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ENVIRONMENT POLICIES AS ACCUMULATION OF SOCIAL CAPITAL

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SOCIAL CAPITAL AND NATURAL CAPITAL: THE ROLE OF NATURAL OF THE ENVIRONMENTAL POLICIES

The stock of capital of a society includes the whole set of assets to promote the development of social welfare and quality of life. The social capital consists of an aggregate broader than physical and human capital, to include cultural heritage and the natural capital in an essential way. Environmental policies are aimed at preserving natural capital, and in this sense they should be considered as policies to promote social capital.

In this perspective, environmental policies should be considered as part of a more general set of public policies to improve the quality of social and economic development. There is no need to abandon the traditional framework in which traditional economic analysis deals with the economic instruments of environmental policy, in the sense that, as in the traditional framework, environmental policies are necessary because of market failures due to externalities (negative or positive) and public goods (or bads) (Tietenberg, 2000; Kolstad, 2000). However these policies acquire a broader meaning, abandoning a limited sector approach and taking up the consistency problem with other policies aimed at promoting economic and social development.

The objective of maintaining the natural capital of a society must immediately face a problem. As a matter of fact, the environment, as natural capital, shows a typical feature of the non completely reproducible social capital: it plays an essential function for the economic system both when preserved and when exploited. Environment is exploited because of its sink function of deposit of wastes and pollutants, and because of its source function providing resources for the functioning of the economic system. On the other hand, environment is being preserved because its preservation has an amenity value and an existence value for the society, and because the preserved environment also has a productive value. The preserved environment enters both the social utility and the aggregate production function with a positive effect.

Exploitation and preservation of the environment imply potentially alternative modes of resource allocation: if resources are devoted to exploiting the environment, they are subtracted to its preservation. This implies that the cost of exploiting the environment is an opportunity cost measured by the foregone alternative benefit of environmental preservation. In a similar way, the benefit of environmental exploitation measures the opportunity cost of the environmental preservation.

The flow of environmental exploitation concerns energy and mineral use, but also flows of pollution and wastes. These are extractive flows, to be considered as private and hence rival goods; the market plays an open and explicit role in determining them.

In particular the benefit from environmental exploitation and the cost of environmental preservation are easily measured by market transactions.

The quality of the preserved environment contributes directly and indirectly to social welfare: directly through the amenity and existence value in the social utility function, indirectly by increasing input productivity in the production function. Environmental quality is a public good: everybody enjoys the benefits from environmental quality and the services offered by this form of natural capital are therefore non rival. This implies that the market has difficulties in measuring the benefit of environmental preservation or, which amounts to the same thing, the opportunity cost of environmental exploitation. It is difficult for the market to perform an adequate role in producing environmental quality, whilst public policies become important.

Environmental policies thus play the essential role of keeping in equilibrium two potentially alternative ways of allocating resources: exploitation and preservation of natural capital.

ECOLOGICAL RELATIONS IN EXPLOITING AND PRESERVING NATURAL CAPITAL

There is a definite dynamic relation between exploitation and preservation of natural capital. Every unit of the extractive flow of natural resources and pollution correspondingly reduces the stock of environmental quality. However the extraction flow of natural resources and pollution can be counterbalanced by the ecological processes representing the capacity of nature to regenerate itself and to assimilate pollution.

If the economy uses less environmental services than those which are made available by the ecological processes, the environmental quality increases over time; if the economy uses more environmental services than those which are made available by the ecological processes, the environmental quality decreases over time.

The flow of services made available by the ecological processes represents the absorption capacity of the environment. An ecological equilibrium, meaning a constant quality of the environment, can only be maintained if the flow of natural resource extraction and pollution remains constant and equal to the absorption capacity of the environment.

In order to understand which factors determine the available flow of ecological services, we must keep in mind that the environment uses and transforms energy; during this transformation process energy is dissipated, becoming less and less useful; this is the meaning of the “entropy law”. If the environment should rely only on the energy it is able to make available itself, it could not preserve itself. This preservation is only possible because of a constant inflow of energy from outside, that is solar energy, which can counterbalance the entropy process.

There is an immediate implication of this statement. Production of ecological services as a result of transformation of solar energy by the environment is an increasing function of the environmental quality, but because of the fact that the input of solar energy is fixed, we must apply the law of decreasing marginal returns. The production function of ecological services is therefore increasing but concave.

Facing this production of ecological services, there is a demand of ecological services necessary to maintain a given level of environmental quality. This demand of ecological services increases with the level of environmental quality because more ecological services are required to maintain a higher environmental quality. Moreover this demand of ecological services increases more than proportionally with the rise of environmental quality, because of the increasing complexity of the ecosystems associated to a higher level of environmental quality. When the quality of the environment is low, few ecological services are being supplied, but on the other hand few ecological services are required because of the low complexity of the ecosystem. When the environmental quality increases, the environment is able to provide a larger flow of ecological services, but it also becomes more complex so that an increasing share of these services is required to maintain this higher level of quality and complexity. The demand function of ecological services to maintain environmental quality is therefore increasing and convex.

The part of production of ecological services which does not fulfill the demand required to keep a given level of environmental quality represents the absorption capacity of the environment, that is the net supply of ecological services. This is a flow of energy, which can be used either by the economy to exploit the environment and the natural resources, or to increase the quality of the environment, making it richer and more complex. The shape of the production and demand functions of the ecological services implies that this available net flow of energy, representing the absorption capacity of the environment, first increases and then declines to zero, where a maximum limit of the environmental quality is being reached (Smudlers, 2000). When the environmental quality has reached its maximum level, all the ecological services provided by the environment are required to maintain that level of environmental quality.

The level of the absorption capacity also has a upper limit, given by the maximum possible difference between production and demand of ecological services. It is not possible to maintain a flow of pollution and natural resource extraction above this maximum level without the environmental quality declining to zero. Hence a sustainable growth path requires that the flow of pollution and natural resource extraction remains below the maximum level of the absorption capacity.

Notice an important implications of these remarks. Economic activity, both of production and of consumption, requires ultimately using energy; such a use is represented by the flow of environmental exploitation as a productive input; this means that this exploitation flow is a necessary input in the economic process, which cannot be entirely substituted by man made capital. Hence both man made inputs and natural inputs are necessary for the development of the economic process.

KNOWLEDGE, IMMATERIAL GOODS AND SUSTAINABLE GROWTH

Production, consumption and man made capital cannot be limited to a strict physical dimension. We not only have material production, but production of services and immaterial goods. Man made capital is not only physical capital but human capital and knowledge. Physical production itself requires energy and knowledge.

Knowledge can be substituted for energy and this possibility of substitution reduces the importance of a minimum requirement of energy. Time dimension plays an essential role in loosing the constraint related to energy requirement. The elapsing of time makes new ideas, new technologies and new production processes available which allow for a lower energy requirement for the whole economy.

We refer to the laws of thermodynamics to claim the existence of an upper limit to the level of the environmental quality; however there is no evidence of a similar limit to the development of human knowledge over time. Production of new knowledge is not subject to a law comparable to the entropy law; in other words there is no reason to assume that the use of the existing knowledge to produce new knowledge reduces the stock of existing useful knowledge (Smudlers, 2000).

This means that using knowledge is non rival, while using ecological services is rival. An idea can repeatedly be used by many persons without becoming obsolete: hence the existing stock of knowledge is not becoming obsolete through use. On the contrary, using knowledge may make it more productive through a network esternality. There is no limit to the process of using knowledge to produce new knowledge; the only problem being that the new knowledge could be used to accelerating instead of delaying, as it would be desirable, the moment in which ecological limits are being reached.

The role of knowledge is fundamental in explaining technological progress, and hence to determine a sustainable growth path for the economy. It is also important to give environmental policies the right size and the appropriate width. Production of knowledge aimed at delaying the moment where ecological limits are being reached should play a central role in environmental policies.

THE FEATURES OF SUSTAINABLE GROWTH

A sustainable growth path is one in which national output increases continuously over time, but a certain level of environmental quality and environmental exploitation are kept constant over time (Rao, 2000; Perman and others, 1999). Starting with some important classical economists, such as Malthus, Ricardo and John Stuart Mill, many still remain pessimists about the possibility of achieving a sustainable growth, and believe that the economy can only achieve a stationary state.

The reason why an economy tends to a stationary state is the presence of decreasing returns to capital accumulation and the absence of any type of technological progress. Notice that the source of decreasing returns lies in the fact that natural resources and hence the possibility of their exploitation are finite and limited. The possibility of achieving sustainable growth is due to technological progress, and derives from the possibilities of development and application of knowledge. Technological progress can counterbalance the decreasing returns to capital that would otherwise lead the economy towards a stationary state. In this way it is possible for capital and output to grow continuously over time, maintaining the flow of environmental exploitation constant within the limit of the absorption capacity.

If the flow of environmental exploitation remains constant over time, and the national output grows continuously over time, this means that the ratio between the environmental exploitation flow and national output continuously declines over time. In other words the effect of technological progress is to make production processes more and more efficient form the ecological point of view, continuously reducing the pressure on the environment per unit of national output. The development of new knowledge should be oriented towards creating a type of technological progress improving the ecological efficiency and continuously reducing the pressure on the environment per unit of national output.

Which level of environmental quality should be achieved and preserved along a sustainable growth path? This depends on the relative weight of private consumption and environmental quality in the social utility function. Private consumption goods require environmental exploitation to be produced; but environmental quality enters both the production function and the social utility function with a positive sign.

Moreover in the choice of the level of environmental quality to maintain along a sustainable growth path, society has also to take into account the rate at which the utility of future generations should be discounted (Smudlers, 2000; Perman and others, 1999).

Even if knowledge and technological progress allow a sustainable growth path to be achieved, society may not choose it and in this case environmental policies are not oriented to this objective. Hence the structure of social preferences plays a very important role. A myopic society and one giving a low weight to the environment as a source of utility could in fact choose an unsustainable scenario where consumption grows and environmental quality deteriorates in the short run, but where in the long term consumption itself has to decline because the environmental quality has reached such a low level to prevent the production process to continue.

On the contrary, society could prefer a path of low growth or even a stationary path in the long run, provided that this is characterized by a long period level of environmental quality sufficiently high, if people in the society prefer environmental quality to continuously growing consumption; in other words, growth, while sustainable, may become undesirable if the weight of the environmental quality in the social utility function is sufficiently strong relatively to the weight of private consumption.

On the other hand, if the society chooses a permanent sustainable growth path, the level of the environmental quality will be higher, the higher is the weight of the environmental quality in the social utility function and the stronger is the role of the environmental quality in improving productivity of the other production inputs.

ECONOMIC INSTRUMENTS OF ENVIRONMENTAL POLICIES: TAXES AND TRADABLE PERMITS

As the flow of environmental exploitation is an input in the production processes, we have to make sure that this input is not being demanded in a measure exceeding the environmental absorption capacity. If firms, when they exploit the environment for productive reasons, do not pay any price, it is very likely that the demand of this productive input turns out to be excessive.

We know from the traditional theory of environmental economics the reasons why the market finds it difficult for a price of environmental exploitation to emerge; basically these reasons have to do with the difficulties of the market to reveal the costs of environmental damages, measured as opportunity costs by the benefits of environmental improvement, because of the fact that environmental damage is a public bad while environmental improvement is a public good.

We can fully recover the teaching of the traditional environmental economics, by claiming that in order to maintain the flow of environmental exploitation within the limits of the absorption capacity required to sustain the environmental quality associated to the chosen sustainable development path, an environmental policy is required in order to achieve an appropriate price for the environmental utilization.

This price should grow over time along a sustainable growth path. As with any productive input, the demand for environmental utilization by the firms will be pushed to the point where the marginal product of such an input is equal to the input price. This implies that the share of national output used for the payment of this environmental exploitation factor must be constant over time. However, given that the ratio between environmental exploitation and national output continuously declines over time, this means that the marginal product of environmental exploitation and the price of the environment utilization both grow at the desired rate of growth for the economy. The growing price for the use of the environment derives both from the increasing productivity of the environmental exploitation and from the increasing willingness to pay of the society to maintain environmental quality.

There are basically two types of environmental policies which can be used to define such an appropriate price for the use of the environment. The first type of instruments implies that the environmental regulator directly fixes the price in such a way to induce the market to achieve the desired levels of environmental exploitation and environmental quality. The second type of instruments implies fixing directly the desired levels of environmental exploitation and environmental quality, and leaving to the market the job of finding out the appropriate price. The typical instrument in the first case are environmental taxes; in the second case are tradable permits for environmental exploitation (Kolstad, 2000).

A serious problem with environmental taxes lies in the difficulty of information for the environmental regulatory authority. As it is well known, the tax should be established at the value of the marginal environmental damage corresponding to the socially efficient level of the environmental exploitation. As a matter of fact this is only true for fully competitive markets where the environmental tax must correct the entire distorsion in resource allocation represented by the environmental negative externality; this externality creates a difference between price and marginal private production cost equal to the marginal environmental damage which is not revealed by the market; hence the tax has to entirely fill this gap. With imperfect markets a difference between price and private marginal costs exists and it is related to the market imperfection distorsion; hence the environmental tax should be fixed at a level lower than the marginal environmental damage (Xepapadeas, 1997).

The implication of this is that under imperfect competition the environmental policy is in general less severe than with fully competitive markets; this conclusion can be extended to the relation between environmental policies and trade policies in open economies. This may lead to the idea that environmental policies should be used as strategic trade policy instruments. However this would be a typical second best type of conclusion. A first best policy should not accept a compensation between different distorsions; it should try to correct both distorsions aiming at full competition and trade liberalization on the one hand and to a first best environmental policy on the other. In open economies, environmental policies should point at internalizing environmental costs so that relative costs can be used to determine comparative advantages on the basis of the social and not only private costs. However we have to be aware that when one form of distorsion exists in the economy, a second best criterion should guide policies dealing with the other forms of distorsion (Ulph, 2000).

Coming back to the correct level of the environmental tax, the problem for the environmental regulator is that it needs a lot of information to determine, first the socially efficient level of environmental exploitation, and second the related marginal value of the environmental damage in order to calculate the environmental tax equal to or related to this marginal value.

However if the regulatory authority has in any case to give priority to the determination of the socially efficient level of environmental exploitation, while does not impose it directly as a standard? We know from the literature that an important element in the choice between a tax and a standard has to do with the nature and the level of information available. If the regulator is imperfectly informed about the private costs of environmental improvement, a tax should be preferred when the value of the environmental damage is very sensitive to the variation of the damage; on the contrary, a standard should be preferred when the value of the environmental damage is insensitive to the variation of the damage. This second situation happens when there are threshold effects, so that below a certain limit of environmental exploitation the marginal damage is very low, and above that limit it becomes extremely high (Kolstad, 2000).

When the regulator chooses some standard corresponding to a sustainable level of environmental quality, the burden of revealing the correct price should be left to the market. This result can be used by using tradable permits as instruments of environmental policy. The price of the input referring to environmental exploitation is the price formed on the tradable permits market.

An efficiently organized permits market allows to achieve the required aggregate standard in a cost effective way. It is well known that the cost effectiveness rule is that the distribution of the effort to improve the environmental quality among the various sources of environmental degradation should equalize the marginal costs of environmental improvement. The permits market fulfills this condition as the sources with higher marginal abatement costs prefer buying permits from the sources with lower marginal abatement costs, which will prefer selling permits, so that aggregate abatement costs will be minimized.

A market for permits must be organized; in order to be efficient this market should be as near as possible to a competitive market. Some rules of the game should be observed and the environmental regulator should monitor that these rules are followed. This may imply very high organization costs. These however are initial costs; once the market has learnt how to function properly, it is likely that the current costs are lower than those related to imperfect and asymmetric information in the case of environmental taxes. The high organizational fixed costs often discourage regulatory authority to establish these permit markets. It is likely that the diffusion of a correct market culture in the public opinion will help to overcome resistance enlarging the experiences in this field.

An argument often used to support environmental taxes is the possibility of linking them to other forms of taxation in the economy. The idea is that introducing environmental taxation could reduce the degree of distortion of other forms of taxation. Many of the taxes required to generate revenue and support public expenditures are in fact distorsive; take for example labor taxes which discourage employment or capital taxes which discourage investment. These distorsion in resource allocation could be reduced if environmental taxes, which are not distorsive as they respond to a negative externality, substitute distorsive taxes such as income taxes.

Recently many proposals of “environmental fiscal reforms” have been launched; according to these proposals substituting environmental taxation for labor taxation produces a “double dividend”: the first dividend consists in the reduction of the environmental damage; the second in the increase of social welfare associated with the reduction of distorsive taxes.

The proposal is appealing, but things are not so simple. The first environmental dividend is beyond dispute; the second dividend however is not granted. The reason lies again in the need of a second best approach, which requires to take into account the implications of the existing distortions. It is true that the fiscal revenue from environmental taxes allows reducing labor taxes in such a way to keep constant the government revenue according to a criterion of fiscal neutrality. This “revenue recycling effect" on the social welfare is positive, as it is associated to a substitution of a non distorsive taxation for a distorsive one.

However we expect that the demand of goods and the demand of leisure are substitutes: if the price of goods increases because of the environmental taxation this will reduce the demand for goods and increase the demand for leisure. There will be an increase in the quantity of leisure exchanged and a reduction in the quantity of labor exchanged on the labor market. A lower revenue from labor taxation will follow which must be covered. Thus we have a welfare loss from the environmental taxation, the so called "fiscal interaction effect".

Notice that this additional inefficiency comes from the introduction of environmental taxation given that a distorsive labor taxation exists; if there were no taxation on labor, there would be non fiscal interaction effect. The fiscal interaction effect opposes the revenue recycling effect; hence the "second dividend" of an environmental fiscal resource depends on the relative size of these two effects. Only if the revenue recycling effect is larger than the fiscal interaction effect, the environmental fiscal reform produces a double dividend (Goulder, 1997).

AN INCREASINGLY IMPORTANT INSTRUMENT OF ENVIRONMENTAL POLICY: LIABILITY

An increasingly important instrument, which tends to induce behaviors observant of the objective of maintaining the level of natural capital, is liability. The increasing awareness of heavy costs deriving from legal action undertaken by public authorities or victims of environmental accidents is a powerful factor in preventive behavior aimed at avoiding natural capital degradation.

In the economic analysis of law, liability plays the role of inducing economic agents to internalizing external costs of their actions and to adopting socially efficient precaution and activity level, aimed to minimizing the social cost of accidents. In this sense, liability is an ex-post instrument of environmental policy which is being applied after the damage has happened, but tending to determine, by potential environmental users, an ex ante behavior compatible with a socially efficient level of environmental exploitation. Expected liability from a produced damage provides incentives to reducing the probability and the size of future compensations.

In the literature two types of liability are considered: strict liability and negligence. Under strict liability, the polluter would be liable for damages resulting from his activities regardless the amount of care exercised in conducting them. Under a negligence rule, a polluter would be held liable for produced damages only if he were deemed to have been negligent in conducting the activity, that is if he has not exercised a due standard of care. In the absence of negligent behavior, the polluter is not liable for damages resulting from his activities. It is easy to realize that there is a correspondence between strict liability and environmental tax on the one hand, and between negligence and environmental standard and tradable permits on the other hand (Segerson, 2000).

Both rules aim at producing an efficient level of care. Strict liability gets this result by imposing on the polluter the whole cost of the environmental damage; in the case of negligence, the polluter will have an incentive to follow the due standard of care in order to avoid paying liability costs.

A limit of strict liability is that it requires that polluters believe they will pay for the whole environmental damage that results from their activities. Often this does not happen. One reason is the difficulty of proving causation when the damages are uncertain, as with long latency periods: it may be difficult to prove that a given cancer case was caused by exposure to a toxic substance many years ago. Similarly, even if held liable, the polluter may not make the full damage payment if the damages exceed the assets available for payment. Another reason can be that victims may not bring suit if legal fees are too high or damages are widely dispersed across various victims each of them adopting a free riding behavior hoping the others will make the first move.

Strict liability also provides the appropriate incentive to the polluter for an efficient level of activity by imposing on him the full cost of the environmental damage. Under negligence, the polluter can avoid liability by following the due standard of care independently on the level of activity. He can intensify this level with out this implying an increase in liability, with a clearly higher probability of producing the damage. Hence as far as the activity level is concerned, strict liability is superior to negligence.

Negligence may be preferred to strict liability when incentives of the victims to care are taken into account. Under strict liability compensation is equal to the damage and this cancels any incentive for the victim to reduce the damage through measures of care. Under negligence, when the polluter follows the due standard of care, the victim is not being compensated and fully bears the damage cost. The victim will respond to this cost translation by using the level of care necessary to minimizing the complementary liability.

From this, it follows that strict liability and negligence differ with respect to risk allocation. Strict liability imposes all of the risk on polluters. This rule can imply big risks for risk averse small firms especially if environmental liability insurance is not available. Large firms may be able to spread risks through self-insurance. Negligence imposes a lower degree of risk on polluters since compliance with the due standard absolves them of liability; risks are on the contrary borne by the victims who are often risk averse or by the government if public victim compensation funds exist.

The empirical evidence suggests that liability rules are very effective when applied to relevant contamination problems where the damages are large and concentrated; for example, land contamination from hazardous waste disposal or oil spills from big ships. Recently liability rules seem to encourage preventive behavior in case of health damages related to exposure to toxic substances provided that the causality relation is not too difficult to establish.

ENVIRONMENTAL POLICIES AND TECHNOLOGICAL PROGRESS

Subsidies to environmental improvement are often invoked as good instruments of environmental policy, especially by polluters hoping to get some help in their pollution abatement initiatives. However there are reasons to prefer taxes on environmental exploitation to subsidies to environmental improvement. Although a subsidy rises the marginal private cost towards the marginal social cost, it however reduces the average cost; hence a subsidy can be considered as source of profit for the firms receiving it. This may push other firms to enter in the market, so that although environmental exploitation by individual firms is lower, it becomes higher at the aggregate level (Kolstad, 2000).

There are of course political economy pressures to use subsidies as instruments of environmental policy: it is always better to receive something than to pay something. However from the social point of view subsidies require taxes to be financed. When these taxes are of a distorsive type, this increases social inefficiency. The situation is even worse from the point of view of social welfare when subsidies go to economic activities directly or indirectly damaging the environment, as it is the case with agricultural subsidies, or with subsidies to polluting forms of energy, or with implicit subsidies in the form of excessive low prices for the use of some natural resource such as water. These types of subsidies can neutralize the effects of other instruments of environmental policy; if they are supported by distorsive taxation, the combination of distorsive subsidies and distorsive taxation has the worst effect on social welfare.

Subsidies and taxes should not be considered as opposite instruments of environmental policy. Environmental taxes do not represent a social cost, as they are redistributed to society as public expenditure. Nothing prevents from using the environmental tax revenue to subsidize environmental improvement provided that secondary perverse effects are avoided. This can be obtained by focusing on support to preventive initiatives. An important form of preventive support to environmental improvement is through financing R&D aimed at this objective, especially when there is evidence that the private rate of return to this kind of knowledge development is lower than the social rate of return.

The type of technological progress which is being introduced in the economy is crucial. It is not automatic that technological progress implies the maintenance of a constant flow of environmental exploitation with continuously increasing national output. A fundamental principle of thermodynamics, the law of conservation of matter, implies the impossibility of a continuous net expansion of physical capital and output; as a matter of fact matter they can only be transformed. Growth of physical capital is therefore limited and this limit can partly be released through recycling; recycling however requires energy, which is itself limited. As we have seen before, the crucial factor in releasing these ecological limits is growth of knowledge, and growth of immaterial capital and output.

Many people claim that this is exactly the feature of the technological progress of our time. First, the new information and communication technologies imply a continuous decline in the coefficient of environmental exploitation per unit of output and an increasing dematerialization of production processes. Second, the same effect come from the continuous modification of the production structure towards service and immaterial goods which characterizes the advanced stages of economic development (Porter, 1990; Grossman and Krueger, 1995). Third, a fundamental role will be played by new energy technologies able to strongly reduce the use of fossil fuels and to promote new forms of energy less dangerous and pollutant, such as fuel cells and solar energy (Lomborg, 2001).

These are positive perspective, which should be properly encouraged; however some caution in this field seems convenient. New information and communication technologies will have some negative side effects related to accelerated obsolescence of material instruments and to wider opportunities of material goods international trade. The development of some services, such as tourism, is bound to have significant impacts on the environment in terms of congestion, waste generation and pressure on cultural heritage. New renewable and less polluting energy technologies must be placed in an uncertain future; they will require huge costs to become marketable and it is especially unclear when transition to the new forms will be possible.

The implication of all this is the importance of policies to provide the appropriate incentives for the development of knowledge and technological progress to be oriented to sustainability and improvement of the quality of life. Combining public and private research effort is likely to be very effective to this end (Carraro, Pomè, Siniscalco, 2001). Different types of environmental policy instruments (taxes, permits, liability rules) each have their specific role to play if appropriately used, in order to provide the right incentives through introducing, in an explicit or implicit way, a price for the environmental exploitation. Hence they must be considered not as opposite, but integrated policy tools. Within a budget constraint, subsidies to environmental improvement and R&D also play an important role in increasing the private rate of return of an environment friendly technological progress towards the higher social rate of return.

All these policies require social consensus. This means that they ultimately depend on individuals' preferences in the society. The higher is the weight of environmental quality in consumers' utility, the higher will be their marginal willingness to pay for a better quality of life. This will not only send appropriate signals to the market favoring more environment friendly goods and production processes, but will also help in sustaining the required environmental policies. In this perspectives any social initiative aiming at promoting environmental awareness and participation, such as environmental education programs, voluntary agreements, social forums like Agenda 21, are essential to make environmental policies more effective in achieving their objective of improving social quality of life.

BIBLIOGRAPHIC REFERENCES

C.Carraro, A.Pomè, D.Siniscalco, Science versus Profit in Research: lessons from the human genome project", FEEM Working Papers, 2001.

L.H.Goulder, Environmental Taxation in a Second Best World, in The International Yearbook of Environmental and Resource Economics 1997/98 a cura di H.Folmer e T.Tietenberg, Edward Elgar, 1997, pp. 28-54.

G.M. Grossman, A.B. Krueger, Economic Growth and the Environment", Quarterly Journal of Economics, 1995, vol.112, pp.353-378.

C. Kolstad, Environmental Economics, Oxford Univeristy Press, 2000.

B. Lomborg, The Skeptical Environmentalist, Cambridge University Press, 2001.

R. Perman, Y. Ma, J.McGilvray, M. Common, Natural Resource and Environmental Economics, Longman, 1999.

M. Porter, The Competitive Advantage of Nations, Free Press, New York, 1990.

P.K. Rao, Sustainable Development: Economics and Policy, Blackwell, 2000.

K. Segerson, Liability for Environmental Damages, in Principles of Environmental and Resource Economics, a cura di H.Folmer e H. Landis Gabel, Edward Elgar, 2000, pp.420-446.

S. Smudlers, Economic Growth and Environmental Quality, in Principles of Environmental and Resource Economics , a cura di H.Folmer e H. Landis Gabel, Edward Elgar, 2000, pp. 602-664.

T. Tietenberg, Environmental and Natural Resource Economics, Addison Wesley, 2000.

A. Xepapadeas, Advanced Principles in Environmental Policy, Edward Elgar, 1997.

A. Ulph, Environment and Trade, in Principles of Environmental and Resource Economics, a cura di H.Folmer e H. Landis Gabel, Edward Elgar, 2000, pp. 479-528.