation, on the other (just like the glass panes of a greenhouse do). Consequently, there is a simple relation: the higher the concentration of these greenhouse gases in the atmosphere, the higher the average temperature.

Among these gases, carbon dioxide is – next to water vapour – most prominent. The amount of CO_2 in the atmosphere results from complex atmosphere-ocean processes with CO_2 being absorbed by oceans or the growth of organic "deposits" (like plants) and released by oceans, the erosion of rocks, the decay of organic materials, and the burning of fossil fuels.

With the beginning of the industrial revolution the amount of CO_2 in the atmosphere, which varied from 200 ppm to 280 ppm in the past 100,000 years, has risen from 280 ppm in 1850 to approximately 350 ppm today; and the CO_2 concentration is expected to increase further; assuming a continuation of present trends levels of 600 ppm in the first half of the next century are deemed realistic.

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[2] For a concise introduction to the problem see: Atmosphere, in: *Encyclopaedia Britannica* 1989, Vol. 14; Climate and Weather, ibid., Vol. 16.

With the subtle CO_2 equilibrium of the atmosphere thus disturbed, the climate will change dramatically (the first signs are already observable); the average surface temperature is expected to rise by 1° to 5 °C by the end of the 21st century (a difference which is of the same order of magnitude as that between the climate of today and that of the last glacial epoch).

The enormous increase of CO_2 in the atmosphere is due to two causes – both of them "human":

First, huge amounts of organic carbon have been – and still are (approximately $5 \cdot 10^9$ tons in 1985) – mined and mainly burned as fossil fuels (oil, gas, coal), with the resultant emission of CO_2. Second, forests, especially tropical rain forests, have been – and are with increasing speed – cut down to give way to cattle, farms and settlements or simply to get fire wood, which raises the total carbon emission to about $6 \cdot 10^9$ tons.[3] On the other side, the absorptive capacity of the ocean, the main "dump" for CO_2 (the sea is a net absorber as its absorption surpasses its release of CO_2), is limited, because the inclusion of CO_2 into the ocean waters depends on their alkalinity respectively the amount of salts in the ocean surface. Therefore the oceans can absorb only roughly one third of the actual CO_2 emission leaving a net emission of $4 \cdot 10^9$ tons of carbon annually to accumulate as CO_2 in the atmosphere.

Of course other greenhouse gases have undergone changes in their concentration, too; but these changes are less significant than the increase of atmospheric CO_2, which doubtlessly represents the most important factor in the actual "climate crisis" as it contributes about 80 % of the total warming potential of all greenhouse gases to global warming in the mid-1980s.[4] Besides, the use of an important group of greenhouse gases – the chlorofluorocarbons – is already about to be phased out (mainly because of their inimical effect on the ozone layer), so that it seems to be justified to concentrate on CO_2.

Admittedly, there are considerable uncertainties as to the consequences of a moderate global warming (by 1° to 5 °C), which – all in all – do not seem to be too drastic (Ibid., 933). However, in the very long run (say, until the year 2300), projections of CO_2 emissions and climate reactions indicate an enormous increase in temperature by 10 °C with undoubtedly disastrous effects on human life.[5]

Because of these most probably catastrophical consequences of a significant rise of temperature, especially for coastal and equatorial regions, the growing concentration of CO_2 in the atmosphere poses a global and most

[3] *Cline* 1991, 905.
[4] *Nordhaus* 1991, 921.
[5] *Cline,* ibid., 914.

serious problem that calls for an effective and immediate solution, since "[o]nce the limits are transgressed (...) irreversible processes may easily be set up which will make it impossible for us to return to past Edens."[6]

II. The Market-Oriented Solution

Most approaches to tackle the problem of the greenhouse effect suffer from deficiencies: Either only one side of the problem (the CO_2 emission from the combustion of fossil fuels *or* from the decline of the rain forests) is confronted or a bureaucratic, centralized solution (with its inevitable inefficiencies) is favoured – like the Kellogg/Mead proposal to assign to every nation the right to generate a certain amount of CO_2 (to be determined a priori and centrally).

In contrast, the following proposal is both market-oriented and comprehensive.

1. The Greenhouse Effect and Property Rights

The problem of the CO_2 concentration in the atmosphere may be described in terms of the property rights approach as follows:[7]

A formerly free good – the right to emit CO_2, or, alternatively, the earth's capacity to absorb CO_2 – has become scarce since the beginning of the industrial revolution, because the ever increasing CO_2 emissions have overcharged the capability of the earth to maintain the subtle CO_2 equilibrium. This scarcity manifests – as the relevant property rights do not yet exist – necessarily in conflicts: On one hand, CO_2 emittents insist on further generating CO_2 (burning fossil fuels and destroying forests) without restriction (i.e. treating the resource like a free good); on the other hand, there are people who want the climate not to be turned upside down and consequently advocate a sharp curtailment of the CO_2 emission and the conservation of the rain forests. Or, to put it differently, because of the lack of well-defined property rights externalities – both negative and positive – have come into being and still persist.

The emission of CO_2 represents a negative externality as it contributes to the concentration of CO_2 in the atmosphere and to the consequent climatic change – a contribution for which the CO_2 emittents do not have to compensate the victims. On the other side, the absorption of CO_2 by the growing of rain (and other) forests and by oceans is a positive externality as it helps to maintain the atmospheric equilibrium and counteracts the CO_2 emission – a

[6] *Boulding* 1970, 43.

[7] *Wegehenkel* 1981, 4 - 12.

help that is not compensated by the beneficiaries. That is why the problem cannot be solved on the basis of the present system of property rights: Although everyone is (or, at least, should reasonably be) interested in a stable climate, free-rider and moral-hazard effects prevent effective action. While the reduction of the CO_2 emission by anyone (or even any country) will not have a significant positive effect, which – if any – will also be enjoyed by all others, it will certainly impose a considerable burden (due to the necessary adaptation) on the respective individual (or country). Correspondingly, every land owner will only enjoy a minute fraction of the small positive effect his own afforestation causes, while the results of any other use will be exclusively attributable to him. The CO_2 uptake by the oceans also represents a positive externality, but – as the "supply" of oceanic CO_2 absorption is de facto fixed and hardly susceptible to human interference – the nonexistence of the respective property right does not disturb allocative efficiency.[8]

To internalize these externalities – which both refer to the same "resource", the right to emit CO_2 (or, in the end, the stability of the climate, at least with regard to this gas) – it is necessary to specify and allocate well-defined property rights for this newly scarce resource.

In general, efficient, well-defined property rights have to fulfill two conditions: First, they must consist of general rules (i.e. equally applicable, abstract and certain rules) in order to enable an efficient integration of the new scarcity in the market system.[9] Second, they must be adapted to the respective state of the technical development in order to guarantee exclusivity, i.e. to secure their effective enforcement.[10]

The last criterion, however, implies in the case of CO_2 a global property right: As the effects of the emission and absorption of CO_2 are not restricted to the area of the emittent and absorber but concern the whole atmosphere (in which CO_2 will disperse more or less evenly) and, consequently, the worldwide climate, the respective property right of CO_2 emission must comprise the whole atmosphere. That is, inevitably the specification of the new property right implies the creation of a resource monopoly – the monopoly of the right to emit CO_2.[11] Likewise, the global effects of afforestation and oceans as to the CO_2 concentrations can only be taken into account on a global scale, thus necessarily leading to a monopsony for CO_2 absorption (to be financed by compulsory contributions from the beneficiaries).

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[8] Barring, of course, "geo-engineering", i.e. certain technical measures which might increase the absorptive capacity of the oceans, and for whose efficient use the creation of property rights concerning oceanic CO_2 absorption would be necessary.

[9] *Hayek* 1973, 85 - 88.

[10] *Wegehenkel*, ibid., 10 - 12.

[11] Unless otherwise specified, "property right" will mean from now on the right to emit CO_2.

At first sight, this seems to exclude any significant role for the market and to necessitate a sophisticated political and bureaucratic solution, which inevitably must suffer from all the typical problems and inefficiencies of administrative, non-market solutions. However, with an adequate definition of the property right of CO_2 emission the role of politics may be minimized and restricted to "only" the property right specification and allocation, leaving all the rest to the market forces.

Let us turn for a moment back to the basic problem: After all, what is the motive of the creation of the new property right?

Definitely, the further rise of the amount of CO_2 in the atmosphere shall be stopped to prevent drastic climate changes with – as is generally agreed upon – disastrous consequences. So, neglecting the process of adaptation for the moment and focusing on comparative statics, it is clear that the emission and absorption of CO_2 must be equilibrated in the end (although the date when this aim is to be reached will be highly controversial). It follows that the mere definition of a right to emit CO_2 will be surely not enough to reach this aim, because whoever this right is assigned to will probably act as a revenue maximizer without giving first priority to the underlying aim. Therefore, to secure the effective and efficient attainment of this aim (that CO_2 emission equal CO_2 absorption, or that the CO_2 net emission be zero) further political action is necessary to complement the relevant property right as follows: The owner of the global right to emit CO_2 must be obligated to aim at the equality of CO_2 emission and absorption *and* has to charge the same price for a unit of CO_2 emitted as he pays for a unit absorbed (which implies that revenues are to equal expenses).

This prescription implies that hypothetical expenses for the (fixed) oceanic "supply" of CO_2 uptake are included among total expenses; therefore, there will be only a calculatory equality of expenses and revenues, whereas actually a surplus (equivalent to the hypothetical expenses) will result that will have to be distributed.[12]

Although in the case of the property right to emit CO_2 it theoretically does not matter to whom the "right" is assigned,[13] it is most probable that it will be conferred upon some international agency to be exerted.

Although seemingly restrictive, the definition of the property right "only" secures a market solution in a non-competitive environment (monopoly for CO_2 emission and monopsony for CO_2 absorption) – with the agency acting like the Walrasian auctioneer and its objective being the usual equilibrium condition (the equality of supply and demand).

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[12] See sec. III.

[13] *Coase* 1960.

Therefore, with the above requirements fulfilled, politics will have played its part and will have to give way to the market forces, which – as is to be shown below – will realize an efficient equilibrium.

However, to repeat, the market forces must be based on a prior political decision as to the value of environmental quality[14] – a decision that is assumed to be in favour of CO_2 stabilization.

Analogously, the dynamic aspects of the problem must be resolved politically: To be sure, sometime CO_2 emission and absorption have to be equilibrated in order to prevent the earth's climate from finally becoming similar to the Venusian – a possibility that hardly anyone could want to be realized. But, it is another question how and when to reach the CO_2 equilibrium, because there is a trade-off between the costs of the climate stabilization and its benefits, which have to be weighed against each other to reach the optimal stabilization path[15] whose final aim – whenever it is to be reached – must consist in a zero CO_2 net emission.

Therefore politics will probably not prescribe the aim of an immediate reduction of the CO_2 net emission to zero but rather tolerate a certain CO_2 "surplus" for some time (although there are even now enough signs that the time for hesitation is through). However, the present article shall not deal with these dynamic aspects in greater detail.

2. The Simple Mechanism towards Equilibrium

Based on the above property right specification and allocation – i.e. the creation of a global property right to CO_2 emission complemented with the restriction to use this right to aim at a CO_2 equilibrium (emission equals absorption) and to set a homogenous price for both emission and absorption of CO_2 – the following mechanism will secure the desired equilibrium.

This is illustrated in figure 1, where A and E denote absorption and emission of CO_2, respectively (if A equals E, the common quantity will be denoted by Q), a and e the price paid for absorption respectively charged for emission of CO_2 (if a is equal to e in absolute terms, p will denote the common value), and Q* and p* the "optimal" quantity and price, respectively, i.e. the equilibrium.

Let us first have a closer look on the curves A and E. What do they mean?

A and E represent the supply and the demand for the right to emit CO_2 (for both curves the usual convexity assumption is adopted, which, however, is not crucial to the argument). Curve A implies that with the price paid for the

[14] *Wegehenkel* 1991, 32.
[15] *Nordhaus*, ibid.

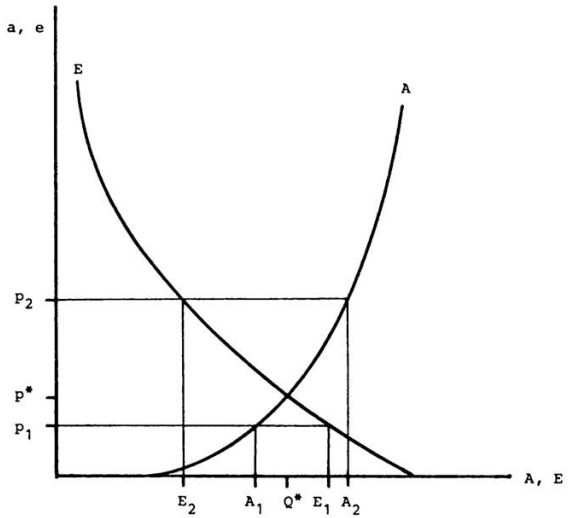

Figure 1: CO_2 absorption and emission

absorption of one unit (however defined) of CO_2 rising, more "absorption capacities" will be provided, i.e. larger areas of forest (and especially of rain forest) will be grown. The price paid must of course be high enough to compensate the land owners for the foregone revenues they could have obtained from alternatives uses (the opportunity cost) – e.g. the use of the ground for agriculture. The curve is positively sloped, as with the area of "unused" forest growing the value of the foregone revenues of the marginal land not put to any other use, i.e. the opportunity cost, rises. On the other hand, curve E shows that CO_2 emittents will intensify their activities as the price they have to pay falls. The price they are ready to pay depends of course on the valuation of the underlying activities (burning fossil fuels for, e.g., car driving, heating of houses or generation of electricity, and the destruction of forests for whatever purpose); therefore, with the price rising fewer activities are valued high enough to be worthwhile paying the price. Alternatively, as the amount of CO_2 to be emitted decreases, among the competing activities those will prevail which are valued most and can thus bear the burden most easily – which accounts for the negative slope of E.

The actual situation is depicted by the points A_o and E_o on the abscissa: No price can be charged or will be paid – there is a CO_2 "surplus" emission of $E_o - A_o$ leading to a permanent rise of the amount of CO_2 in the atmosphere and the present problem of the notorious greenhouse effect. A_o represents the amount of CO_2 absorbed by the sea, which is taken to be fix; it is assumed that there does not exist any other significant "voluntary" CO_2

absorption (which is not a very restrictive assumption since new forests are hardly grown anywhere and the mere existence of mature ones does not absorb CO_2; for this purpose an increase in biomass is necessary).

Obviously, in the optimal situation, p* and Q*, not only is the aim of a zero CO_2 net emission realized but at the same time it is also realized efficiently. For, at the equilibrium, i.e. the intersection of the two curves, the marginal opportunity cost of CO_2 absorption equals the marginal value of CO_2 emission.

Let us suppose, for example, that the zero net emission is attained with higher quantities of both A and E (which, naturally, entails $a > e$); then, at the margin, the opportunity cost of the "unused" land would be higher than the value of the CO_2 generating activity which is made possible by the very CO_2 absorption of growing forest on this area – a clearly suboptimal situation; the same is true for the reverse disequilibrium, of course.

Alternatively, these disequilibria fail to realize the highest possible sum of consumers' and producers' surplus which is maximal at equilibrium – with the CO_2 emittents as consumers and the CO_2 absorbers as producers.

For the intersection of A and E to be a "true" optimum it is of course necessary that other externalities concerning CO_2 absorbing or emitting activities do not exist (or are compensated), because these – although not able to prevent the aim of a zero CO_2 net emission – will cause inefficiences: For example, car drivers not burdened with the total cost of their activity (excluding the cost of CO_2 emission) are able to pay a price too high in relation to the social value of car driving and thus will command too much CO_2 emission "rights" (in relation to, e.g., consumers of electricity). Doubtlessly, this condition is not fulfilled, which, however, should not be an obstacle for the proposed solution, because its chief aim will be realized despite these imperfections, which, for the most part, can and have to be solved in a more decentralized way. Furthermore, an optimum requires that both suppliers and demanders behave competitively (be price takers), which does not seem to be too unrealistic an assumption on a global scale. Given this condition, then even the fact that the agency employed is both monopolist and monopsonist simultaneously will not lead to inefficiencies; above all, no bargaining strategies will be or can be used.[16] Besides, because of the well-known problems with public property,[17] the higher the proportion of private suppliers and demanders, the faster the price signals will be responded to.

With the optimum thus determined it becomes apparent that it can be reached very easily (at least in theory). The agency that is in charge of the property right simply has to pursue the following policy: Set a uniform price

[16] *Johansen* 1979.

[17] *Wegehenkel,* ibid., 96 - 98.

for CO_2 absorption and emission and vary this price until revenue equals expenses (not considering operative costs which are to covered from elsewhere).[18] That is, under these circumstances there will not be any discretionary power that could be abused!

This process towards the equilibrium is illustrated in figure 2.

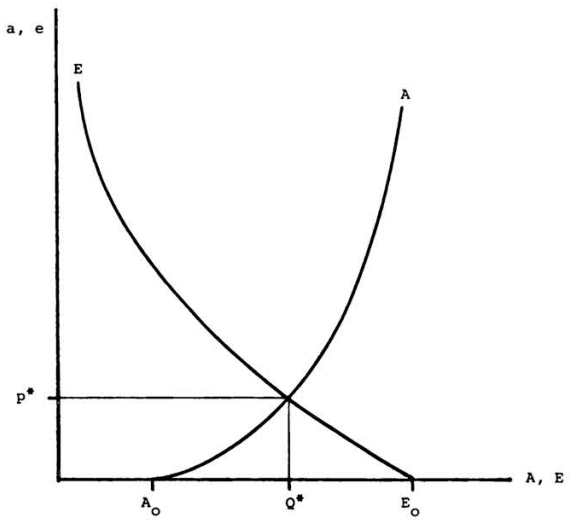

Figure 2: The trial and error process towards equilibrium

With the price paid equalling the price charged, the (calculatory) equality of expenses and revenues is an unequivocal sign of the equilibrium being reached. Also any inequality gives a clear hint how to correct the price. If the agency first fixed the price at p_2, expenses would exceed revenues, which indicates a necessary lowering of the price; analogously, a price too low, like p_1, entails a revenue surplus which is a signal for raising the price. In this way, equilibrium can easily be reached via a trial and error process.

For this process to succeed, i.e. to attain the optimum, no detailed information is necessary! In fact, the only precondition is that A and E are positively and negatively sloped, respectively; a precondition so weak that it can be taken for granted without hesitation.

To be sure, this process – that contains an element of centralization in the form of the agency – can only be a rough simulation of a "real" market at best. Because of certain practical and informational problems the adapta-

[18] Remember the hypothetical expenses for the oceanic CO_2 absorption.

tion of the price by the agency must needs be slow and imperfect. Nonetheless, the proposed solution represents the best approximation to a market that is possible in the case of global externalities, which by their very nature preclude any completely decentralized solution. The reason for such a market approximation to work at all consists in the equivalence of positive and negative externalities in this case (due to the aim of a zero CO_2 net emission), which can be interpreted as supply and demand linked together with the clear equilibrium condition. The remaining imperfections have to be accepted, especially as also the "normal" markets in reality are imperfect and never actually reach equilibrium.

Of course, it is necessary to specify A and E exactly. In theory, every CO_2 emission would have to be paid for and every CO_2 absorption would have to be compensated: Everyone would have to pay for the CO_2 he produces when breathing, and the owner of every garden would have to receive a compensation for the trees he is growing. Clearly, this would make the whole approach absolutely unfeasible because of excessive transaction costs.

However, the unfeasibility of the "first-best" solution does not imply the senselessness of any other, less perfect, solution.

First, externalities are only to be internalized to the degree, where, at the margin, the gains of their internalization are at least as high as the necessary costs.[19] Therefore, it makes economic sense not to exert the property right totally, i.e. insofar as it concerns only minor CO_2 emissions, and also to neglect minor absorptions.

Second, in a world of informational scarcity "third-best" policies may well be appropriate – policies that take only the more important effects into eccount and neglect all probably insignificant aspects.[20]

Especially our problem allows a clear-cut division: Definitely, the rise of the CO_2 level is attributable almost exclusively to the burning of fossil fuels and the destruction of vast areas of (rain) forest. Therefore, it seems to be admissible to concentrate on these two factors: So only prices for the burning of fossil fuels and the destruction of forest areas will be charged and only premiums for the growing of forests will be paid. Although thus only these components of the global CO_2 balance will be equilibrated, it is a safe assumption that all the other constituents of this balance alone will not create considerable disturbances.[21] Hence, this „third-best" policy can be taken as a good approximation to the "real" (but unrealizable) optimum.

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[19] *Demsetz* 1967, 350.
[20] *Ng* 1977.
[21] *Cline,* ibid., 905.

The main advantage of our proposition consists in the role it assigns to the homoeostatic market forces: Given the indispensable initial political action of goal determination and the corresponding property right creation, the efficient attainment of this goal (the zero CO_2 net emission) can be mainly left to the market forces, which only will be coordinated (but not disturbed) by the intermediary – but "unpolitical" – agency. In this way, it is secured that the climate stabilization is reached with the least sacrifice in terms of foregone CO_2 generating activities and alternative land uses.

3. Practicability

To be practicable, our general proposal has to be complemented by several "technical" rules.

First, how to charge the price and how to pay the compensation?

With the focus on the combustion of fossil fuels and the development of the forested areas the payment execution poses no unsurpassable problem: The uniform price for the CO_2 emission may be charged, first, as a "tax" on fossil fuels and, second, as a "tax" on the destruction of forest (with the exact amount depending on the specific carbon contents of both different fuels and forests). Likewise, the uniform compensation for CO_2 absorption (equal, of course, to the above tax in absolute terms per unit of CO_2 emitted) is to be paid on the basis of the afforested area – dependent on the absorptive capacities of the different forests (e.g., the price paid for one square mile of tropical rain forest per unit of time will considerably exceed that paid for the same area of some northern wood or taiga).

Obviously, it will be necessary to rely upon the national governments and tax administrations to charge the tax on the use of fossil fuels and on deforestation effectively and to prevent "free riding"; their commitment to such support is, however, already implicitly contained in their agreement to the property right creation, which otherwise would be completely void of significance in the first place.

Furthermore, in the case of forests, the agency will also use widely available satellite analyses or the earth's surface to determine both the size and the "quality" of the afforestation resp. deforestation. Because of technical limitations there will be a lower bound for the size of a forest to be taken into consideration (the "forest unit"), presumably round about one square mile. The least problem is posed by the calculation of the hypothetical compensation for the oceanic absorption, necessary to reach the calculatory equality of expenses and revenues: With the annual CO_2 absorptive capacity well known the hypothetical expenses can be easily calculated; also the adaptation of these "payments" to a possible change in oceanic CO_2 absorption poses no problems as it would proceed very slowly.

Apparently, an efficient CO_2 "allocation" in the way just outlined necessitates the absence of any distortion interfering with the CO_2 prices: Consequently, a special tax on fossil fuel – apart from the above surcharge – must not be levied; although not preventing the global aim of a zero CO_2 net emission, any such tax would cause a misallocation of the CO_2 amount at disposal (and thus an inefficient attainment of this aim), because in the countries imposing this tax "too little" CO_2 would be emitted whereas in the other countries the opposite would be true. Analogously, if earnings derived from forests are taxed at all, they have to be taxed uniformly to prevent a similar distortion.

Furthermore, the generality of the rules is crucial; there must not be exceptions for, say, a particular use of fossil fuels or certain countries or what have you, because any exception not only will disturb the allocative mechanism directly but also will create both uncertainty and an incentive to bargain for further exceptions. For the same reason the aim of a CO_2 equilibrium must be beyond any doubt and fixed unconditionally (which will enable a safe prediction of the general price "policy").

Second, how to reach and maintain equilibrium?

Though finally reaching the aim, without some a priori reasoning the trial and error process may easily involve a considerable waste of resources due to disruptive price movements. Therefore, it goes without saying that detailed and careful analyses of the relevant supply and demand curves (especially as to the price elasticities and reaction times) be undertaken before setting the price for the first time.

In theory, instantaneous price adjustments could lead nearly immediately to a stable equilibrium; in practice, however, any announced price has to be valid for a certain minimum period of time – because it takes the addressees some time to adapt themselves to the actual price (and this adaptation will only take place, if the price is considered to be comparatively stable) and because of technical limitations as to the determination and the carying out of payments. One might conjecture that the price be valid for, say, three years and payments be effected once every year. Also the equilibrium price, if reasonably approached to, should not be adjusted too quickly in order not to cause unnecessary instabilities; if a small disequilibrium (i.e. a divergence of expenses and revenues) persists or arises, the price should only be adapted in the case of an unambiguous tendency towards an increasing disequilibrium (caused, e.g., by a shift in demand or by technical progress) disregarding minute disequilibria or possible stochastic fluctuations, which hardly can be avoided (although the distinction may not always be an easy one).

Nonetheless, it is possible to make a virtue of the necessity to carry out a trial and error process: The sudden realization of the zero CO_2 net emission

is hardly feasible (see below); therefore, a gradual approach towards the final equilibrium not only will be appropriate because of the uncertainty as regards the "correct" price but also because some time will be needed for adaptation to the internalization of the new scarcity. Starting on the safe side with a price low enough to allow still considerable CO_2 net emissions will serve both to mitigate the adaptive pressure and to prevent a possible overshooting or disruptive fluctuations of the CO_2 emission price.[22] Besides, also the way towards the equilibrium will thus be efficient insofar as no discrimination will occur and the CO_2 emission will always be put to its highest valued use; this does not imply, however, that the time path itself will be efficient.

Although, whatever level of CO_2 in the atmosphere one might be ready to tolerate, the adoption of a zero net CO_2 emission policy finally will become inevitable, its instantaneous realization is clearly unfeasible: Under present conditions[23] a CO_2 equilibrium would mean a reduction of the net emission by roughly $4 \cdot 10^9$ tons of carbon which may be accomplished, e.g., by a reduction of the combustion of fossil fuels by 80 %, or a complete stop of deforestation combined with a cut in the use of fossil fuels by 60 %, or – most impressively – by completely refraining from deforestation and growing about $4 \cdot 10^6$ to $5 \cdot 10^6$ square miles of forest.[24] This huge forest area (equivalent to three times the farm land of the USA) would absorb the CO_2 emission due to the use of fossil fuels on its current level, yet not for good but only until the forest would have grown and would henceforth not accumulate any further carbon, i.e. for about 100 years. Obviously, the actual fossil fuel combustion cannot be maintained ad infinitum (let alone further increased) and just must be cut sooner or later, which will necessitate a major restructuring of the world economy that cannot be brought about overnight. Most probably our final aim can only be reached by way of a slowly, gradual process involving mainly a reduction of the combustion of fossil fuels, complemented by – at most – a stop of deforestation, whereas afforestation probably will not be able to contribute significantly because of the steadily growing demand for food which prevents vast parts of fertile soil from being used for growing forests.[25]

Third, to whom assign the property right?

In this case the Coase theorem is undoubtedly true: Because the holder of the property "right" cannot but aim at the equilibrium, it theoretically does

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[22] Of course, in the transitional period there will exist a revenue surplus due to the price too low, in addition to that caused by the hypothetical expenses for oceanic absorption (with the latter being smaller than in the equilibrium situation).

[23] See sec. I.

[24] *Cline*, ibid., 917.

[25] *Nordhaus*, ibid., 929 - 935.

not matter to whom it is assigned. In reality, of course, an international organization (in particular, some UN subdivision) would be most appropriate – above all for political reasons.

III. Distributional and Political Aspects

The realization of our proposal would also entail major distributional consequences which are, at first sight, not in accordance with the prevailing conceptions of fairness and global distributional justice.

To be sure, the industrial countries as the main emittents of CO_2 will have to pay for their emission which – in the end – will have to be severely curtailed; in contrast, any payments relating to forests will only be negligible – although major afforestations do not seem to be very probable, it will not be too difficult, on the other hand, to prevent a further destruction of the remaining forests. The developing countries, however, will be struck much harder on the way towards a new CO_2 equilibrium: Their process of industrialization, which actually depends heavily on the use of cheap energy (i.e. fossil fuels), will be hampered, they will be prevented to use (or, abuse) part of their natural resources, their forests, by having to pay for deforestation, and they will hardly be able to bring about major afforestation to receive some compensation for it. Of course, they will also benefit from the prevention of a significant global warming – and not the least, because they, mainly situated on the lower latitudes, would suffer most from a further rise of the temperature. However, in the face of current famines and misery these prospective benefits may not count too much against the corresponding sacrifices in terms of economic growth.

On the whole, although not having to pay as much as the developed countries (in absolute terms on a per capita basis), the developing countries would bear the main burden of the adaptation, which clearly is not only ethically unacceptable but also renders the Third World's consent to our plan and therefore (as it depends on worldwide consent) its success most improbable.

However, there is a chance to reconcile the Pareto principle with ethical considerations[26] by way of the oceanic CO_2 absorption and the revenue surplus it causes in our plan. It has hitherto been neglected[27] but will turn out to be an indispensable feature of our proposal. For it represents a chance to alleviate the otherwise negative distributional consequences and to make

[26] *Mishan* 1967, 276 - 280.

[27] That is why in the above scenario both groups of countries would have to pay, causing a revenue surplus equal to the hypothetical expenses for the oceanic CO_2 absorption.

our plan generally acceptable. Why not distribute the revenue surplus due to oceanic CO_2 absorption among the developing countries?[28]

After defining the terminus "developing country" the surplus[29] could be distributed appropriately on the basis of population, per capita income or some combination thereof.[30]

This surplus transfer to the Third World would possess several advantages: First of all, also the distributional consequences of our proposal would be acceptable. With the oceans absorbing one third of the current CO_2 emission and the developed countries being by far the most important emittents, the developing countries would become net recipients (and, consequently, the industrial countries net payers). Moreover, this global redistribution (generally thought to be desirable) would be achieved efficiently as it would not interfere with the market system.[31] Furthermore, a permanent revenue surplus with the price setting agency could be prevented which otherwise would elicit continuous bargaining activities. Admittedly, also the transfer of the surplus to the developing countries and its exact allocation will be subject to some dispute; this could, however, be settled for quite a long time (the time one thinks the developing countries to remain underdeveloped, probably several decades), once the transfer is recognized as a crucial component of the plan and once the general principles for the surplus distribution are agreed upon and irrevocably determined.

Any other approach – such as "free" CO_2 emissions – to alleviate the consequences of our plan for the developing countries would inevitably lead to inefficiencies endangering its success. Of course, also CO_2 emittents in the developing countries will have to pay the regular price; this will counteract the transfer these countries will receive but cannot – despite the former free CO_2 emission of the now developed countries – be called unfair: The actual scarcity simply then was not yet present and the fact that any price once was zero does not at all entitle anybody to claim further being charged no price; any such pretension or even "right" would hinder the internalization of

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[28] Alternatively, one could create and assign property rights concerning the oceanic CO_2 absorption, which ought to refer to the ocean surface (to which, ceteris paribus, the CO_2 absorption is proportional). Of course, this would not imply that the ocean as such would become the property of any country or group of countries; only for one of the several uses of the natural resource "ocean" property rights would be specified – the freedom of the seas would not at all be restricted. This would be possible because the CO_2 absorption by the ocean neither influences nor is influenced by other ocean-related activities, such as fishing or navigation.

[29] The transfer to the developing countries could also – in the transitional period – include the revenue surplus due to a disequilibrium price; see sec. II. 3.

[30] Of course, for the final distributive effect the distribution of these payments within the respective countries would be decisive.

[31] The same would go for the specification of property rights mentioned in note 28 which, in general, would represent an allocatively neutral redistributional instrument; *Wegehenkel,* ibid., 66 - 68.

every externality and thus block the adaptation of the market system to a changing environment.

Of course, the rise of the prices for fossil fuel will have much the same distributional consequences like an excise tax. Though these consequences will not be incontroversial, people probably may be convinced of the necessity of measures to cope with the menace of a climatic change; on one hand, the awareness of environmental problems has grown, and on the other, the proposed mechanism leads to international transfers that correspond to widely accepted ethical premises.

The main problem to be overcome in order to realize our proposition clearly is a political one: All countries must agree upon the creation of a property right as described above and its assignment. This also means the surrender of part of the national sovereignty: All countries must be willing to enforce the charging of the price for CO_2 emission (however high it may be), which technically will be easily possible, as virtually all countries tax fossil fuels, but rather will be a major political difficulty.

It stands to reason that most countries would be only – if at all – ready to assign this property "right" to a supranational institution to exclude the possibility of a single country dominating and exploiting all others and any injury of national pride. Furthermore, such an institution would also have easy access to the satellite analyses needed for the payments relating to forests. Also the transfer of considerable amounts to the developing countries for their consent to the CO_2 equilibrization plan will not be easy to accept for the industrial countries.[32]

However, the crucial condition for our proposition to be successful does not only consist in creating and assigning the property right but also – and most importantly – in simultaneously refraining from any subsequent deliberate intervention. It is only then that the described mechanism will be both effective and efficient – in the absence of political discretion that inevitably entails bargaining, non-general rules, exceptions and the consequent inefficiencies. An agreement depends on the consent of both the developing and the developed countries, with the latter bearing the main burden – in addition to the intense adaptations of their economic structure they will have to pay the necessary transfers to the Third World. However, that only seems to be fair, because they are both best able to bear the burden and mainly responsible for the present climatic problem.

Despite these reasons political opportunity probably will prevent a solution like that proposed, because to most politicians of the developed countries, who are interested in reelection, this kind of cure must seem to be

[32] Although these might reduce their burden by cutting the developing aid.

worse than the disease, so that they are inclined to continue occupying the free-rider position.

Therefore, at best a piecemeal solution, with discretionary transfers from the developed to the developing countries conditional on certain conservation measures of the latter and with quite high CO_2 emission limits fixed bureaucratically in the former, seems to be realizable.

IV. Conclusion

The most important conclusion to be drawn from our reflections certainly is that of the applicability of the market order even in cases of global problems – under certain conditions. Despite its globality the problem of the greenhouse effect allows the reliance on market forces to a considerable degree, as supply and demand exist in the form of a positive respectively negative externality concerning the same resource. Of course, politics has to play its role: As is the case with every externality the creation and allocation of property rights concerning the resource whose scarcity gave rise to the externality is an indispensable precondition. In addition, because of its globality, the problem of the greenhouse effect necessitates not only the decision to internalize the externality but also the determination of the final aim this internalization shall lead to, equilibrium (i.e. the zero CO_2 net emission); this involves the creation of a very special and restricted kind of property "right" – a property right combined with the prescription how to use it – that has to be assigned to a central holder. However, after its creation and assignment the assignee can and must be relied upon to solve the problem on his own; i.e. by mediating without any distortive interference between supply and demand and with an unconditional aim as his guideline.

Additionally, otherwise negative distributional consequences are to be mitigated by transferring the surplus resulting from "free" oceanic CO_2 absorption to the developing countries.

The main handicap of the proposal is political: All countries must agree upon the creation of such a property right and abstain from any further interference. This partial surrender of national sovereignty, especially if it implies a considerable burden (as in the case of the industrial countries) is so mighty an obstacle that it unfortunately can only be overcome, if the climatic change already under way becomes much more dramatic and severe, although even now the necessity of effective and immediate action can hardly be disputed.

Summary

To deal with the problem of the greenhouse effect it is suggested to create and assign the global property right to emit CO_2 (with its holder restricted to set a uniform price for both emission and absorption of CO_2 and to equate revenues and expenses) in order to reach the plausible aim of a zero CO_2 net emission.

Though both practicable as a "third-best" policy relying mainly on market forces and ethically acceptable (due to the possibility of transfers to the developing countries) there are serious political obstacles to be overcome.

Zusammenfassung

Um das Problem des Treibhauseffektes marktwirtschaftlich zu lösen, wird vorgeschlagen, ein globales Verfügungsrecht, CO_2 emittieren zu dürfen, zu schaffen (das mit der Restriktion verbunden ist, einen Einheitspreis für sowohl Emission als auch Absorption von CO_2 zu setzen und ein Gleichgewicht von Einnahmen und Ausgaben anzustreben), um das plausible Ziel einer CO_2-Nettoemission von Null zu erreichen.

Obwohl dadurch dieses Ziel effizient erreicht und auch Distributionsgesichtspunkten (aufgrund der Möglichkeit von Transfers an Entwicklungsländer) Rechnung getragen werden könnte, bestehen erhebliche politische Probleme hinsichtlich einer Realisierung dieses Vorschlages.

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